A CRITICAL SURVEY ON EFFICIENCY AND SECURITY OF INTERNET OF THINGS BASED INTELLIGENT TRANSPORT SYSTEM

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ABSTRACT
With urbanization and increase in population and vehicle usage, transportation sector and people experience major challenges like traffic congestion, high accident rates, transportation delay, and air pollution. Nowadays, it has become a challenge to manage crowd and vehicular traffic in a way that is both efficient and safe in transportation. Traditional transport management system is ineffective in terms of time, cost, energy consumption, security, and quality of service (QoS). The Internet of Things (IoT) integration into transportation systems has helped alleviate such issues, while also facilitating the collection of useful commuting data that has led to the development of intelligent transport systems (ITS). Though ITS helps in reducing traffic congestion, accident rates, transportation delay, and air pollution, it is associated with certain challenges like cyber-security and energy efficiency issues. Hence, we presented a survey on recent techniques involved in enhancing energy efficiency and security of vehicular communication in IoT-based-ITS. Initially, architecture of ITS involving different layers, including data collection, sharing, and storage layers, is discussed. Then various applications and challenges in IoT-based-ITS are explained. Following this, recent approaches involved in mitigating the challenges encountered by IoT-based-ITS, are presented in this survey. Future trends to be incorporated in ITSs for alleviating efficient traffic control, monitoring, and management are also discussed.

Keywords: ***Internet of Things (IoT), Intelligent Transport System (ITS), Traffic, Communication, Security, Efficiency.***

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I. INTRODUCTION

Transportation infrastructure has a significant role in a country's ability to compete globally, its economic health, and its level of productivity. Currently, transportation networks are crucial to almost every aspect of modern life. Forty percent of people, on average, are out and about for an hour or more every day, according to a recent survey. People's reliance on transportation networks has increased dramatically in recent years, posing new possibilities and problems for these networks. Cities grow in size as their populations do, and with that come a corresponding growth in the total number of automobiles on the road. The contemporary city's daily routine and environment are both negatively impacted by the widespread traffic congestion that has emerged as a global issue in recent years. Transport-related difficulties include, but are not limited to, delays in departure times, excessive fuel use, and increased pollution levels. Developing and developed countries alike have challenges from the environmental noise, air pollution, energy waste, and other elements afflicting modern transportation in big cities. These issues have arisen as a result of the rapid pace of urbanization, motorization, modernization, the growth of the urban population, the proliferation of faster vehicles, the saturation of the urban transport system, and other factors. Consequently, there has been a rise in the frequency of accidents. The end effect is a high number of people dying in traffic accidents. According to WHO, road accidents account for more than 100 million deaths and up to $500 billion in annual economic losses throughout the world every year. As a consequence of inadequate or delayed medical attention, more over half of all accident victims die (Goyal et al. 2022). Since this is the case, traffic management officials have a formidable obstacle in keeping tabs on the flow of traffic.

There is, without a doubt, a need to both lessen the number of traffic accidents and identify them after they have already happened, so that their aftermath may be lessened. Traffic jams might occur due to numerous reasons like natural hazards, tree falls, flooding, avalanches, and other forms of natural road hazards pose a threat to public safety. For intelligent transport networks to be realized, conventional traffic management needs a large number of calculations and a wide range of information. Transport management system has several limitations and is constrained by existing technologies. As the world becomes increasingly interconnected and information technology advances at a rapid pace, conventional modes of transportation can no longer keep up with the demands of economic and social progress. As a result, intelligent transportation has emerged as the industry standard, ushering in a new era of innovation in the realm of urban transportation. Integration of vehicles into intelligent transportation networks paves the way for more smart traffic management; detection, prediction, and avoidance of collisions; detection of malicious or anomalous activity inside a specific vehicular network; and authentication and other forms of security.

ITSs refer to the use of modern forms of communication and computing to solve issues plaguing more traditional modes of transportation. To make the transportation system more secure, reliable, efficient, accessible, and environmentally friendly, these companies use cutting-edge technology in these areas. Wired systems, which are a part of traditional ITS, are not very adaptable. Millions of IoT-enabled devices are needed to realize the vision of smart and intelligent transportation. By quickly detecting environmental restrictions, sending the detected data, and presenting a detailed report utilizing visualization tools, the IoT application in ITS promises to expand the range of services available to users. By 2020, according to a Gartner forecast, the Internet of Things will include 30 billion linked smart cars capable of sensing, communicating, operating, and maybe acting upon one another. To increase efficiency, lessen congestion, make roads safer for drivers, save resources, and safeguard the environment, countries often use the ITS approach (Zhang et al. 2020). The advantages of ITSs are illustrated in figure 1. By using the Internet of Things, transportation systems can increase carrying capacity, enrich the passenger experience, and make cargo delivery more reliable, efficient, and secure. By combining smart traffic management with citywide sensor networks, the police, emergency services, and other government agencies can better monitor the city as a whole and react more quickly to calls for assistance.

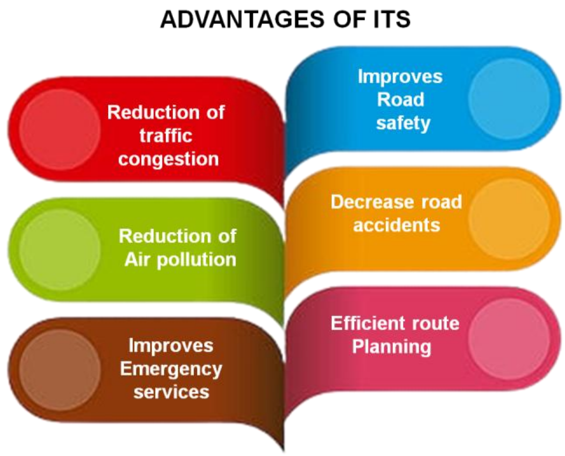

Figure 1: Major Benefits of Intelligent Transport System

ITS offers smarter opportunities but has certain challenges in implementing ITS. Due to the heterogeneous nature of the connected vehicle environment in ITS, algorithms must be developed to give in-vehicle communication devices the intelligence they need to make decisions based on factors such as the QoS parameters of the requested application and the current traffic/environmental conditions. Similarly, information security mechanisms must be developed to guarantee the safe transfer of sensitive traffic/accident data. Emergency applications require a network connection with low delays. The real-time nature of applications, the rapid mobility of vehicles, the broad range of relative speeds between nodes, and the large number of system and application related requirements all provide technical obstacles in ITS implementation. A comprehensive survey on applications, challenges, recent approaches that are utilized in enhancing energy-efficiency and security of ITSs is less available. This motivated us to conduct this survey. This survey presents the overview of benefits and challenges in ITSs, and emerging techniques in improving energy efficiency, security, time efficiency, and QoS of vehicular communication in ITS.

II. ARCHITECTURE OF INTELLIGENT TRANSPORT SYSTEM

IoT-based ITSs have been created that can consolidate many different types of infrastructure into a single operating unit, such as those responsible for sensing, communication, information distribution, and traffic management. Data collection, data analysis, data/information transfer, and data storage are the fundamental building blocks of any ITSs. Figure 2 depicts the different layers in ITS.

Data Acquisition layer: The data-collection elements of the transportation system gather all visible data for the aim of assessing the present traffic condition (including, but not limited to, traffic volume at a specific location on the road network, average travel time for a certain road segment, ridership on a specific transit line, etc.). As sensing and imaging technology improves, alternatives like video cameras and radio-frequency identification (RFID) scanners are being considered more seriously for use in traffic data collection (Torre-Bastida et al. 2018). Mobile, position, improbable occurrences, natural dangers, etc. are just some of the data that may be gleaned from a vehicle's on-board device or sensor (OBD) with the use of OBUs (on-board units). Each car will include a GPS receiver, accelerometer, speedometer, and gyroscope, all of which will capture relevant data.

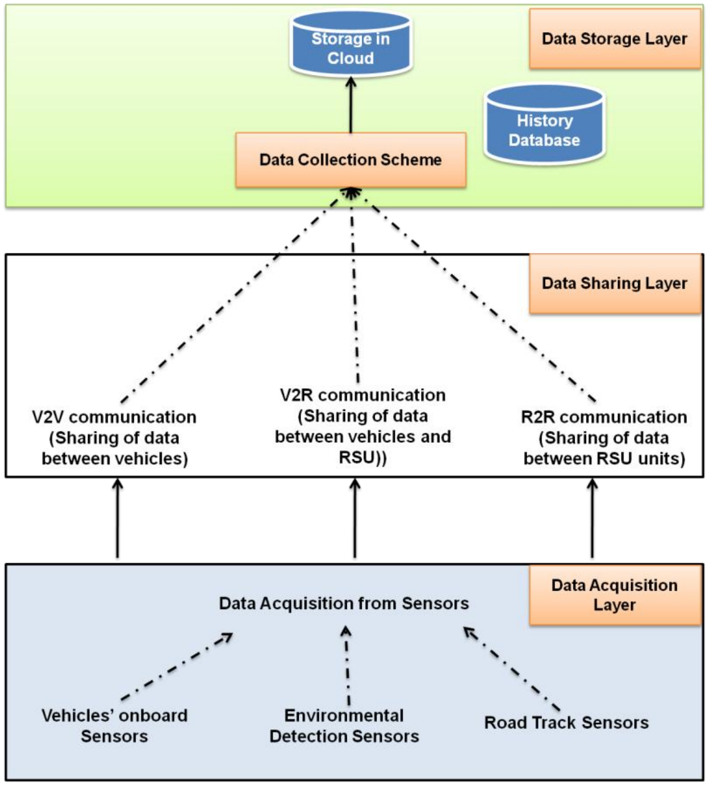

Figure 2: Layers in IoT enables ITS

Data sharing layer: After being received by OBU, the data will be processed, evaluated, and severity predictions made before being relayed to nearby cars and RSUs. With this system, automobiles communicate sensor data with one another and RSUs (Road side units). The vehicles and RSUs in IoT enables ITS use the communication channels to transfer information regarding traffic conditions, road status, or uncertain incidents. Fitah et al. 2018 employed Dedicated Short Range Communication (DSRC) protocol for low latency networking in ITS. Vehicle-to-vehicle communication (V2V), Vehicle-to-RSU (R2R), RSU-to-RSU (R2R), RSU-to-cloud (R2C) can occur in vehicular environment of ITS.

Data storage layer: The traffic/accident data generated and exhanged between vehicles and RSUs will be stored in the cloud (Finogeev et al. 2019). In the event of an emergency, the cloud-stored data will notify the relevant authorities (such as Google Maps or the Environmental Protection Agency) and immediately begin providing services (including evacuation routes and response teams) in response. New vehicles entering the road where the incident took place are given a warning and encouraged to choose another route.

III. Applications of Intelligent Transport System

This section shows some of the applications of ITS like traffic monitoring and management, congestion avoidance, and accident detection and enhancing emergency services in smart cities.

a) Traffic Monitoring and Management

The registration of vehicle data to the RSU is the initial stage in the traffic management concept in ITS. The location where the vehicle is expected to arrive is also specified. One area's traffic data is collected by a roadside sensor that is linked to another in a different area. One possible vehicle route and its associated traffic data are studied. If the first suggested path is doable, it is offered. If not, the next option is explored, and so on. Because of this, the car is sent along the most efficient path possible, helping to ease congestion in populated regions (Fantin Irudaya Raj and Appadurai 2022). Figure 3 shows an example of congestion avoidance in ITS. Eswaraprasad et al. 2017 suggested new IoT dependent Traffic Management that uses a "hybrid artificial neural network with a hidden Markov model (HANN-HMM)" to make short-term decisions on management of traffic for more precise and time-efficient traffic clearing in intelligent transportation systems. Kuppusamy et al. 2019 propose a smart traffic control framework based on a combination of a locally hosted traffic smart server, an optimised regression algorithm, and a server in the cloud to speed up the processing of traffic signals and thus decrease congestion, emissions, and the amount of time vehicles spend waiting at intersections. In order for ITS applications to be successful, an efficient traffic flow prediction system must be implemented to cope with potential road situations in advance. Boukerche, A. aims to improve the accuracy of traffic flow forecasts by using machine learning. In 2020, researchers Wang, J., and Wang, J. examined several machine learning techniques. By combining unsupervised online incremental machine learning, deep learning (DL), and deep reinforcement learning, Nallaperuma et al. 2019 offered a comprehensive smart traffic management platform (STMP). The STMP unifies the various big data sources, classifies traffic incidents into those that occur frequently and those that don't, and uses that information to improve such things as traffic flow forecasting, commuter sentiment analysis, and the efficiency with which traffic control decisions are made. A new DL framework named "Spatial-Temporal Graph Attention Networks" was introduced by Zhang et al. 2019 to capture dynamic spatial interdependence of traffic networks for traffic data analysis.

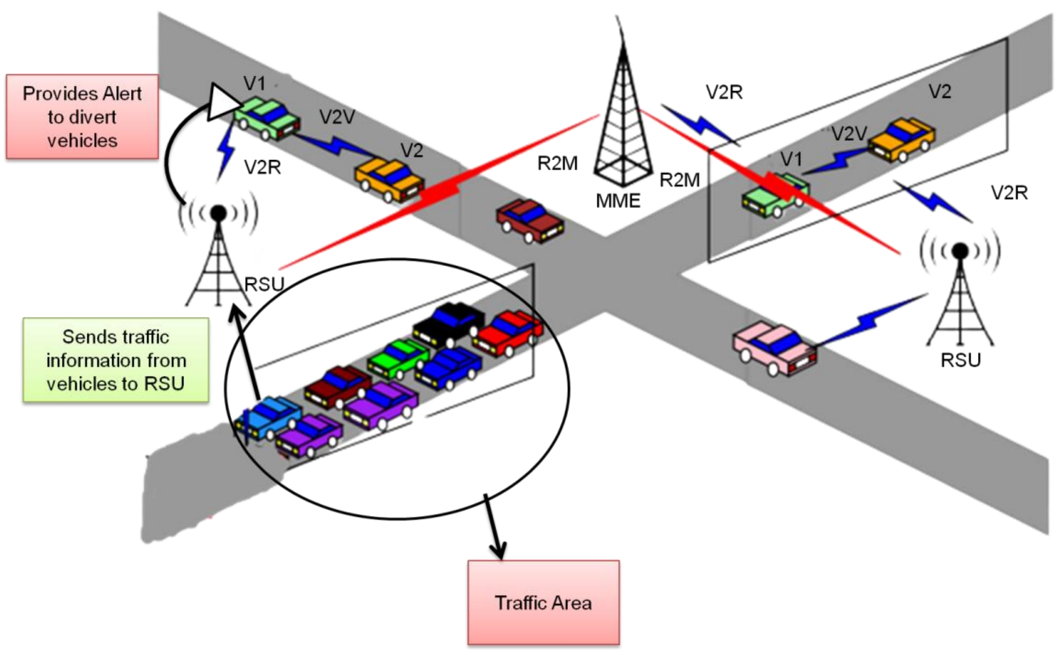

Figure 3: Traffic monitoring and congestion avoidance in IoT enabled ITS

b) Enhancement of emergency services

The victim's chance of survival is directly related to how quickly an ambulance can get them from the scene of the accident to the hospital. Most people injured in car accidents do not suffer life-threatening injuries, and may be saved if emergency workers get to them quickly enough. An automatic accident detection and alert system must exist in ITSs to overcome this situation. For this reason, pinpointing the scene of an accident and communicating this data to responding authorities as quickly as possible is crucial if we are to increase the likelihood that the victim will be saved. The hospital's emergency room receives word of the incident and sends an ambulance to the accident site (Dar et al. 2019). Figure 4 shows the transfer of accident message to hospitals in IoT based ITS. The DeepCrash system, proposed by Chang et al. 2019, is a cloud dependent DL server and cloud dependent management platform for the Internet of Vehicles (IoV), which consists of an in-vehicle infotainment telematics platform with a front camera and a vehicle self-collision detection sensor. Hadiwardoyo et al. (2018) presented Messiah, an Android app that may alert normal vehicles regarding the presence of emergency vehicles like fire brigades, ambulances, and police cars so that drivers can make informed decisions on where to go. Using blockchain technology, Vangala et al. 2020 created a certificate-based authentication mechanism, BCAS-VADN, for ITS's vehicle accident detection and notification. Bhatti et al. 2019 introduced a new IoT-based solution for smart cities to report and record accidents.

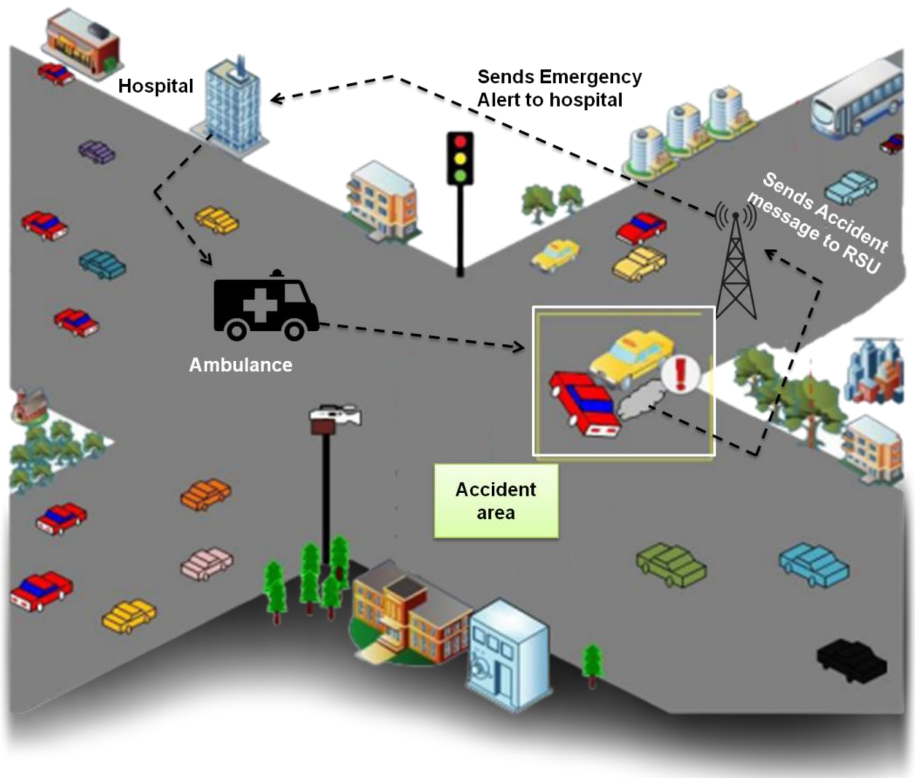

Figure 4: Accident detection and emergency alert scheme in ITS

IV. CHALLENGES IN ITS

The following sections explore some of the difficulties inherent in implementing effective ITS in smart cities. Due to factors like increased vehicle mobility and frequent link disconnection, the routing procedure in such networks is difficult. There are numerous constraints that must be overcome in order to design an effective routing protocol that fulfils latency constraints with minimal overhead (Fatemidokht et al. 2021). New obstacles for ITS are effective traffic segregation, interference management, and allocation of available resources. Improved dependability requires effective suppression of interference from cochannel use or neighboring channels (Sedar et al. 2020).

The authentication of highly mobile cars is another issue for security and privacy in vehicular clouds, as is the complexity of trust relationships between various vehicular nodes. Improving ITS's information distribution reliability and efficiency requires defining selected network coding techniques, which is a difficulty in and of itself. Data-centric trust and verification, anonymity, privacy, and responsibility of traffic data sent in ITSs provide unique challenges that must be identified and managed via thorough risk analysis and management (Camacho et al. 2019). Furthermore, a crucial responsibility in ITSs is the identification of malevolent vehicles. Malicious attackers/malicious vehicular nodes in ITS might transfer new/modified traffic data or emergency alert data (false data) to other vehicular nodes which makes vehicular nodes to carry out wrong travel decisions. In addition, they can prevent emergency data alerts to reach other vehicular nodes which result in traffic congestion and road clashes. Figure 5 shows the malicious attack occurring in ITS.

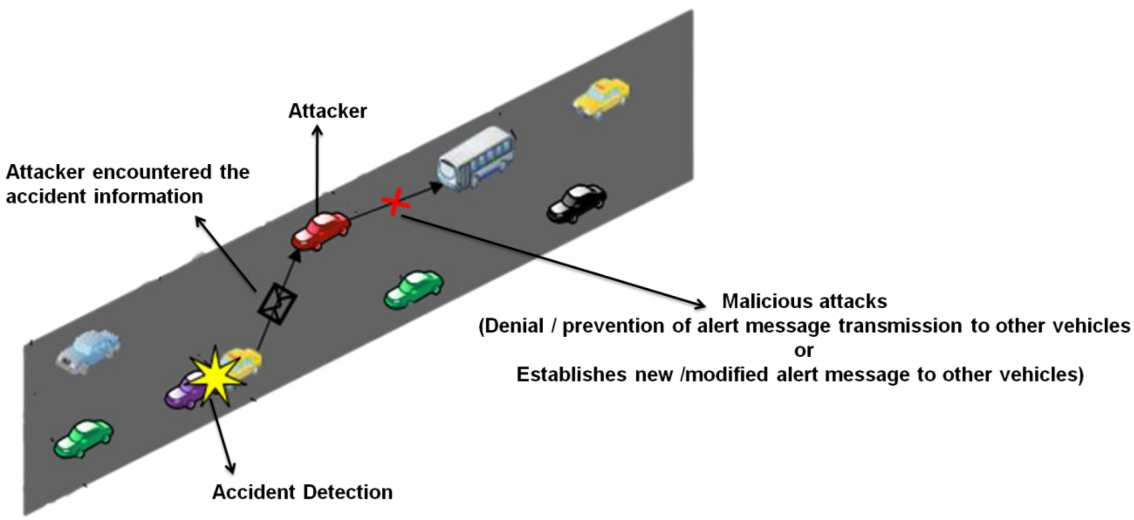

Figure 5: Occurrence of malicious attacks in ITS

When it comes to V2X communication, high precision for relative and absolute positioning, trajectory alignment, etc., is challenging to attain due to the increased mobility of the devices involved and the dynamic nature of network topologies. Harsh propagation conditions caused by the V2X dynamics, such as high delay spread and Doppler effect, owing to moving receivers, transmitters, and scatter devices, prevent the seamless and instantaneous monitoring of traffic. Maintaining confidentiality and integrity of communication across the entire network of ITS devices is a challenging task (Hahn et al. 2019; Ali et al. 2018). There may be many research programs dedicated to linked vehicles at the moment, but the biggest obstacle is raising enough public awareness to encourage governments and automakers to fund the installation of the essential technology and infrastructures in cars, streets, and highways.

V. TECHNIQUES TO ENHANCE ENERGY EFFICIENCY OF ITS

Communication between cars and infrastructure is a key feature of ITS, but it is limited by the high power requirements of embedded wireless sensor nodes in the road network (Bhardwaj et al. 2019). For this reason, studying methods to lessen ITS's energy footprint has become a priority. Cooperative communications in ITS networks, as suggested by Peng et al. 2019, is one approach to lowering the network's overall power usage. Because of the limited resources of edge nodes, a greater number of data packets will be lost due to the nodes' heavy energy consumption and short battery life. In 2020, Sodhro et al. will release a study proposing an unique 5G-driven reliable algorithm and a 5G-dependent self-adaptive green (that is energy-efficient) algorithm to enhance the energy efficiency of vehicle communication in ITS. Sodhro et al. 2019 employed a "QoS-aware, green, sustainable, reliable and available (QGSRA)" algorithm to support energy efficiency (greenness), sustainability, reliability (less traffic data loss), and availability (higher coverage) in multimedia transmission in V2V across emerging edge computing networks powered by the IoT in ITS. Kuppusamy et al. 2020 optimized the energy of metro systems by incorporating improved genetic algorithm with LSTM. The current state of IoT-ITS surveillance relies on fixed infrastructure-based sensing applications, which result in many network overheads and failures due to their exorbitant energy consumption. Drones were proposed as a gateway for "Low-Power Wide Area Networks" by Sharma et al. 2018, who also proposed a communication strategy depending on stress, energy consumption, and resilient factor of the area all of which contribute to precise localization, enhanced coverage, and energy-efficient surveillance with reduced overheads, redundancies, and isolations. To improve the QoS offered by ITS, Cao et al. 2022 investigated the problem of intelligent resource allocation inside B5G-enabled VANETs. To solve the problems of resource allocation in ITS's vehicular communication and connection, Manogaran et al. 2022 introduced the "Permissible Service Selection and Allocation" technique. To minimize computational resource available at the nodes in ITSs and maximize V2X service placement in a hybrid edge environment, Moubayed et al. 2020 used the Greedy V2X Service Placement Algorithm.

VI. TECHNIQUES FOR SECURING COMMUNICATIONS IN IoT based ITS

This section deals with emerging approaches to mitigate malicious activities in IoT based ITS for establishing secured transmission of traffic/accident data. To protect against adversarial assaults in ITS, Yamany et al. 2021 offerd a unique "Optimized Quantum-based Federated Learning (OQFL)" framework for performing automated hyperparameter adjustments for federated learning. For the purpose of uncovering malicious network activities in traffic data transmission, Ashraf et al. 2020 described a DL-dependent Intrusion Detection System (IDS) for ITSs that makes use of Long Short Term Memory (LSTM). It was recommended by Javed et al. 2020 that an "Outlier Detection, Prioritization, and Verification (ODPV)" protocol be used to more effectively separate out erroneous data and enhances the quality of traffic management choices. Specifically, ODPV use the isolation forest method to identify anomalies, fuzzy logic to rank them in importance, and C-V2X communications to confirm their authenticity. To address the issue of traffic data vulnerability, Abbas et al. 2021 suggested a decentralised data management system for secured smart transportation that makes use of IoT and blockchain in a sustainable smart city setting.

Tyagi and Dembla 2019 suggested a method for improved network connection and security against assaults on routing protocols in ITS. This technique allows for the identification of an attacker node or a chain of attacker nodes, and the IP addresses of the identified attacker nodes are excluded from the ITS network. To safeguard the identity and position of vehicles in ITS, Bao et al. 2019 presented a decentralised blockchain dependent system for pseudonym management. Haydari et al. 2018 suggested a new approach depending on non-parametric statistical anomaly detection to identify and defend against distributed denial of service attacks in ITS. A LSTM dependent SQL injection attack detection system that can automatically learn the most useful data format of attacks was developed by Li et al. in 2020. Ju et al. 2020 provide a modified generalised likelihood ratio technique to identify and quantify sensor deception attacks in ITS. Blockchain and DL modules are used to offer two levels of security and privacy in ITS by Kumar et al. 2021. A blockchain module is first created to securely transport ITS data between automobiles and RSUs, and an enhanced Proof of Work (ePoW) method depending on smart contracts is then created to ensure data integrity and prevent data poisoning attacks. Second, to protect against inference attacks, a DL module is created that uses the LSTM-AutoEncoder approach to encode ITS data into a new format. Finally, "Attention-based Recurrent Neural Network" uses the encoded data to identify intrusive occurrences in ITS infrastructure.

VII. CONCLUSION

The globe over, especially in densely populated urban and suburban regions, transportation infrastructure is under growing strain, and improvements are urgently needed. ITSs are designed to increase safety, productivity, and command of transportation networks by sharing contextual data inside such networks and their surrounding communities. New mobility technologies like IoT must be used, integrated, and implemented to improve ITS. In this paper, we've outlined a few of the most promising new techniques that may improve energy-efficiency, sustainability, reliability, and security of ITS. The survey provides deep insights into applications and challenges in implementing ITS. We suggest that the future of sustainable transportation solutions and increased road safety lies in the seamless integration of the IoT and decentralized technologies with ITS. The limitations of the presented survey are that applications of big data technology in improving decision making process for vehicular nodes in ITSs are not discussed. In the future, applications of big data technology in improving decision making process for vehicular nodes in ITS must be studied.

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