The Notion of Wireless Technology for Intelligent Transportation Systems

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ABSTRACT Communication, cutting-edge electronic and computer technologies, control, and detection are all related to the intelligent transportation system (ITS). WSN is a collection of minuscule, interconnected sensor nodes that can do the real-time computation, wireless communication, and sophisticated sensing. Through the transmission of real-time information, it improves safety, effectiveness, and traffic situation. The real-time gathering of transportation data and communication between targeted nodes play a big part in all ITS applications. It is exceedingly difficult and expensive to deploy a wired sensor for data collection and communication from a wide area. Wireless sensor deployment offers an appealing platform for data gathering and dependable communication in ITS due to the cheap maintenance costs. In this paper, the fundamental ideas and practical information needed to create an objective and routing protocol for WSNs are described. The network distribution in ITS utilizing various WSN approaches is also explained, which may aid various scholars in comprehending various difficulties in building the WSN-based ITS.

KEYWORDS Intelligent Transportation System, Wireless Sensor Network and Vehicular Ad-hoc Network.

I. INTRODUCTION

The uses of cutting-edge advances, including information communication technologies (ICT), data sensing with navigation systems, integrates under the aegis of intelligent transport systems (ITS). The principal points of utilizing such innovations in transport is to mitigate existing concerns including traffic flow control, traffic congestion, air and clamor contamination by redefining information gathering for tending to the vehicle-related concerns. ITS applies propelled advances of gadgets, sensing, detecting and communicating the desired information in the transportation framework. It also possesses in mind the end goal to enhance efficiency, services and security through transmitting real-time data. Deployment of a wired sensor for the data gathering and correspondence from the substantial geographic range is extraordinarily troublesome and exorbitant [1]. WSN is a blend of little-interconnected sensor hubs with detecting, figuring and remote correspondence abilities. Likewise, organizations of sensors are arbitrarily scattered and low support cost. These elements of WSN give an alluring stage to data gathering and correspondence in ITS. In ITS utilizing WSN, there are two varieties of sensor hubs utilized: fixed sensor node (FS) and the mobile sensor node (MS). FS nodes are randomly scattered in the vast region, and MS nodes are put in vehicles. Today, traffic congestion is the most vital social issue, and various researcher works for reducing congestion [2] Evolution of the Web 3.0" and "Introduction to the notion of wireless technology for Intelligent Transportation Systems" could be the role of connectivity and data exchange in shaping the future of technology-driven domains [3]

One of the essential objectives of the intelligent transport system is to enhance safety by decreasing danger. There is a vehicular telematics approach for creating to accomplish safety and profitability in transportation framework [4]. Recently the ADAS (Advanced Driver Assistance Systems) has been intended to enrich road safety and increase driver comfort. In any case, the impact of ADAS on individual and gathering level needs to examine [5]. A decade ago, because of the popularities of the Internet of Things (IoT), a few research endeavors had examined rising IoT application situations. The accessibility of gadgets, smart mobile phone and a remote sensor, organized empower physical gadgets like RFID and similar technology provides a platform to universal coordination [7]- [12]. The paper can be summarized as follows:

1) It provided some elementary conceptions associated with the ITS and WSN.
2) Pointed out the unique characteristics, designing objective and the specific routing requirements of the WSNs for ITS.
3) A brief overview of the general issues and corresponding defensive methods.

In this paper, the first section includes the introduction and second section talked about the intelligent transportation system. The third section gives a detailed picture of a wireless sensor network. The fourth section provides the details of

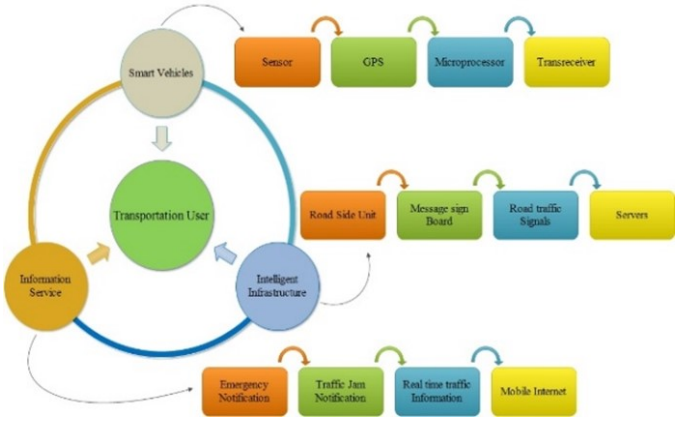

FIGURE 1: The components included in ITS.

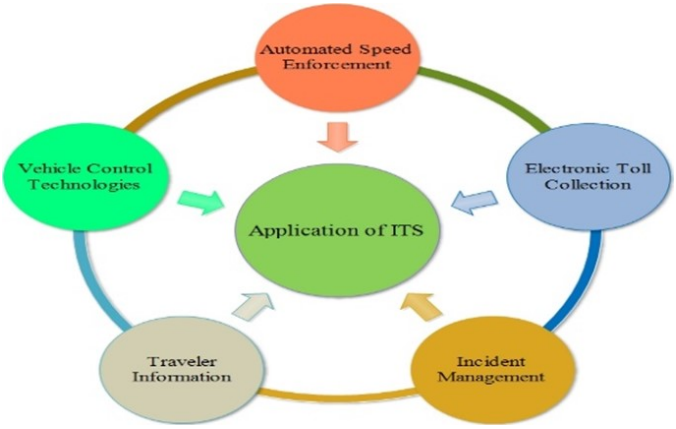

FIGURE 2: The application of ITS.

designing and functionality of WSN for ITS. The fifth section gives a reviewed-on literature to satisfy application objective. Finally, we summarized the paper in the last section Furthermore, the wireless technology aspect could be relevant in the context of the data communication and exchange between the traffic sign categorization system and other components of the ITS, such as cameras, sensors, or traffic management systems. The use of wireless communication could enable real-time data transmission, allowing for efficient traffic sign recognition and categorization [12].Traffic Accident Prevention in Low Visibility Conditions Using VANETs Cloud Environment" and "Introduction of the notion of wireless technology for Intelligent Transportation Systems" are closely related, with the wireless technology aspect being a key element in enabling traffic safety measures in the context of ITS using VANETs and cloud computing [13]- [15].

II. INTELLIGENT TRANSPORTATION SYSTEM

In the last decades surely, ITS attracted the automotive industries, researchers and governments. The different projects have been conducted by governments and research institutes from the whole of the world. ITS integrate innovative technologies of electronics, sensing detecting multiple objects and real-time communications, in all kinds of the transportation system. This integration improves efficiency, safety, services and traffic situation by the exchange of real-time information [16]. There are four integrated components of ITS. These components include Intelligent Infrastructure, Smart Vehicles, Transportation User and Information Services, as shown in Figure-1.

A. INTELLIGENT INFRASTRUCTURE

Intelligent transport system's backbone is infrastructure. Intelligent infrastructure utilizes the advances in servers, road traffic signal, message sign-board and efficient road-side unit. The key is to use the information exchange with a vehicle to infrastructure that relevant to help obtain full potential of both old and new infrastructure.

B. SMART VEHICLES

As the traffic density is increasing, the information exchange between vehicles to vehicles becomes more difficult. Therefore, smarter vehicles utilize advanced sensors, GPS and Data communication technology. The human factors aspect is crucial in the context of ITS as it considers how people interact with and respond to the technology used in transportation systems. This includes understanding how human factors can influence the design, development, and implementation of ITS solutions, and ensuring that the technologies used in ITS are designed with human-centric considerations to promote user acceptance, trust, and safe use [17].

C. INFORMATION SERVICES

One of the essential objectives of ITS is to have enhanced services, efficiency and security. It also provided movement circumstances data information to the transportation user in real-time. Information Services includes mobile internet, Emergency notification real-time traffic information and traffic jam/accident notification. Based on the advances in smart vehicles and intelligent infrastructure, ITS found in various application, as shown in Figure-2.

ITS delivers real-time traffic situation of the geographical region to the transportation user and also provides accident information to the concerned authority. It is also utilized in electronic toll collection, speed enforcement and vehicles control technologies.

III. WIRELESS SENSOR NETWORK (WSN)

The new innovative technologies in wireless communications and multi-functional sensor nodes make WSN is the ultimate cost-effective in data gathering from a broad geographical region. One of the leading advantages of WSN is low power and low cost. WSN tiny nodes are capable of observing environmental and physical conditions such as temperature, light, pressure and humidity. Based on observed information commands are generated to operate devices such as motors, switches that control different environmental and physical

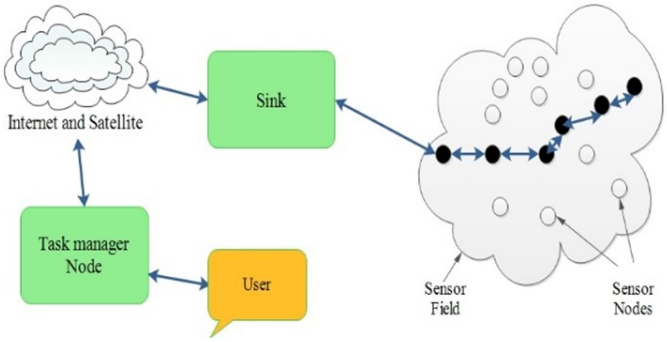

FIGURE 3: Sensor nodes distributed in a sensor field of WSN.

FIGURE 4: The application of WSN.

conditions. The tiny nodes are mostly distributed in the sensor field [18] as shown in Fig.3.

Every tiny sensor node has abilities to collect data from the dispersed area and send the data back towards the sink. The sink forwards these data via internet or satellite to the task manager. The data is analyzed, and the information send to the user by the task manager. The WSN has an advantage and capability to collaborate a large number of nodes for gathering the valid information, which is not possible from a single sensing node. In WSN deployed thousands of sensor nodes in a broad geographical region where these sensors detect the environmental conditions. The collected data computed and communicated to desire node in a well-organized way. WSN applications in different fields such as rescue operation, environmental, health, building surveillance, military application etc. [19]. Application of WSN is shown in Fig-4.

Deep Learning in Robotics for Strengthening Industry 4.0" likely focuses on the utilization of deep learning techniques, including artificial neural networks with multiple layers, for improving the capabilities of robotics in the context of Industry 4.0. This could involve the development of advanced robotic systems that are capable of autonomous decision-making, perception, and control, which could greatly enhance the efficiency and productivity of industrial processes [20]

IV. WSN SUPPORTED INTELLIGENT TRANSPORTATION SYSTEM

Intelligent transportation systems (ITS) is the fast-growing field by the uses of advanced in electronic technologies. The advances in communication and information processing technologies are used for enhancing transportation efficiency and safety. A vital role in all intelligent transport application is transportation information collection and communication [21]- [25]. Deployment of a wired sensor for the information collection and communication from the large geographic area is challenging and costly [26]. Exploring Convolutional Neural Network in Computer Vision-based Image Classification" pertains to the use of Convolutional Neural Networks (CNNs) in computer vision, which is a key technology for image classification tasks. It involves the training and deployment of CNNs to automatically analyze and classify images, which could have potential applications in intelligent transportation systems [27].

Wi-Vi and Li-Fi based framework for Human Identification and Vital Signs Detection through Walls" likely involves the use of Wi-Vi (Wireless Vision) and Li-Fi (Light Fidelity) technologies for human detection and vital signs monitoring through walls. Wi-Vi uses Wi-Fi signals to detect human presence and movement through walls, while Li-Fi uses visible light communication to transmit data. Such technologies have the potential to enable advanced surveillance and monitoring capabilities for various applications, including security, healthcare, and rescue operations [28].

In ITS, network distribution is the most useful application in the transportation system. Many researchers believe that Agent-based approach is one of the most impotent technologies which can be used for network distribution in traffic and transportation system [29]. An Agent system has two types of agent's: stationary and mobile agent. This algorithm provides mechanisms for agent communication, supervision and directory maintenance. It also supports the relocation and implementation of mobile agents. This technology is used in ITS, such as roadway system, transportation system, railway systems. Today, traffic congestion is the most important social issue for humans. The various researcher works for reducing the congestion. Traffic congestion can be reduced by:

a) Improve the existing infrastructure,
b) Sharing the resources,
c) Notification or variable message sign on the roadside
d) Reliable communication.

In fact, vehicular traffic continually increases the whole world, especially the urban area. The existing infrastructure of traffic surveillance, traffic flow maintenance and traffic control are not capable in terms of cost-effective, better performance and easy maintenance. WSN effortlessly deploy in traffic light control application. WSN provides a quick update of traffic information which analysis and apply strategies for traffic flow control as compared to existing infrastructure. WSN based infrastructure reduces congestion and average waiting time [16] [30] [31]. The state of global

traffic congestion level in the entire network during specific time intervals is evaluating and based on evolution pattern clustering, and prediction is performed, which can improve the traffic flow [32]. Many researchers believe that congestion can be reduced by sharing the vehicle such as car-pooling concept [33] or car-sharing concept [34]. Some researcher believes that by deploy of notification or variable signboard on the road-side, which provides the incident information prior to congestion area makes help to reduce the congestion [25] [35] [36] . During the congestion area communication overhead on network increases, which causes information is lost. The information loss or packet loss can be reduced by decentralized congestion control method [37] [38]. One of the primary goals of ITS is to improve safety by reducing risk. The researcher explores various vehicular telematics approach for developing to achieve safety and productivity in the transportation system [4].

V. DISCUSSION

Different kinds of research papers are going through in this study which contains conference papers, articles, workshop, preceding and journals. Many of these focus on routing problem in WSN, Vehicular communication technologies and traffic flow control strategies in ITS. A sample of proposes routing protocol that consider few constraints of WSN is shown in Table-I. It is strong that numerous hard works have been made to improve the lifetime of WSNs through a diversity of energy efficient approach. It is also giving the idea that network lifetime of WSNs strongly reliant on data aggregation. Also, scalability of networks effects the overall performance of a network distribution. Indeed, Energy-efficient routing protocols and data aggregation scheme directly influence network latency. For example, we can see that energy-efficient routing protocols can improve the robustness by using sink relocation that provides balanced distribution in case of large energy depletion. The notion of wireless technology for Intelligent Transportation Systems" likely involves a discussion or exploration of the concept of wireless technology in the context of intelligent transportation systems (ITS). This topic may cover the use of wireless communication, sensing, and data exchange technologies for enhancing transportation systems' efficiency, safety, and sustainability [62]. Hhowever, it is worth mentioning that machine learning techniques, including AutoML, can be utilized in ITS applications for tasks such as traffic prediction, traffic flow optimization, and driver behavior analysis. Additionally, the data collected from wireless technologies in ITS can be used as a valuable source of data for training and testing machine learning models. Therefore, there may be potential opportunities for collaboration between the two areas of research in the future, as advancements in AutoML and wireless technologies continue to shape the field of intelligent transportation systems [63]- [66].

Furthermore, the wireless technology aspect, which is an essential part of both IoT and ITS, could be critical in enabling seamless communication and data exchange between different devices and components of the security surveillance system. This could involve the use of wireless protocols, such as Wi-Fi, Zigbee, or cellular networks, for transmitting data between IoT devices and backend systems for analysis and decision-making [63]. Furthermore, In Table-II (which represents the application specific problems) provides of solution proposes in the literature to satisfy application objective. Road safety, traffic flow control and reliable communication are the important requirements that can be used to classify ITS applications based on their primary purpose. However, road safety and traffic flow control are not completely separated from reliability of network. For instance, a collision of two or more vehicles can lead to a traffic jam. The information of this event conveys a safety warning for nearby drivers for event awareness. The same information broadcast in ITS network with reliable infrastructure which may be used for different purposes. For example, we can use this information for road congestion management which can provide drivers with the best routes to their destinations and also determine the best time schedule for smooth traffic along the overall route. AI algorithms can be used for real-time monitoring of vehicle data, predicting vehicle failures or maintenance needs, optimizing vehicle routing and scheduling, and enhancing vehicle safety through advanced driver assistance systems (ADAS) or autonomous driving technologies. The insights and findings from the paper on AI in manufacturing can provide valuable inputs for the development and deployment of AI-driven vehicle control technologies [60] Traffic Accident Prevention in Low Visibility Conditions Using VANETs Cloud Environment" may propose the use of VANETs and cloud computing technologies to prevent traffic accidents in low visibility conditions. By enabling real-time communication and data exchange between vehicles and infrastructure, the system may provide warnings and alerts to drivers to prevent accidents in challenging weather conditions [59]

VI. CONCLUSION

The main objective of designing the routing protocol is to increase the lifespan of the network. That is possible only when sensor nodes having a long operating time. In this paper, we conclude the unique characteristics, design objective, routing protocols, and presented the requirements of the WSNs for ITS. Here, we consider a number of categorization criteria, including network heterogeneity, path redundancy, data processing, location information, and path redundancy. These standards aid in reviewing a routing protocol sample. Finally, we summarized and made a table that includes the different application of ITS with their problems. In this table we also reviewed the required solution. Confidently, by impression this paper, the beginners can better understand of routing protocols and countermeasures in WSNs. Also, the researchers can be motivated to design intelligent infrastructure, smarter vehicles and more robust secure information system

TABLE 1: Routing Protocol for WSNs

Routing Protocol	References	classification	Energy-efficient method	Data aggregation	scalability	Query-based	QoS
EASR	[39]	Flat	Sink relocation	No	limited	Yes	No
EHGUC-OAPR	[40]	Hierarchical	The energy-based Cluster head	Yes	Good	No	No
NCPR	[41]	Hierarchical	Reduce broadcast storm in a cluster network	Yes	Good	No	Yes
CNSMR	[42]	Hierarchical	Heterogeneous node	No	Good	No	No
MBR	[43]	Hierarchical	Cluster head selection parameter is mobility and residual energy	Yes	Good	No	No
SCADD	[44]	Flat	N/A	Yes	limited	Yes	Yes
ACR	[45]	Flat	N/A	Yes	limited	No	Yes
IMHT-LEACH and DMHT-LEACH	[46]	Hierarchical	Minimize data transmission distance	Yes	limited	No	No
P-SEP	[46]	Hierarchical	Elect Cluster head based on average energy and probability	Yes	Good	No	No
EARP-GA	[48]	Hierarchical	Genetic Algorithm for data sharing	No	Limited	No	No
MAHEE	[49]	Hierarchical	Cluster head based on higher Energy	Yes	limited	No	No

TABLE 2: Its Application Problem and Solution

Year	References	Application	Problem	Solution
2014	[36]	Traffic Flow control	Traffic congestion	Balancing Lane Use with VMS
2015	[38]	Vehicular Control Technologies	context-awareness in VANET	Decentralizing the information processing in VANET
2016	[50]	VANET	Broadcast Overhead	Beacon Information Independent Routing Algorithm
2016	[51]	ITS	Automated ITS	Cooperative Vehicular Techniques
2017	[52]	Traveler Information	Effective Routing	FAVOUR algorithm
2018	[53]	VANET	QoS Of 802.11P	Adaptive Transmission And Clear Channel Assessment Power Scheme
2018	[54]	Highway VANET	Reliable Routing	Collision Aware Opportunistic Routing Protocol
2018	[55]	Urban VANET	Routing Delay	Cross Layer Cooperative Routing Protocol with IEEE 802.11P
2019	[56]	VANET	Broadcasting Overhead	Robust Multi-Point Relay Selection Procedure with Optimized Link State Routing Protocol
2019	[57]	VANET	Channel Utilization	Optimized Link State Routing Protocol with Minimum Multi-Point Relay Selection Algorithm
2019	[58]	VANET	Collision and Delay	Demand Aware Media Access Control Scheme Based on Multi-Channel Cooperative Cooperation

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