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EVALUATION OF REGIONAL ROAD TRANSPORT SAFETY SERVICE LEVEL WITH EDGE COMPUTING IN SCALABLE SENSOR AND ACTUATOR NETWORKS

XIAOXU DANG*, GUOYU WANG†, XIAODONG ZHOU‡, AND SHIHUI WANG§

Abstract. In contemporary society, road transport has assumed a pivotal role in the daily lives of individuals, with virtually everyone being a road user in one capacity or another. Unfortunately, a significant portion of road accidents stem from user negligence and a lack of awareness regarding road safety principles and regulations. The majority of these accidents are fundamentally a result of human errors, errors that could potentially be averted through the comprehensive utilization of technology. The integration of edge computing within actuator networks, combined with the scalability of sensors, holds the potential to proactively detect and prevent impending collisions. This cutting-edge approach not only accumulates and processes sensor-generated data but also employs it to mitigate the occurrence of road accidents. This discussion delves into the potential advantages offered by smart sensors and advanced technology, focusing on the enhancement of safety within transportation networks. The core attributes of these intelligent technologies facilitate the establishment of robust connectivity and the effective implementation of processes, ushering in an innovative era in the realm of road safety through smart technology.

Key words: Road transport, Safety services, Edge computer, Scalable sensor, Actuar networks

1. Introduction. In contemporary society, road transport has seamlessly integrated itself into the fabric of daily human existence, impacting the lives of individuals from all walks of life. Whether it's the daily commute to work, the school run, or leisurely travel, road transport plays a crucial role. However, this convenience comes at a cost, as road accidents and mishaps continue to pose significant threats to public safety. The root causes of these accidents often stem from human factors, primarily the carelessness of road users or their inadequate knowledge of road safety principles and guidelines. The consequential human errors leading to road accidents underscore the imperative need for a paradigm shift in road safety strategies. It is within the boundless potential of technology that the solutions to these persistent challenges may lie. In particular, the emerging field of edge computing, in synergy with actuator networks and scalable sensor technology, holds the promise of transforming road safety by proactively detecting and preventing collisions. This innovative approach involves the gathering and processing of sensor-generated data, utilizing it to predict and avert potential accidents.

The Internet in the modern era is a great revolution of the advances technology has been thus far. This revolution of the digital world has brought a huge change in the lifestyle, economies, and societies. Technology in the digital era has transformed the lives of the human, which can only be possible to imagine just a few centuries ago.

Although the rise in road accidents due to the errors of drivers is alarming, it is very important to address that and use edge-computing technology to decrease the maximum loss possible [2]. The aim of this study is to understand the safety services of regional road transport with edge computing in the sensor that is scalable and an actuator network.

This research discussion delves into the potential advantages offered by smart sensors and cutting-edge technological advancements in the realm of transportation safety. By focusing on the enhancement of safety within transportation networks, this research aims to explore the transformative role that technology can play in revolutionizing road safety measures. The core features of these intelligent technologies facilitate the creation of robust and stable connectivity, thus ushering in an innovative era in the domain of road safety through the implementation of smart technology. This study endeavors to shed light on the evolving landscape of road safety,

*Institute of Management, Xi'an University of Science and Technology, Xi'an, 710054, China (xiaoxudangres21@outlook.com)
†Institute of Management, Xi'an University of Science and Technology, Xi'an, 710054, China
‡Department of Transportation of Shaanxi Province, Xi'an, 710075, China
§Institute of Management, Xi'an University of Science and Technology, Xi'an, 710054, China

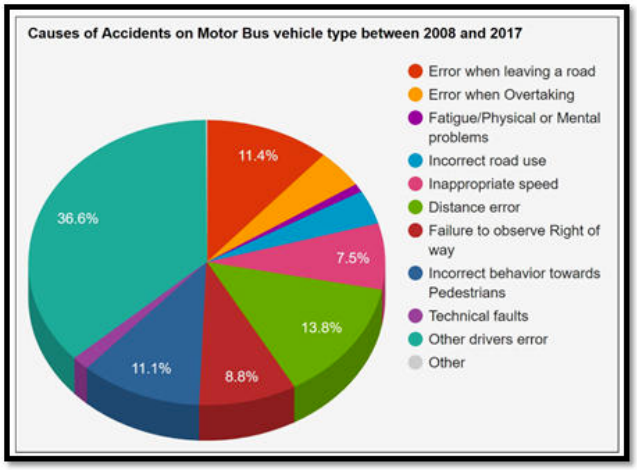

Fig. 1.1: Causes of motor bus vehicle-type accidents, 2008 to 2017

offering insights into the synergy between technology and transportation safety, with a particular emphasis on the possibilities and advantages of smart sensors and advanced mechanisms.

2. Objectives. In this study, some of the key objectives of the research have been identified and evaluated. This includes the basic concept of regional rod safety services, edge computing, and other related things. The objectives also include minute details of the relations between the key terms of this study. The identified key objectives are as followed:

RO 1: To identify the basic concept of safety services of regional road transport

RO 2: To evaluate the idea of edge computing in scalable sensor and actuator network

RO 3: To determine the importance of safety services in the regional road transport

RO 4: To investigate the impact of edge computing in scalable sensor and actuator networks in terms of safety services in the regional road transport

RO 5: To analyze the challenges faced by safety services in regional road transport while implying edge computing in scalable sensor and actuator networks

RO 6: To evaluate the recommended strategies in order to mitigate these challenges faced by safety services in regional road transport while implying edge computing in scalable sensor and actuator networks

The motivation for undertaking this research is rooted in the pressing need to address the persistently high rate of road accidents and mishaps that threaten the safety and well-being of road users worldwide. Road transport has become an integral part of modern human life, providing unparalleled convenience, yet it also presents inherent risks, primarily stemming from human errors, negligence, and a lack of awareness about road safety. These accidents not only result in a loss of lives and property but also place immense burdens on healthcare systems and infrastructure.The research is driven by the realization that technology, particularly in the form of edge computing and smart sensors, has the potential to revolutionize road safety by providing real-time monitoring, data analysis, and proactive collision prevention measures. As the world becomes more interconnected and data-driven, harnessing technology's full potential in enhancing road safety is not just a promising endeavor but a necessity.

The advent of smart sensors and cutting-edge mechanisms offers an unprecedented opportunity to advance road safety by mitigating human errors, predicting potential collisions, and enabling timely interventions. The motivation for this research lies in exploring how these innovative technologies can be effectively integrated into transportation networks to not only reduce road accidents but also to foster more efficient and sustainable road transport systems. By comprehensively examining the potential advantages and impacts of smart sensor technology and advanced mechanisms in road safety, this research seeks to contribute to the broader goal of making road transport safer, more reliable, and environmentally sustainable. Ultimately, the motivation is to

Table 3.1: Tips for road safety

Tips for Road Safety	Do not use mobile phones while driving or riding Walk carefully on the footpaths and cross the road when the traffic light is red using the zebra crossing Never drink and drive Be careful of the pedestrians, children, and all the citizens Wear helmets and seatbelts accordingly Never go above the speed limit

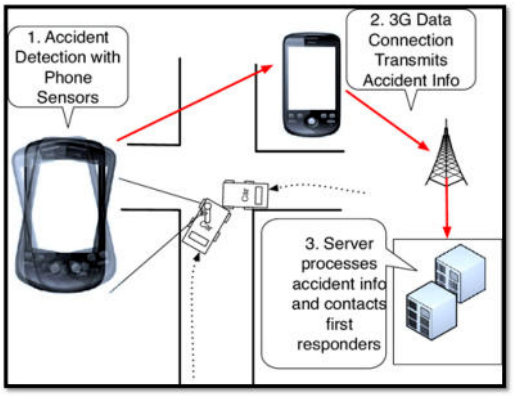

Fig. 3.1: Cooperation of multiple vehicles and avoiding collision in automated vehicles

pave the way for innovative solutions that can significantly reduce the toll of road accidents and enhance the quality of life for all road users.

3. Methodology. This research has chosen the secondary qualitative method for conducting this research. In this section, this work represents all the data and information that are collected. The collected data and information helps to understand the current situation of the safety services in the regional transport system, specifically on the road [1]. This work also examines the possibilities of edge computing in scalable sensor and actuator networks and how it can be used to minimize human error. This study evaluates the challenges that can be seen in road safety services during implying edge computing in scalable sensor and actuator networks [5]. The data also reveals a few suggestions for minimizing the challenges of regional road safety services as much as possible with the help of edge computing in actuator networks and scalable sensors. This data and information gained from the research will help the regional road safety services to take proper measurements and precautions for the best safety [6].

3.1. Identifying the basic concept of the safety services of regional road transport. In the modern era, road safety has become an important part of human evolution. Everybody uses the road in one way or the other. The current system of road transportation has been able to minimize the distance but it has increased the number of road accidents in an alarming number [10]. The reports show that almost in every country numerous numbers of road accidents happen, and this not only results in the loss of human and animal lives in a huge number, but also damages the lives of other humans and cause harm to other resources. For instance, in India, a report says, almost eighty thousand people are killed in different types of road accidents, statistically saying which is on and about 13 percent of the total fatality that happens all across the globe [8]. These accidents basically happen due to the lack of awareness of the road safety in the regional area or the carelessness of the drivers or the other users of the roads.

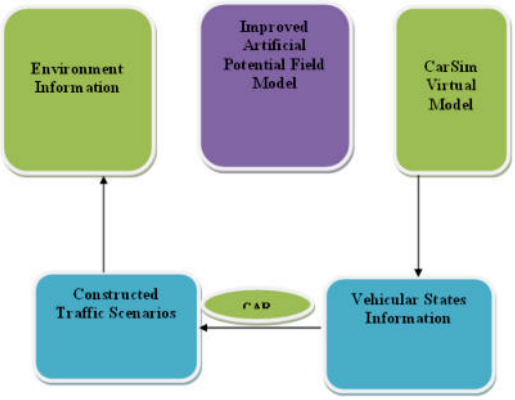

Fig. 3.2: Co-simulation for avoiding obstacles in road

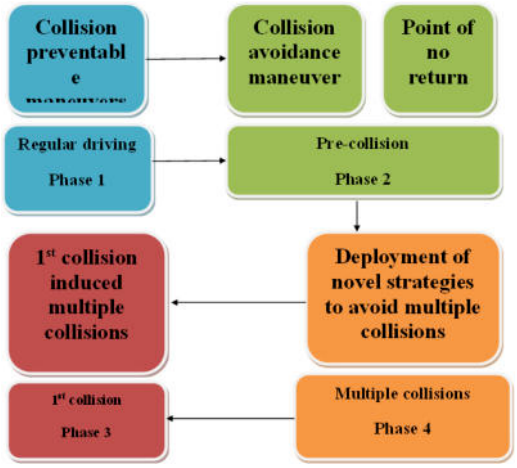

Fig. 3.3: Factors of interaction while driving

3.2. Evaluating the idea of edge computing in actuator networks and scalable sensor. The above picture shows that if the cars become AI enabled that will help the vehicles to sense other vehicles from distance and avoid possible collision [11]. It can also cooperate with multiple vehicles at the same time and the automated vehicle helps to reduce the human errors in times of mishaps.

Edge computing refers to an information technology that is distributed and an architecture where the data of the client is being processed at the periphery of the selected network [12]. This happens very close to the source of the data where the data originated in the first place.

In the above figure, the scenario is constructed on the hypothesis, the vehicle that can be possible obstacle is moving on a straight road and the speed limit is 15 km per hour. Another vehicle is running on the same lane at the speed of 80 km per hour. In order to avoid any kind of collision the above architecture is made.

On the other hand, scalability refers to the basic ability of the off computing in order to handle all the resources that are growing as per the requirements [13]. These requirements can include the new cases that are being used and on boarded, as well as measuring the already used cases that are present all across the current facility.

Figure 3.3 shows different Edge computing which allows all the devices that are connected to the network in different remote locations to process and analyze all the data that are presented in the 'edge' of the specific network. This data processing and analysis happened with the help of a local server or by the device [15].

Table 3.2: Road safety rules for cars and bikes

Rules of road safety for Cars on the Road	Wear seatbelts Avoid being distracted while driving Respect the mentioned speed limits Maintain the condition of the car and keep servicing regularly
Rules of road safety for Bikes on Road	Wear ISI-certified helmets Avoid swerving between lanes while riding

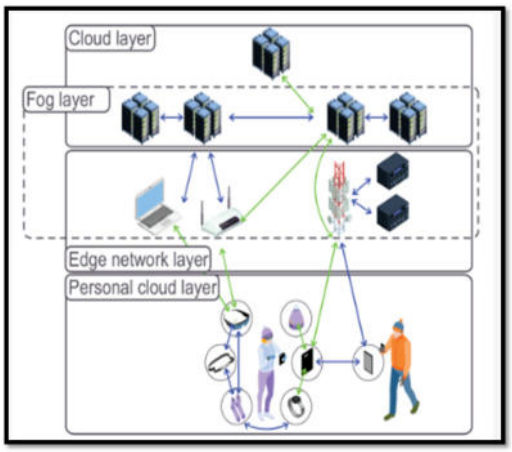

Fig. 3.4: Architecture of edge computing for safety services

When the data needs to be analyzed and processed in the data entered at the central system, the server only transmits the important ones, which can help to minimize the latency of the data.

3.3. Identifying the importance of safety services in the regional road transport system. According to the Bureau of National Crime Records in 2019 almost 467171 road accidents happened in a particular country. When the number of mishaps is so high, it is very important that these issues need to be addressed as shown in table 3.2. The importance of road safety lost its meaning of it when the public do not maintain the basic road safety rule [14]. The basic rules follow crossing the road in the zebra crossing when the traffic light is red; the black and white strips are there for a reason. In addition, the traffic light should be followed while driving to ensure the safety of both pedestrians and others including the safety of the driver. Another important thing to keep in mind while driving or riding is to avoid any kind of drugs or alcohol [17]. Drinking and driving not only puts the driver in a risky situation, but it can also harm others on the road too.

3.4. Discussion of the impact of edge computing in scalable sensor and actuator networks in terms of safety services in the regional road transport. The sector of information security regarding the technical process of safety and monitoring through cloud computing is forming an advanced ecosystem. The conventional structure of edge computing in terms of safety services in the local transportation system has to go through some significant layers of understanding.

Figure 3.4 represents the steps of cutting-edge cloud computing through its mechanical process [3]. The global report of the World Bank states that more than 5% of the individual country's economy is affected by road accidents. Apart from the digital cities, the regional transformation has faced the rapid issue of inconveniences of road trouble.

The lack of qualified workers, from certified drivers to experienced specialists, has made it difficult to fill positions in the transportation sector [4]. The usage of the cloud layers of cutting-edge technology and scalable sensor enable improved workforce allocation with a constrained workforce. Technology has also contributed to

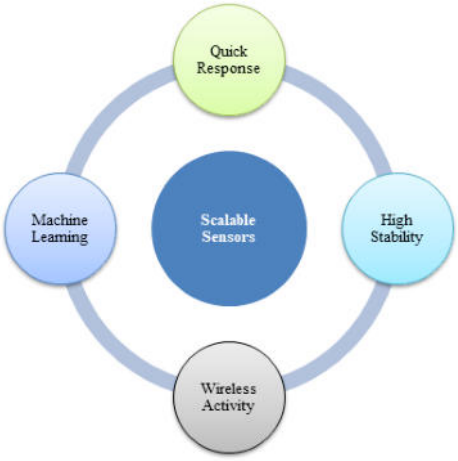

Fig. 3.5: Key feature of Scalable sensors in road safety

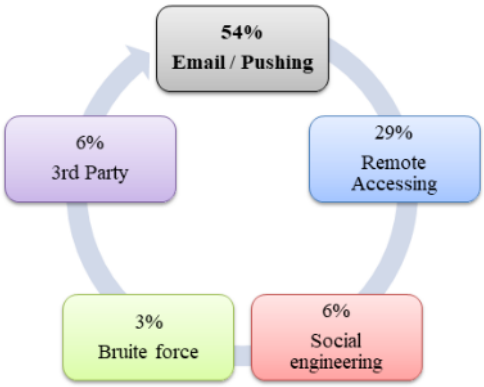

Fig. 3.6: Key feature of Scalable sensors in road safety

the development of motion sensing and monitoring of the whole road network even in regional areas through the cloud connectivity of certain technology which easily monitors driver's road skills.

Figure 3.5 highlights the key components of the scalable sensors that have laid out an innovative approach to prevent probable accidents [7]. The features consist of transmission of quicker response between receiver and sender, optimization of machine algorithm, and wireless connectivity for boundless operation. The cloud network-based computation process is much more stable, and durable, and provides real-time performance. This modern technology can assist the regional road transportation system in the section of improving operator skills and reducing potentially high-cost expenses by identifying behaviors that lead to wear and tear, such as forceful braking and acceleration, monitoring fuel economy, and guaranteeing on-time deliveries [9]. Direct delivery of notifications and alerts from the front end to the drivers makes them aware of the probable occurrence beforehand.

3.5. Evaluation of the challenges faced by safety services in regional road transport during the implementation of edge computing in sclable sensor and actuator networks. The diversity of this ecosystem comes with certain limitations, particularly boundaries and security challenges. This systematic discussion includes the identify similarities, differences, situational attacks, and cyber hacks in the various layers of the computing process. The significant challenges point out the essential security and privacy threats.

Table 3.3: Probable challenges of sensor components

Sensor components	Internal challenges
Framework design	The systematic transmission will fail if the sensors have to perform a wider network and complex algorithms. The power consumption and maintaining accuracy with the swift flow of transmission can face misbalance.
Signal processing capability	The circuit framework of smart sensors is the key point for the monitoring and transmission of signals. The key components of the sensor's placement are too dense to transmit a stable and noise-free signal to the receiver.
Reliability maintenance	The reliability and ease of accessing functions hold the whole operation of practical usage of cloud cutting-edge programs in smart sensors. A huge maintenance burden can be faced for the repair and maintenance of the smart sensors if breaks down to technical error.

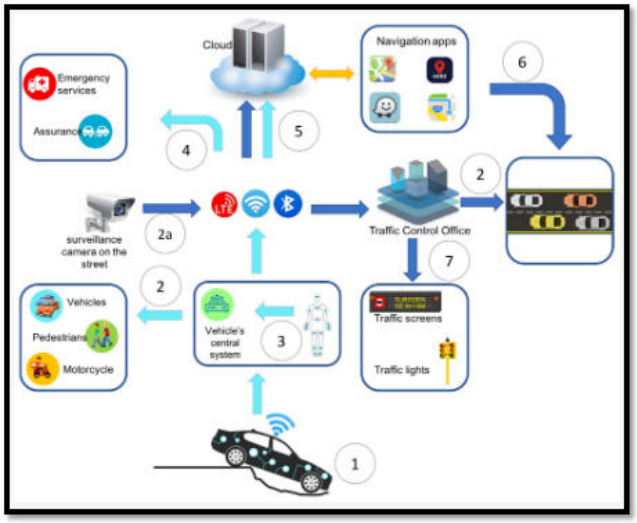

Fig. 3.7: Recommendable Strategies for Improving the Scalable sensor technology

Figure 3.5 focuses on the types of cyber-attacks in percentile status on the implementation of sensors and edge technology[16]. Around 54% of email or phishing attack on the technology is established through the criminals followed by the remote accessing technology that holds 29% of the cyber bullying types. Brute forcing, parameter blocking, and transmission preventing are some other important functions of cyber-attacks on the activity of sensors in edge computer networking [19].

Table 3.3 discusses the significant problems and internal challenges of the sensor components [20]. Coalition of transmission loss ransomware and networking failures are the prominent hindrance to the cutting-edge technology in smart sensing that needs to be checked and monitored properly.

3.6. Assesment of the recommended strategies in order to mitigate these challenges faced vy safety services in regional road transport in scalable sensor and actuator networking. The problems regarding the implementation of sensor technology in road transportation in the rural area require some strategic changes to improve the networking activity and the better development the sender-receiver transmission process.

Figure 3.7 describes the probable recommendation of updating for improving the technical features of cutting-edge technology in the smart sensor networking process [21]. To decrease the number of traffic inconveniences and control better road accession a thorough network connection has to be improved in terms of

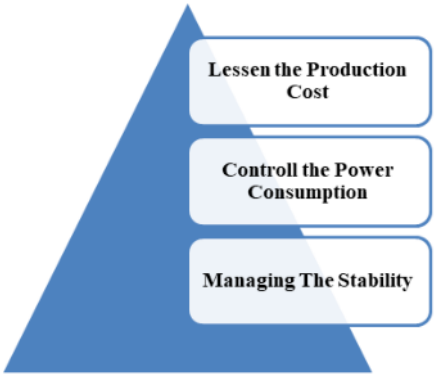

Fig. 3.8: Suggestion for Machinery advancement

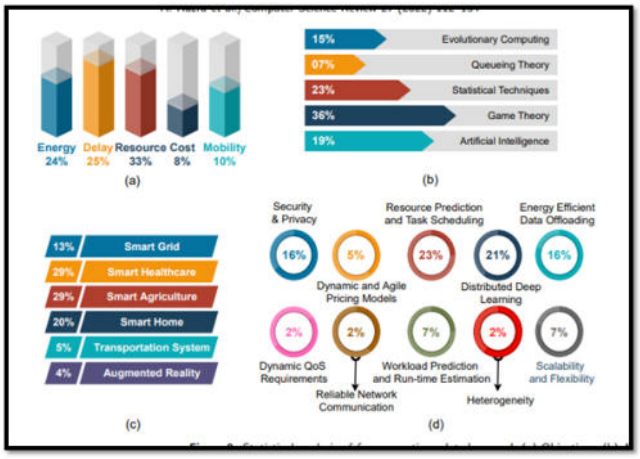

Fig. 4.1: Networking solutions depend on the IoT in the data computation

the vehicle's core system, and differentiation technology for identifying pedestrians, bikes, and light and heavy vehicles. The motion radar system can help to detect traffic symptoms automatically. The continuous existence of surveillance cameras in the street help to cover road occurrence [22].

Figure 3.8 highlights the machinery updating suggestion apart from the other key features [24]. It deals with the management of lessening the production cost and can focus into expanding the business requirement. The practical usage of controlling power consumption is a significant aspect of improving the network strategy. Advancement of wireless connectivity and proper coverage of network tower can enhance the coverage of controlling devices and helps to increase the durability of the network function.

4. Result. In the modern data of world, the advancement of technologies and the systematic implementation of fog technology make the development of road safety. This includes the application of sensor technologies for increasing safety. The computation of Fog technology helps to obtain the working performance of the sensors. It depends on the challenges created by IoT in computer and network sensing technology. The major portions of the road safety technologies of networking solutions depend on the IoT in the data computational. It makes the 57 per cent of the challengers as per a survey from 2018 to 2021. As the technologies are based on Artificial intelligence techniques so this adopts and makes creative changes within the technology as per the required change.

These changes in the computing technologies of the sensors impact the 43 per cent safety of transporting

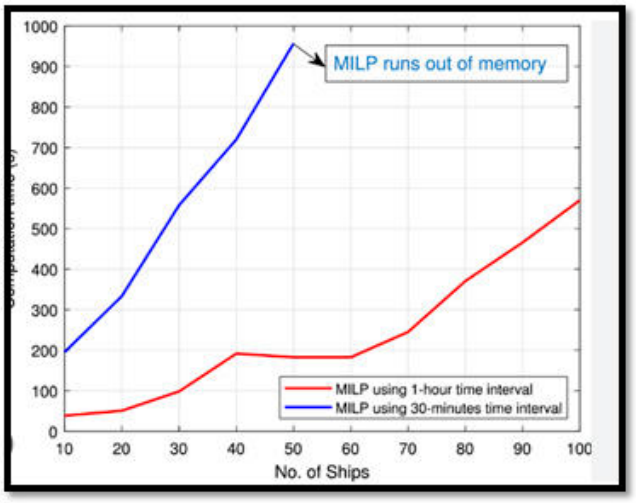

Fig. 4.2: Developments in MILP

vehicles as shown in Figure 4.1 [8]. The improvements of the technologies include the decreasing of data transformation to cloud networks by decreasing latency. Thus in the situation of analyzing the traffic gets easily managed and the time consumption in the transportation also decreases. Therefore these technologies include collecting data from the sensor networks to cloud storing technologies and they use those for making certain predictions to develop the safety and smooth running of transportation on the Road. This technology basically makes digital communication between the networking server and drivers, traffic management, and Police by the application of internet servers.

The application of IoT technologies in data storing of the regional networking servers makes the provision of information through cloud servers. This process includes the performance of FOG computation that directly collects the information as the resources and operates them in the cloud networking server. The technologies include the performance of operating directly through the cloud and this helps in regular monitoring of traffic control. The technologies of the Fog computation make the development and the transformation speed of the information collected by the traffic sensors to a cloud server. This helps in the transformation of the information about the regular changes in the traffic situation to all users quickly. These technologies in the cloud storing and transformation policies impact 39 per cent [18]. The programming technologies of the server are based on algorithmic language programming so they automatically adapt themselves with the adaptive changes. Thus the procedures of FOG computation with a low rate of latency make the major preference of the transporting bodies like the drivers.

This preference and the application benefits of algorithmic programming help in attracting the communication preference and reduce the time of responses. This response is based on the result of communication between the Fog server and the consumer. This also makes the reduction of consumption energy of the server and the drivers get actual and proper time-to-time information about the road circumstances. The cloud storage of the fog computation server includes storing data in the Databus increases the reliability band security of the data [18]. This implementation of the Fog computation helps to make the performance sharing, securing and storing of data smooth. This workflow and the smooth running of the sensor networking technology decrease the whole rate latency and consumption of energy. Therefore these technologies include collecting data from the sensor networks to cloud storing technologies and they use those for making certain predictions to develop the safety and smooth running of transportation on the Road. This infrastructure of the FOG computation makes the development of the traffic system in the regional division as well as in the different locations.

5. Problem Statement. People often avoid a much concerning issue while driving is their health issue. It is suggested that if a person has some health issues that can distract the person while driving, the person

should avoid driving. Every country has its own kind of rules and regulations that must be followed while driving, riding, or even walking on the roads there [18]. Most of countries use different types of sign boards to signal the slowdown, schools, and hospitals ahead, different turns and no turning corners, different hand gestures, even the usage of horns and all that should be followed to be safe on the road. These safety concerns do not only focus on the drivers, most of the time when a road accident happens but there are also two sides to that accident [23]. On one side, there is the driver who is injured and harmed, while on the other side, there can be a pedestrian, another vehicle, or anybody standing safely can be harmed. Therefore, it is very important to abide by all the rules so and be safe while on the roads to avoid any kind of mishaps.

6. Conclusion. In concluding part it can be stated that the advancement of sensor technology in rural areas can now improve the radar facility with the progression of wireless networking and Bluetooth connectivity. Updated navigation maps and cloud networking helps the drivers to have all the necessary information regarding the position of individual vehicles and the present traffic updates. Smart sensors can also be employed in new domains thanks to machine learning and artificial intelligence applications developed in recent years, computation, and model training, It surely helps to the enhance processing power of embedded systems. These technological improvements are characterized by reduced data transmission to cloud networks, leading to decreased latency in traffic analysis and management. The integration of sensor data collected from networks into cloud storage systems facilitates predictive capabilities, thereby promoting road safety and traffic efficiency. Notably, this technology fosters digital communication among networking servers, drivers, traffic management, and law enforcement agencies through internet-based applications.

Additionally, the utilization of IoT technologies in regional networking server data storage facilitates information provision via cloud servers. This process involves the execution of FOG computing, which efficiently collects, processes, and operates information in cloud networking servers. Consequently, the performance and speed of information transformation from traffic sensors to cloud servers significantly impact traffic monitoring and control, contributing to 39% of the overall effects. The server programming technologies, characterized by algorithmic language programming, seamlessly adapt to dynamic changes. FOG computing procedures, with low latency rates, are preferred by transportation stakeholders, notably drivers, due to their effective communication and timely response capabilities. This not only reduces server energy consumption but also ensures drivers receive accurate real-time information about road conditions. Furthermore, the cloud storage of the FOG computation server, along with data storage in the Databus, enhances data reliability and security.

The implementation of FOG computation substantially enhances the flow of sensor networking technologies, resulting in decreased latency and energy consumption. This infrastructure facilitates the development of traffic systems across regional divisions and diverse locations. The collective impact of these innovations is a promising step towards more efficient, secure, and reliable road transportation

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