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Review on IoT Based Smart Traffic Management System

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----------**ABSTRACT**----------
This work proposes an IoT-based system model to acquire and store real-time traffic data for such conditions because of the massive amount of private vehicle traffic that has ultimately led to exceedingly complex traffic in urban regions. The paper shows information about using roadside units to provide real-time traffic updates on traffic congestion and unusual traffic incidents, improve vehicle safety distances, and conduct data analysis. This paper also discusses the evolution of IoT technology, including its benefits and drawbacks, as well as smart traffic management systems with IoT. Simplified data is also useful for future work.

Keywords - **Smart traffic, IoT Technology, traffic prediction.**

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I. INTRODUCTION

Traffic disrupts urban life and affects the environment; traffic congestion is a significant problem everywhere in the world. The number of automobiles on the highways has increased in tandem with the growth of cities and populations. Due to this, traffic congestion is a significant problem in many big cities throughout the world. Most of the time, the traffic moves unevenly and dangerously to crossroads in all directions. Since this element is not taken into account by the conventional traffic management system, there is an uneven distribution of traffic from all directions, which leads to severe traffic jams that cause various issues like wastage of time, the possibility of accidents, air pollution, and other health issues. The sustainability and intelligence of the idea of a "smart city" depend on the technology that is utilized to make people's lives better. One crucial aspect of smart city initiatives is the intelligent traffic management system, which can provide a technological solution for effective traffic management.

1. VEHICULAR GROWTH IN INDIA

India is expanding, so have the country's mobility needs. In 1951, there were just 0.3 million registered automobiles; by 2022, there would be over 340 million

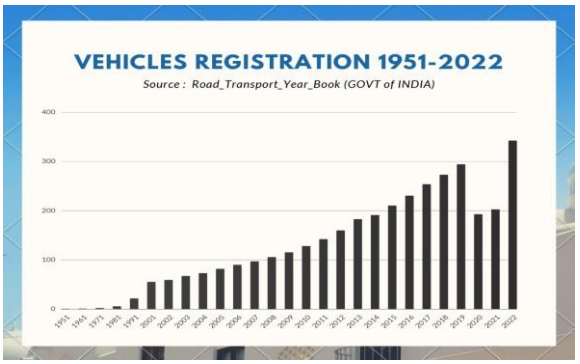

Fig 1 Vehicles Registration 1951 to 2022

TABLE I. VEHICLES IN MILLION

Year	Vehicles	Year	Vehicles	Year	Vehicles
1951	0.3	2005	81.5	2014	190.7
1961	0.7	2006	89.6	2015	210
1971	1.9	2007	96.7	2016	230.03
1981	5.4	2008	105.3	2017	253.3
1991	21.4	2009	115	2018	272.6
2001	55	2010	127.7	2019	293.8
2002	58.9	2011	141.8	2020	192.36
2003	67	2012	159.5	2021	202.23
2004	72.7	2013	182.4	2022	340.02

Source: Road_Transport_Year_Book (GOVT of INDIA)
URL: https://morth.nic.in/e-books

A smart traffic control system will be constructed to improve traffic movement. As moving cars are fitted with sensors and Internet of Things gadgets that can

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communicate, the roadside sensor system will gather data utilizing those sensors.

A city with smart traffic management uses information from many sensors, including cameras and other devices, to effectively monitor and regulate the movement of traffic. The monitoring and controlling systems have the capacity to continually adapt to changing vehicle movement circumstances by learning from the collected data.

A nascent technology called the Internet of Things (IoT) enables data to be shared and gathered independently of a human body. It is described as a "system of connected objects embedded with sensors, software, and control systems". In order to keep up with the pace of the global economy, every business is moving towards connected devices as a result of technological advancements like machine learning. Traffic congestion has gotten worse and more difficult in densely populated places, making it a serious issue and a burden for city people. Slow automobiles have an influence on more than simply how we drive. They impact the economy by squandering time and fuel, the environment by polluting the air, and personal health by raising stress levels. When rescue trucks attempt to negotiate through heavy traffic, it might be potentially deadly.

Kevin Ashton created the expression."Internet of Things" (IoT) in 1999. IoT covers a variety of physical items and how they are successfully represented online. IoT provides a future where all of the naturally occurring items around us are connected to one another and have communication capabilities[12]. IoT nowadays aims to advance both the state of humanity and the planet. IoT is the newest and most popular model. The physical and digital worlds are connected via the Internet of Things. The creation of intelligent ecosystems based on self-aware, ever-evolving items is one of the fundamental objectives of the Internet of Things. With the rise of the Internet of Things (IoT), more objects and entities will have individual identities and the capacity to send data autonomously through networks. Additionally, there can be more traffic on the roadways as a result.

Today's increased number of vehicles on the road contributes to greater pollution and a sharp rise in traffic accidents in the majority of the world's nations. It is really concerning that more individuals are dying in automobile accidents every year. Nowadays, everyone uses the internet. Working with internet traffic control in transportation has never been easier as more devices become internet-compatible. Because of the exponential increase in car ownership, there are more traffic issues. It seems reasonable to additionally handle matters like speed limit enforcement, pollution inspections, vehicle monitoring, alcohol detection, and emergency response to traffic accidents in order to make life simpler.

II. MOTIVATION

In many nations, including a number of wealthy nations, traditional traffic lights continue to have the following significant issues, despite the tremendous efforts made to enhance and improve traffic flow: (a) They wastefully manage traffic at crossings and make commuters in cars wait, which results in traffic congestion, pollution, further delays, etc. (b) They lack intelligence and the ability to adapt. (c) They don't offer protection against certain weather situations, such as rain, fog, and similar ones. They might not function properly or be visible in this circumstance. Accidents and fatalities are a result of this. (d) There is no system in place to give emergency vehicles (such as ambulances, fire trucks, police cars, etc.) priority. Even before they reach the intersection, to make room for such vehicles, traffic signals must be precise. (e) Due to the traditional traffic signals' inability to contribute to the provision of vibrant and adaptive services, there are numerous other disadvantages to traditional traffic management systems. The objective of the paper is to highlight the work of the current traffic management system, the current scenario, and recent work, as well as discuss the future scope of real-time traffic management.

III. RELATED WORK

1. Few vehicle characteristics, such as the fuel level and speed immediately transmitted to users within the car only while the vehicle is in operation, according to communication between the vehicles and the vehicle owners. An onboard processor, however, can help the user get current updates even when the automobile isn't being driven and the user isn't inside. [1][2].
2. Vehicles and a central server can communicate with each other. The computer transmits the data gathered from the vehicle to the closest communications node. The node then transmits the information via satellite to the server's communications node, which keeps track of breaches. [4].
3. Communication between the server and outside parties like a fire truck, police car, or ambulance. This method of communication is used by the server and many third parties, such as:
   - 3.1. Emergency vehicles quick response like fire-engine vehicle, ambulance etc.[21]
   - 3.2. Police patrolling vehicles.
   - 3.3. Pollution management The data pertaining to vehicle collisions, theft, temperature spikes, etc. is considered to be of the utmost importance.[20]

   These data are sent to the appropriate third parties after being submitted to the server by the onboard computer of the vehicle.
4. Direct communication between roadside units and emergency vehicles with prompt signal-lighting decisions.[11][21]
5. Using 5G service with an IoT device to increase data transfer speed and speed up data collection.[6][11]
6. Using IoT technology, smart signals and other city-wide devices are being developed.[2][3][6]

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7. Utilising Privacy-Preserving Identifiers for IoT-based vehicles to identify special vehicles, give them precedence, and let them through while reducing traffic.[10][21]
8. Create an IoT-based transportation system that can identify the location of a vehicle at intersections.[20] .
9. The application of image processing to the IoT for traffic signal monitoring and control based on density has advanced the image processing system. The camera-captured image is the system's primary point of emphasis. To determine the density, the captured image would be compared once more with an existing image that was loaded onto the server. The regulation of traffic flow is based on vehicle density. This reduces the overall wait time and creates a steady traffic flow. [3]
10. The traffic management system in a major city area is built on emergent intelligence techniques. The analysis and prediction model included historical data, contemporaneous data, and traffic flow parameters as inputs .[31]
11. The most up-to-date methods of traffic finding include the use of ultrasonic sensors, RFIDs, security cameras, and light rays. All of these sources have benefits and drawbacks, but in the context of the upcoming system, security cameras and ultrasonic sensors are the most appropriate sources. Due to its efficiency and ease of maintenance, a surveillance camera is the most popular tool for detecting traffic in this area..[30]
12. The most recent advancements in smart traffic management system research include applications to convey messages to roadside devices and system models for traffic congestion methods and traffic updates. Modern developments have reduced the price and power consumption of wireless sensor devices used to monitor traffic. The Internet of Things uses circuit boards with sensor devices to identify vehicles, estimate their speeds, and classify them. These gadgets' characteristics, as well as their benefits and drawbacks, are discussed. [1]
13. Current scenario of the traffic management.
    - 13.1. Intelligent Traffic Control Systems: Adopting sophisticated technologies like cameras, sensors, and data analytics, several cities were putting smart traffic control systems into place. These technologies seek to improve overall transportation efficiency, lessen traffic congestion, and optimize traffic flow.
    - 13.2. Navigational aids and apps for traffic: Drivers were still able to get other routes and real-time traffic information by using navigation apps such as Google Maps, Wage, and others. These applications rely on information from multiple sources, such as user reports and GPS.
    - 13.3. Vehicles with Connectivity: The idea of interconnected automobiles grew in popularity. These cars are capable of exchanging data about traffic patterns, collisions, and road closures with the infrastructure and with one another. It is anticipated that this connectivity will enhance overall safety and traffic management.
    - 13.4. Combining AI and Machine Learning: Large-scale data analysis and traffic pattern forecasts are made possible by traffic management systems through the growing use of artificial intelligence and machine learning. In addition to improving signal timings, this can aid in proactive traffic management.
    - 13.5. Initiatives for Public Transport: Many cities concentrated on enhancing the infrastructure of public transportation to entice people to utilize it and so lower the number of single-occupancy automobiles on the road.
    - 13.6. Adaptive Traffic Signals: Dynamic traffic signaling systems have been put in place in certain places, and they modify signal timings in response to the flow of traffic. The goals of these technologies are to lessen traffic jams and enhance overall traffic flow.
    - 13.7. Parking Management: To make parking places easier for cars to discover, smart parking solutions were being adopted. This not only lessens traffic jams but also raises parking infrastructure's general effectiveness

IV. ABOUT IOT

IoT, also known as the Internet of Everything (IoE), is the umbrella term for any web-connected devices that gather, transfer, and perform on data from their immediate environments utilizing embedded sensors, computers, and communication gear. These gadgets, which are frequently referred to as smart devices, can occasionally link to other similar devices and act on the data they receive from those devices [14]. Although humans can set up gadgets or devices and give them commands to access data, the majority of the work is done by the gadgets independently of human intervention.

The abundance of modern small mobile devices and our home and business networks' constant connectivity have both made it possible for them to exist. Massive volumes of Internet traffic are also produced by connected devices, most of it including data that can be mined for further uses in addition to making the devices useful. Concerns about privacy and security are raised by all of this new data and the gadgets' ability to access the Internet. We have never before had access to real-time data, but new technology makes it possible. To keep our houses and families safe, we can keep an eye on them from a distance. Businesses can enhance their operations to increase productivity, decrease material waste, and avoid unexpected downtime. The use of sensors in city communications can help ease traffic congestion and alert us to potential transportation problems.

Openly displayed gadgets can keep an eye out for changes in the environment and alert us to impending calamities. The Internet of Things (IoT) devices gather data and transfer it to a central server, where it is compiled, analyzed, and used to facilitate server activities. The advantages of IoT are enjoyed by businesses, organizations,

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government bodies, and people in general. The Internet of Things includes, to name a few, smartphones, computers, Apple watches, refrigerators, coffee makers, Google Smart Homes, and Fit bits. As long as a gadget has sensors and an Internet connection, it can be connected to the IoT. Because it offers real-time data, connections, and intelligent automation,

The Internet of Things (IoT) significantly contributes to the transformation of traffic management systems. IoT-enabled traffic lights can modify their timing in response to current traffic conditions. IoT-enabled cameras and sensors can be installed at strategic locations to track traffic patterns, gather information on vehicle movement, and assess traffic conditions. IoT-enabled smart parking sensors can be integrated into parking spaces to offer real-time information on parking availability. The Internet of Things (IoT) can be used to detect and prioritize emergency vehicles in traffic, provide drivers with real-time traffic information through navigation systems, and allow vehicles and infrastructure to communicate.

IoT sensors on roads and infrastructure can also be used to monitor the state of roads, bridges, and other transportation assets. Real-time traffic information is available to connected cars, enabling them to modify their routes to avoid clogged regions and enhance overall traffic flow. Real-time tracking and monitoring are made possible by Internet of Things (IoT) sensors installed on public transportation vehicles. IoT data is used to notify drivers in real-time about traffic conditions, accidents, road closures, and other routes.

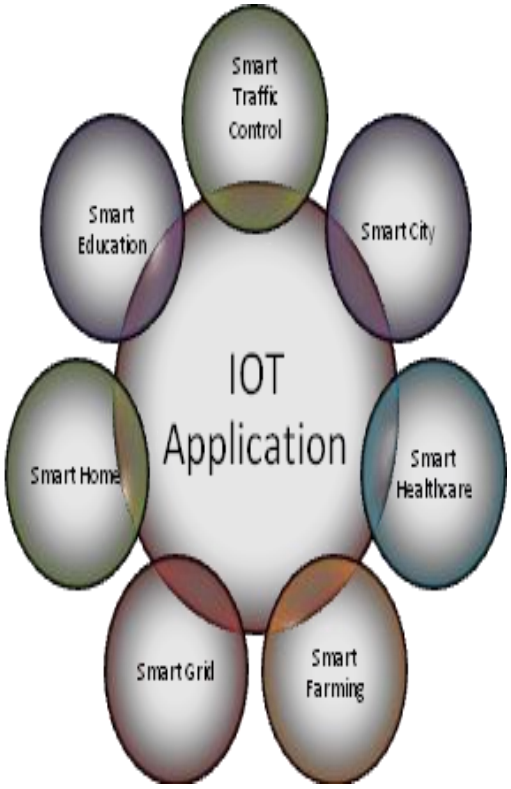

Fig 2 Application of IoT.

1. Advantages and Disadvantages of IoT
   1.1. Advantages
      1.1.1. Communication linking Devices: The Internet of Things (IoT) promotes machine-to-machine (M2M) connectivity[29], often known as communication among gadgets. As a result, the physical devices are able to maintain their connection, making complete clarity possible with just minimal insufficiency and better quality.
      1.1.2. Control with Automation: There is a significant element of automation and control in the mechanism since physical things may now be connected and controlled digitally and centrally through wireless communications without the need for human participation[6].
      1.1.3. Information about everyday moments: It is obvious that having more knowledge helps to make wiser selections. greater information is better since it gives you greater power, whether it's making everyday decisions like what to buy at the grocery store or determining if your company has enough resources and widgets.
      1.1.4. Observe: The IoT has several advantages, but observation and monitoring stand out the most. Knowing the actual stock levels or the standard of the air in your home can reveal additional data that was previously difficult to gather.
      1.1.5. Time: Time might be significantly saved because to IoT, as implied in the debate. More time would be beneficial for everyone. we live in today.
      1.1.6. Economic Benefit with saving Money: ecoonomical benefit using Saving wealth is the IoT's main advantage. If monitoring and cataloguing tools are more expensive than the money saved, the Internet of Things won't be extensively used..
      1.1.7. Saves Time with Efficient: Since machine-to-machine communication is more effective, the timely arrival of accurate findings is possible. This saves time that would otherwise be wasted. It allows people to perform different, unique duties rather than the same ones day after day.
      1.1.8. Better Quality of Life: All of these uses of technology lead to greater ease, convenience, and management, raising overall standards of living.
   1.2. Disadvantages
      1.2.1. Compatibility: For the classification and monitoring of IoT on devices, there is currently no global standard of compatibility. The easiest flaw to fix is this one. The requirements for this device's production facilities are that they accept standards for things like Bluetooth and USB drivers.

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1.2.2. Density or complexity: Like all complicated systems, there are greater chances for failure. With the Internet of Things, errors could increase dramatically.

1.2.3. Privacy/safety: The danger of losing privacy increases with the transmission of all this Internet of Things data. How securely will the data be stored and transmitted, for instance? Safety[5]: The Internet is connected to all household appliance, manufacturing tools, civic services like water supply and transportation, as well as many other devices, making a wealth of information available online. These data might possibly be attacked by hackers. It would be quite bad if unauthorised intruders were able to gain private and sensitive information.

1.2.4. Unemployment of Manpower: As a result of the automation of daily tasks brought on by IoT devices, unskilled workers, employees, and others may lose their jobs. This may lead to problems with unemployment in the community[8]

2. EVOLUTION OF IOT

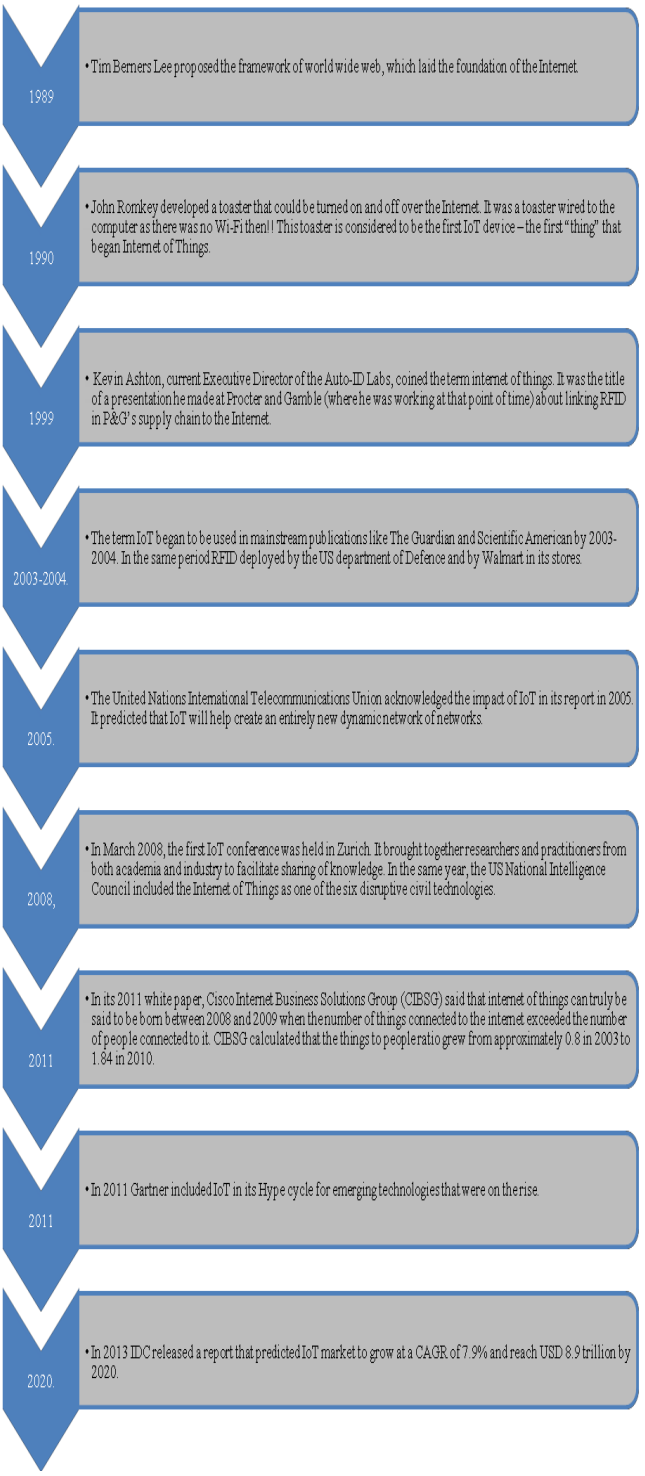

FIG 3. EVOLUTION OF IOT Source-Website: https://www.techaheadcorp.com/knowledge-center/evolution-of-iot/

V. IoT IN TRAFFIC MANAGEMENT

Today's emerging nations must overcome many infrastructural challenges, one of which is traffic management. IoT is already being used by developed nations and smart cities to reduce traffic-related problems. People from various kinds of countries have quickly improved the car's character. No matter how effective or bad public transit is or how much time and money it will

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take them to reach where they're going, people typically choose to drive their own automobiles in most cities

1. Background
   - 1.1. Existing System
     The traffic police typically have authority over the exiting traffic system at intersections. The main drawbacks of this technology are that it isn't smart enough to handle traffic gridlock. At a crossroads, the traffic police may choose to temporarily close one road while allowing traffic on another road to pass, so the official's choice may not be the best one. Additionally, even though traffic lights are fixed, the duration during which cars will display a green or red signal is also fixed. Consequently, it might not be able to find a solution to the traffic problem. In India, it has been observed that traffic police remain on duty long after traffic lights have been installed, indicating that this system requires more people and is less efficient.20]
   - 1.2. Disadvantages of Existing System
     - 1.2.1. Traffic congestion: The traffic police, which are frequently overburdened as a result of the traffic problem, control the current traffic situation [21].
     - 1.2.2. No means to detect traffic congestion: The lights at specific traffic signals in the existing system are controlled by a timer that does not take traffic into consideration [30].
     - 1.2.3. Number of accidents is more: Currently, many more accidents occur as a result of the conventional traffic management system.
     - 1.2.4. It cannot be remotely controlled: Modern traffic management systems are entirely regulated, and decision-making is done without the use of computers.
     - 1.2.5. It requires more manpower: Each junction has grown larger as a result of increased traffic, and more staff is needed to handle this traffic.
     - 1.2.6. It is less economical: A traffic management system might be characterized as excessively expensive because it requires more personnel and raises other costs
2. Function of IoT in Smart Traffic Management
   - 2.1. Utilizing road sensors and video monitoring establish incidents and report them right away to emergency units.
   - 2.2. Objectives Reduce traffic volume as much as possible while maintaining driving safety.
   - 2.3. Highway lanes, vehicle speed limits, and exit counters are also included. It also includes on-road cameras, sensors, and cellular devices that automatically modify traffic signals or lights.
   - 2.4. Give citizens accurate, real-time information regarding available parking spaces.
   - 2.5. Gathered information on junctions and improved traffic signaling to reduce congestion and enhance travel.
3. Advantages of a Smart Traffic Management System
   - 3.1. Reduce accidents and traffic congestion at intersections.
   - 3.2. Showcase large efficiency gains through real-time infrastructure monitoring.
   - 3.3. Make sure that emergency vehicles have clear access.
   - 3.4. Preserving the environment by preventing the annual waste of billions of gallons of gasoline.
   - 3.5. Accurate vehicle tracking during searches and prompt recovery of stolen and lost automobiles.
   - 3.6. With the aid of a smart traffic management system, traffic lights can operate automatically and in real-time based on traffic blocking.
   - 3.7. Because of smart traffic management, less pollution is produced. Save your gasoline.
   - 3.8. The likelihood of traffic accidents can be decreased by using smart traffic management systems.

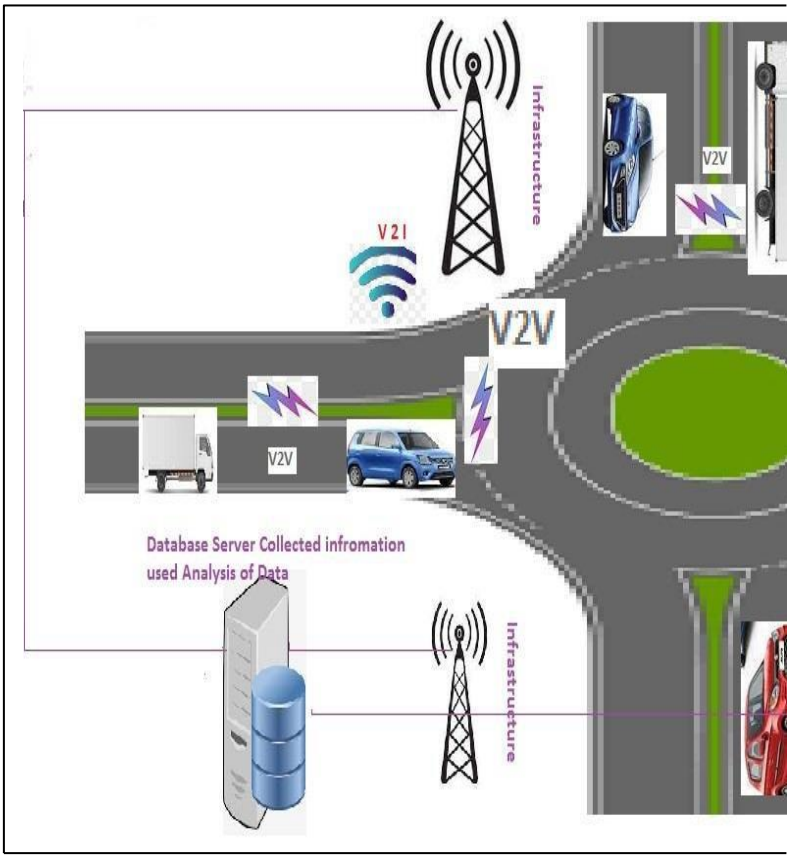

Fig 4 Smart Traffic Management system using IoT

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4. Execution of a Smart Traffic Management System – type Elements
   - 4.1. Collect data using sensors: To a centralized system, the collected data are sent.
   - 4.2. Data analysis: Adjusting the signal strength of lights by performing analysis on the data from junction sensors on a centralized system
   - 4.3. User level applications: the program that enables users to instantly receive alerts about backups in traffic and other routes. Applications at the administration level are utilized by control centers, which transmit instructions to actuators to change traffic signals
   - 4.4. System gateways: the gathered and compressed data from a centralized system before moving it to a cloud platform.
   - 4.5. Cloud System: Ensure the traffic management system's cloud storage system and system gateways are both capable of transmitting data securely.
   - 4.6. Structured the data: processing and transformation of unstructured, raw data in order to store it for later use in data mining

VI. FUTURE WORK AND LIMITATIONS

For remote monitoring and management of traffic on roadways, a specifically designed system is required. By analyzing the local level of each city's traffic, we can also create algorithms in numerous ways. The traffic signal light can be made dynamic and switched on and off in accordance with the volume of traffic, thanks to the prediction algorithm. This would benefit a city with high-tech, intelligent infrastructure. The development of smart cities in the future may start with the implementation of an IoT-based traffic control system.

It can be argued that installing an AI-enabled traffic management system as a roadside unit as part of the infrastructure is possible when it comes to traffic management systems for infrastructure like roads and intersections. A traffic management system with AI capabilities can offer more ways to safeguard the environment. AI will be used to monitor traffic in real time by the smart traffic management system. Automated traffic signals will be one of the system's major tools. It will assist the traffic office in analyzing the present traffic flow, the number of vehicles, and the data they have gathered. This data will then be sent to the cloud and utilized to control the traffic. It will also include capabilities like high-resolution CCTV cameras to record commuters and drivers disobeying the law and automated number plate recognition cameras to send the Chillan (fine slip) to offenders' houses. Smart traffic management technologies will be used for traffic control in the future. Their communities benefit from a higher degree of safety, security, and efficiency as a result. Utilize AI in The connecting factor that combines AI, data analysis, and real-time feedback for useful information is the smart traffic platform. Using this platform for traffic management enables traffic management specialists to move traffic effectively, lower the risk to pedestrians, and provide better, more skilled service on the roads in their communities. AI in traffic management presents difficulties, such as data achievement and awareness of the difficulty. Processing data and removing features for predictive modeling Monitoring, deploying, and upgrading models dealing with data ambiguity and noise Analysis of feedback and error-learning are substantially more challenging. Scalability refers to a system's ability to handle growing loads as cities get bigger. Concerns over Privacy: What uses or disclosures are planned for personal information? Can AI be used without making significant extra infrastructure investments? Standardization: Will the same traffic-management system be used by all municipalities?

VII. APPLICATIONS

For remote monitoring and management of traffic on roadways, a specifically designed system is required. By analyzing the local level of each city's traffic, we can also

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create algorithms in numerous ways. The traffic signal light can be made dynamic and switched on and off in accordance with the volume of traffic, thanks to the prediction algorithm. This would benefit a city with high-tech, intelligent infrastructure. The development of smart cities in the future may start with the implementation of an IoT-based traffic control system. A vehicle's associated information can be supplied to traffic control centers in cities by extracting data from CCTV feeds. The information from adaptive accident aid systems and traffic light sensors can be coupled with this information. IoT-based traffic control has a variety of uses, including Another situation where IoT-enabled sensors can be used to collect data is at traffic signals. These sensors are placed specifically for this purpose. The data gathered can be studied to provide better traffic signals and alternative routes for drivers. Roadside lights are one example of an IoT-based traffic control system in which smart lights might be used by utilizing environmental sensors to adjust brightness in accordance with the lighting conditions at the time. The collected data is used for future analysis and provides the most useful information about vehicle owner details for regional or road transport offices (RTO) and municipal corporations.

This application has two levels: a user level and an admin level. The user-level application allows users to see real-time traffic and provides other routes or ETAs for resolving traffic jams at intersections. The Internet of Things (IoT) is poised to drastically alter our lives, both personally and professionally. Numerous of the aforementioned developments are, in some capacity, already in use. Undoubtedly, there is no turning back. No sector can ignore the IoT's incredible level of control and efficiency. Another application is employed in administrative offices and has the capability of data storage, data retrieval from lost or stolen vehicles, analysis of daily traffic jams at intersections, generation of reports on various time periods of traffic jams at intersections, and control of light signals..

Smart traffic control systems based on the Internet of Things have many advantages, but they also have drawbacks and difficulties. Security issues, including device and data security, are a few of the main restrictions. Dependability, such as device and network dependability. Scalability is similar to interoperability, privacy concerns, and data privacy in infrastructure scaling. Costs include the initial outlay and upkeep. Similar to sensor accuracy, data reliability, and accuracy. Integration challenges include public acceptance and adaptation, user acceptance, and legacy systems

VIII. CONCLUSION

When it comes to developing countries' transport systems, traffic congestion is a major problem. This is an uneven distribution of traffic from all directions increase in which leads to severe traffic jams which causes various issues like wastage of time, possibility of accidents, air pollution and other health issues. Combining computer vision and IoT technologies makes it possible to create intelligent systems that can effectively manage traffic. A few efficient traffic system networks have been developed to provide drivers with real-time information about the condition of the roadways. IoT-based smart roads reduce traffic bottlenecks, increase road safety, and shorten commute times. Any sophisticated algorithm can be used to run these systems. Reduced traffic congestion is brought on by the lower setup costs and mobility of these systems. The ccollected data is used for future data reference by organisations like the Road Transport Office (RTO) and Municipal Corporation for getting vehicle owners information, and it also guarantees the safety of pedestrians. This allows for an increase in fuel outflow and also leads to air contamination. The combination of computer vision technology with that of the IoT aids in building smart systems that can manage traffic in an efficient way.

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