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'AN IOT CLOUD SYSTEM FOR TRAFFIC MONITORING AND VEHICULAR ACCIDENTS PREVENTION IN UTTARAKHAND'

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Abstract—The ongoing traffic challenges in Uttarakhand ne- cessitate innovative solutions. This paper proposes an Internet of Things (IoT) cloud-based system designed to tackle real-time traffic monitoring and accident prevention in the region. By utilizing mobile traffic sensors installed in private and public vehicles, the system collects real-time data. The OpenGTS and MongoDB are used to process this data, allowing for prompt detection of congestion, automated rerouting, and identification of potential accident hotspots. A systematic analysis, including pilot testing, indicates the effectiveness and efficiency of the proposed system, showcasing a significant enhancement in road safety and traffic management. The implementation of this technology represents a substantial step towards modernizing the region's transportation infrastructure and could set a precedent for similar applications in other areas.
Index Terms—CloudBased System, Internet of Things (IoT), MongoDB, OpenGTS, RealTime Traffic Monitoring, Uttarak- hand

I. INTRODUCTION

In Uttarakhand, an area noted for its high topography and severe weather, road congestion and accidents are significant issues. Because of their patchy coverage, the current solutions, including fixed traffic sensors, are insufficient. In order to monitor traffic in great detail and avoid accidents, this article presents a state-of-the-art Internet of Things cloud system that uses real-time data processing and mobile traffic sensors.

One of the main causes of injury or death to individuals, loss of property, and financial outlays are motor vehicle accidents. In 2016, 845.384 persons died in road accidents globally, according to real-time statistics [1]. A total of 24.100.573 persons were wounded in motor vehicle accidents, which cost

$356.688.482.686 to fix. According to the National Safety Council (NSC) [2], over 40.000 people will die in vehicle accidents in the United States alone in 2016. With a rise of 14% from 2014 and 6% from 2015, this is the largest two-year increase in mortality in more than five decades. The overall number of autos has dramatically expanded in this regard, rising from 921.642.000 in 2006 to 1.282.270.000 in 2015 [3], and it is predicted that this number will double by 2040 [4]. Nonetheless, this tendency indicates that the frequency of car accidents would increase.

Accidents involving vehicles are typically the result of avoidable human error and poor driving practices. Recent developments in sensor technology have increased the viability of autonomous, networked, and self-driving vehicles. Using direct or indirect interactions between vehicles, infrastructure, and vehicles (V2V, V2I, and I2V) can prevent accidents in a distributed system that distributes sensor data from moving objects. Drivers may enhance their driving experience thanks to sensor technologies integrated into their vehicles. As a result, it is practical to deploy a network of gadgets along highways to serve as fixed waypoints and provide instructions and notifications. Drivers who reside in distant places where traffic sensors cannot be installed on the roadways will find this information to be of particular utility.

One of the main factors in auto accidents is a sudden stop in traffic, especially on busy routes and highways where visibility is poor. It could be caused by further collisions, ongoing road construction, traffic surges, and other factors. Tight curves, fog, poorly lit tunnels, and other circumstances can all impair a driver's vision. Technology like Google Maps, which gathers traffic data from sensors posted on roads and transmits warning signals to users' mobile applications through the 4G network, can assist alleviate the problem in areas where these sensors are not present.

Due to the quick development of technology, there is a greater requirement for Intelligent Transport System (ITS) services in this situation. In this study, we offer a workable alternative ITS approach for dealing with such a problem, taking into account mobile GPS-based traffic sensors put directly in volunteer cars and private/public transit. In order to prevent accidents, this situation necessitates a speedy real-time study of crucial traffic data. We propose an Internet of Things (IoT) Cloud system built on OpenGTS andMongoDB for the rapid processing of large volumes of traffic data. Mobile GPS-based sensors mounted on test subjects' automobiles, private/public transit, and other vehicles serve as a real-world reference conditions in this scheme. Individual motorists and those operating emergency vehicles like ambulances would benefit greatly from this strategy. Experiments on MongoDB show how effectively our system handles inserting and re- trieving data of varying quantities. Both the latency of the 4G network used to relay traffic data from public transport vehicles to the IoT Cloud system and the latency of warning messages transmitted from the IoT Cloud to the driver's mobile APP (I2V) are considered to be constants in these studies. The whole system allows drivers to get alarm messages via mobile applications at opportune times, increasing safety and decreasing the likelihood of accidents.

The IoT Cloud system was created to keep an eye on traffic and alert drivers to potential dangers. The current traffic situation is represented in Open Street Map in real-time thanks to the use of mobile sensors. GSM/GPRS/GPS TK103 trackers installed in vehicles are examples of these mobile sensors. These programs gather speed and position information, trans- mit it to an OpenGTS server, and then store the informa- tion in a SQL database.

Additionally, a GeoJSON parsing microservice inserts unstructured geolocation data acquired from third sources into a MongoDB database. In order to alert drivers arriving from nearby locations of any potential abrupt traffic delays, another micro-service watches the movement of cars in a specified region close to them. Through a 4G network connection, the data is transported. The Open GTS server and the microservices are both deployed using Docker containers to benefit from resource virtualization, a scalable Cloud-based architecture, and to make use of. The remainder is written in the following way. Information on the setting and pertinent literature may be found in Section II. By using an actual police record from Messina, Italy, we present a genuine example of an accident caused by an unanticipated traffic delay on a highway in Section III. Section IV provides a description of the architecture of our IoT Cloud service. Section V discusses experiments that focused on handling queries and data insertion for MongoDB traffic. A summary and a forecast may be found in Section VI.

I. LITERATURE REVIEW

Every traffic authority's main goal is to completely manage the amount of motor traffic. The concept of traffic control has several potential applications when considered in an urban setting. The environment, accident avoidance, speedier vehicular circulation, improved public transit, and social issues are all positively impacted by traffic management.

Congestion is a major problem on European roads. The European Commission conducted a study that found its influence may increase by 2% per year [5]. Since constructing brand-new infrastructure is now unfeasible in the vast majority of (Western) countries, many have turned to other methods of increasing road utilization and coming up with novel approaches to enlarging the capacity of the existing road network. Some of the features of modern traffic control systems are intelligent speed limits, adaptive ramp metering, and dynamic routing. Centralized traffic management, which is the basis for these examples, controls actions and reactions according to the volume of traffic at any given time.

Autonomous cars with adaptive cruise control (ACC) technologies are the cornerstone of a local approach, as discussed in [6] and [7]. The underlying presumption is that autonomous cars' traffic-avoiding driving techniques may also serve to expand the route's capacity and lessen traffic congestion. ACC systems are now commercially supported for a wider range of vehicle types. Inter-vehicle communication (IVC) is now possible because to modern automotive communication technology that several manufacturers have implemented. The fundamental building block of distance ranging is flight time. Once the flight has been established, the distance is measured using the airborne sound speed. For instance, beamforming, one of the most crucial methods for traffic management and accident avoidance, has an influence on choosing an operating frequency that is over 40 kHz and below 500 kHz to decrease absorption.

Data processing and recovery is a key concern as well, especially in light of the volume of data that must be dynamically collected and stored for traffic management and regulation [8]. Urban police groups have a problem as a result of the requirement for exact distance retrieval caused by heavy traffic congestion and accidents. Music and Esprit techniques [9] are employed to do this, despite having significant limitations in terms of their ability to recover closer distances and construct an overlay of objects and boundaries. A specific approach using the sparsity matrix as its model is presented in [10] as a means of preventing this. Specialized cameras with clear and infrared vision as well as other sensing devices without cameras that can create microwave and/or acoustic imaging can be used to change urban environments [11]. The aforementioned frame of view raises worries about big data and the Internet.

According to [12], [13], and [14], the Internet of Things (IoT) and vehicle cloud computing are becoming increasingly important for managing traffic on the roadways. In [15], the difficulties of integrating ITS with IoT, cloud computing, and linked vehicles are highlighted. Fuel prices, carbon dioxide emissions, transportation congestion, and improvements in road safety are all examined in detail. [16] presents a distributed storage video Cloud (DSVC) for ITS video storage, which aims to offer reliable and efficient video monitoring. In addition, [17] discusses a gateway solution that is hosted in the cloud and provides Internet connectivity for ITSs. Using this strategy, clients give over control of gateway governance tasks including registration, discovery, selection, dispatching, and handoff to authorized Cloud servers. For proactive safety on the road, [18] describes a mobile vehicle equipped with cooperative adaptive cruise control. Adaptive platoon synchronization (APS), cooperative vehicle platooning (CVP), and shockwave-avoidance driving (SAD) are all components of the cooperative adaptive driving (CAD) method. By proposing an intelligent transport service based on a vehicular Cloud network, [19] highlights the need for practical solutions to reduce traffic and traffic accidents. [20] provides a cloud computing performance analysis of an automobile ad hoc network using numerous highway traffic situations. Some performance variables, including as throughput, E2E latency, and packet loss, have been shown to have a considerable influence in studies employing two different highway settings, including varying car numbers and simulation lengths. In [21], we learn about a massive data mining effort for automobile traffic with the goal of reducing crashes and traffic-related expenses. A large dataset of traffic incidents is analyzed using big data methods in order to determine fatalities that can inform new traffic laws and regulations, reduce the number of accidents, and increase road safety. Feature selection methods are applied particularly to identify the most important predictors. We found no academic research on an IoT Cloud system for traffic monitoring and alert notification based on big traffic data processing from mobile sensors directly installed on automobiles, despite the growing interest in vehicular Cloud computing.

II. MOTIVATION

We next cover a real-world accident that occurred in Messina, Italy due to an unanticipated stoppage in traffic after a brief introduction of common ITS systems for vehicle traffic monitoring. This helps to underline the potential for avoidance afforded by a GPS-based Internet of Things (IoT) Cloud system.

A. Vehicular Traffic Monitoring Technologies

Overview Multiple methods have been developed to monitor vehicular traffic. UHF and VHF radio communications have been heavily utilized by ITS for both short and long-distance data delivery. For instance, WiMAX (IEEE 802.16), GSM, 3G, and 4G may be used for long-distance communications, whereas IEEE 802.11, GSM, 3G, and 4G may be used for local area networks. A gantry with a dish antenna embedded in the roadway is an example of a common fixed traffic monitoring system. Other stationary traffic monitoring systems employ either beacon sensing or Radio Frequency Identification (RFID) technology. The magnetic field of a roadbed inductive loop may be used to detect moving cars. Likewise, sensors installed alongside the road and equipped with Bluetooth technology could be able to identify approaching vehicles. A combination of honking, engine idling, tyre, and air turbulence noises may be evaluated by fixed audio detection sensors to estimate the volume of traffic along the route. The traffic at key intersections along highways may be monitored and incidents can be detected automatically with the use of permanent cameras. Data fusion-based systems combine information from several sources, such as sound, images, and sensor readings, allowing for widespread use. The aforementioned solutions have the potential problem of requiring roadside sensor equipment to be left permanently.

Floating car data (FCD), also known as floating cellular data, is a method for determining traffic speed on a road network by compiling data on vehicle locations and travel times from drivers' mobile devices. Triangulation, pattern matching, or cell-sector statistics are used to examine network data to infer traffic flow under these conditions. Data from devices installed in cars with unique serial numbers are collected by stationary detector arrays deployed along a road to facilitate vehicle re-identification. Using in-car satnav/GPS systems that provide position data is one GPS-based way of determining vehicle speeds. In today's smartphone adoption campaigns, telematics 2.0 techniques are deployed. Finally, the accelerometer, audio, and GPS sensors included in smartphone-based rich monitoring systems are employed to identify and quantify traffic congestion density and speed. Recent innovations in data analytics and storage [22] for traffic monitoring are being ignored in the aforementioned approach.

In order to collect massive amounts of traffic data and inform drivers via smartphone applications, this study focuses on a mobile sensing GPS-based technique that uses mobile sensors installed on public and commercial transit buses and other volunteer vehicles. Because it does not rely on the installation of fixed traffic sensors on roads, this method is inexpensive to develop; it can cover a large area of the city, even in the peripheral zones with little traffic, because it uses mobile traffic sensors installed on private and/or public transport vehicles; it can use the 4G network for sensor data exchange; and the system is reliable.

III. SYSTEM DESIGN

In this part, we'll discuss how the IoT Cloud traffic monitoring and alarm notification system was conceived. We use the term "IoT Cloud" to describe a Cloud system that goes beyond traditional service models such as infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS) by integrating its storage, processing, and networking capabilities with different kinds of fixed and mobile sensing assets. [23], [24]. Using the cloud paradigm in the IoT can boost service discovery [26], provide more security [27], and open up new business possibilities [25].

In order to determine velocity, acceleration, and other metrics concerning motion, our IoT Cloud system makes use of mobile sensors based on tracker devices installed in private and/or public transportation vehicles (like buses, taxis, farm machinery, trucks, and delivery vans) and other individual volunteer vehicles.

Two separate Machine-to-Machine (M2M) procedures are required by the IoT Cloud system in order to collect data from cars and transmit messages warning drivers of unforeseen traffic delays to their mobile applications. The system detailed below is cloud-based because its essential micro-services are elastically scaled up and down using Docker containers. All geolocation data collected in real-time from moving vehicles is received by the OpenGTS server, which then saves it in a SQL database and utilizes OpenStreetMap to display traffic conditions.

Additionally, incoming unstructured geolocation data is added to a distributed MongoDB database via a GeoJSON parsing micro-service. Another micro-service monitors traffic patterns close to drivers in order to alert them to potential surprise traffic delays via their mobile devices. With the help of a 4G network connection, the data transmission is accomplished. The cars serve as the entry point for the data transfer, as shown in Figure 4. Every single one of them has a commercial satellite tracker like the GSM/GPRS/GPS TK103 tracker, which calculates geolocation coordinates, as seen in Figure 6. All of the following are offered: geolocalization, location, monitoring, and emergency alerts. It is useful for tracking trucks or other moving objects because to its small size and straightforward operation. The TK103 also features SMS and GPRS data transmission capabilities.

Vehicles may transmit this data to an OpenGTS server via a 4G connection thanks to their data transfer capabilities. The ATM buses in Messina, Italy, are only one example of the public transit vehicles that are now monitored by these technologies. Vehicle tracking on the internet is provided by OpenGTS, an open-source project that makes use of the Apache software license. Specifically, a RESTful method is used to implement communication between the trackers and OpenGTS. The widespread use of satellite tracking systems is proof that this technology is a fantastic choice for general-purpose vehicles like cars utilized for personal, public, and/or private transportation. This data collection has two objectives. The OpenStreetMap open-source project is used as one component of OpenGTS to show geo-located data on a map.

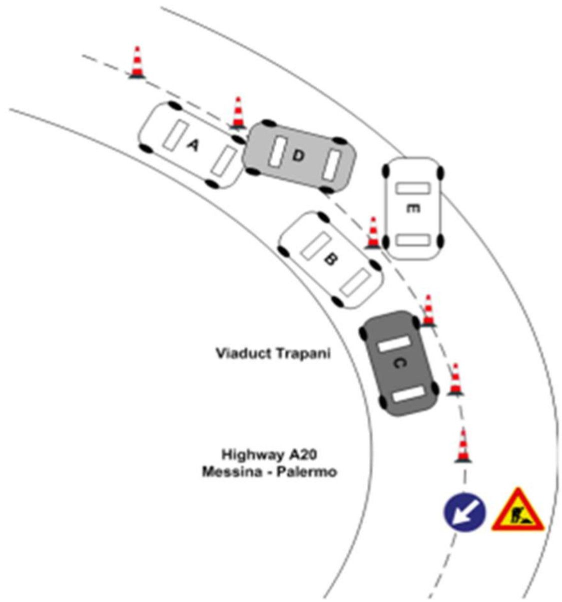

Fig 1-Accident Scheme

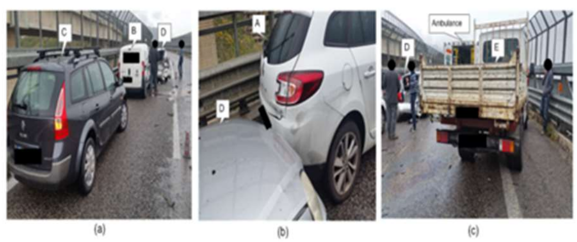

Fig 2- Images of the Mishap

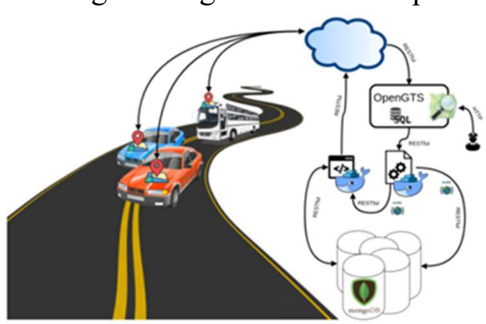

Fig. 3.IoT cloud solution for tracking traffic and sending alerts.

Fig. 4. An illustration of a TK103 GSM/GPRS/GPS tracker for automobiles

IV. RESULT

We considered the idea of using smartphone apps to deliver drivers timely alarm notifications in an effort to cut down on traffic accidents. We concentrated our research on data parsing and insertion as well as query time processing because of the persistent 4G network delay in transferring information from cars to our infrastructure (V2I) and returning the alert message from our infrastructure to vehicles (I2V). On our testbed, we used Docker containers to install and run all of the necessary software on two distinct types of servers: one for data collection and modification, and the other for data storage and retrieval. OpenGTS, the software powering the data transformation and collection server, is installed on a machine with 32GB of RAM, a 3.40GHz Intel(R) Core(TM) i7-6700 CPU, and Ubuntu server 16.04 LTS 64-bit. MongoDB was installed on a storage server powered by a 3.70GHz Intel(R) Core(TM) i3-6100 CPU and running Ubuntu server 16.04 LTS 64 BIT. Although MongoDB permits a distributed deployment via the sharding approach, it was originally created with a single server architecture. The dissemination of mobile applications is outside the scope of this paper.

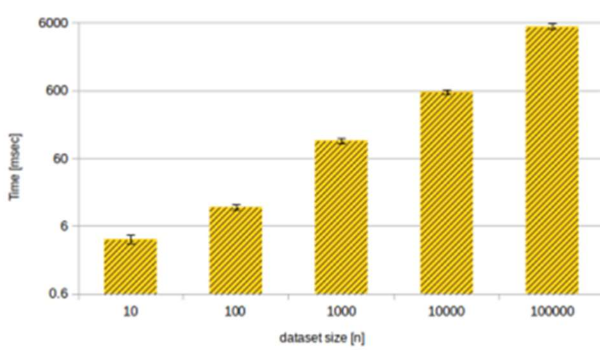

Fig.5.performance row to GeoJSON parsing

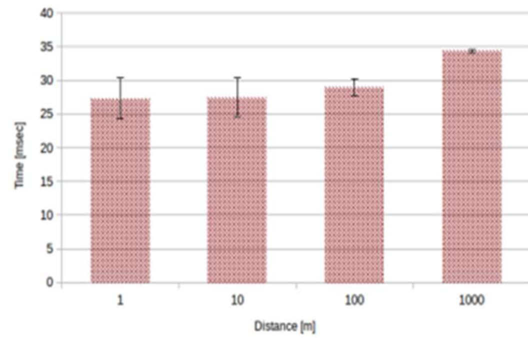

Fig.6 In terms of performance, the GeoJSON parsing row

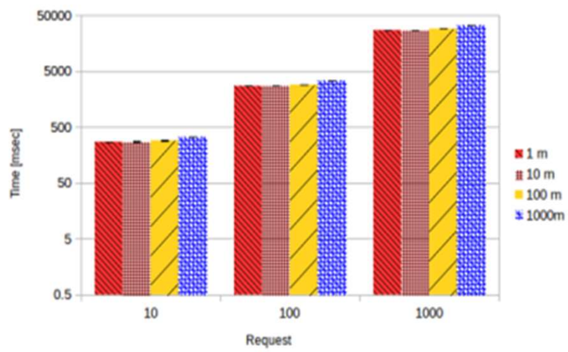

Fig.7.Processing performance at query time.

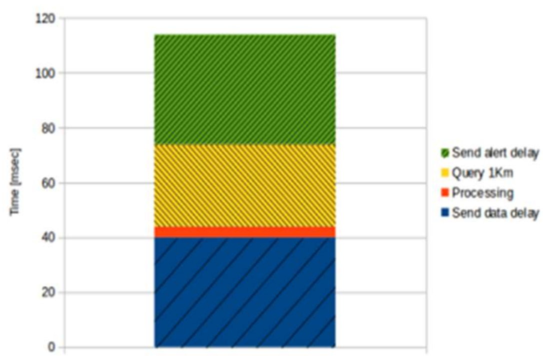

Fig.8. Time in total

Throughout the entirety of the project, we conducted scalability evaluations for both of these scenarios. For the purpose of obtaining reliable results, we ran each experiment thirty times. On our charts, we depicted the average values as well as the confidence intervals for 95%. Figure 7 presents an illustration of MongoDB's performance regarding the parsing and insertion of row data to GeoJSON. On the graph, we plotted the reaction time (on the y-axis) and the size of the dataset (on the x-axis). The values that are expressed along the y-axis are done so in milliseconds. It would appear that response times increase in a linear fashion as the number of datasets grows. Our primary focus was on completing the processing of 100k data in fewer than 6 seconds. The GPS tracker's sample interval can be set according to your preferences. In many instances, the default option is fifteen seconds.

In order to have 100,000 automobiles participating in our system at the same time and to have a system that is more responsive, we made the assumption in our example that each automobile would submit one piece of data every six seconds. In our calculations and estimates of the amount of time needed to get documents from MongoDB, we took into consideration 300000 documents. In the course of our inquiry, we made use of four different kinds of settings. Our primary focus was on expanding the distance between the rows of automobiles, beginning at a distance of one meter and reaching as far as one km. Figure 8 illustrates the consistency of reaction times, which remain at a value of 30 milliseconds on average. In order to evaluate the system's capacity to scale, we subjected it to stress by increasing the number of requests it had to process. This was done so that we could determine how well the system would perform under real-world conditions. Particular attention was paid to Fig. 10. Time does not stop moving forward. 1000 more questions were asked. Figure 9 is an illustration of the pattern that was found. The amount of time needed to respond significantly lengthens as the number of inquiries received grows, as can be shown.
Our IoT Cloud solution for traffic monitoring and alarm notification is excellent, as shown by the study that came before it. In reality, an automobile traveling at 120 km/h needs 30 seconds to complete one km. As shown in Figure 10, our system can convey an alarm across a one-kilometer distance in around 120 milliseconds. We assumed a typical 4G delay of 40 milliseconds for our testing, and for that, we used the processing and query durations depicted in Figures 7 and 8, respectively. When employed in a real-world setting, our technology can avoid accidents since it can send timely alarm signals to drivers' mobile applications.
Good performance can be guaranteed with the hardware and software described above; however, response times can be further reduced by using a distributed MongoDB configuration operating in sharding mode and increasing the virtual hardware capabilities of cloud-based resources in accordance with an on-demand IaaS model.

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V. CONCLUSION

Accidents caused by cars can be significantly increased when there is a sudden pause in the flow of traffic, particularly on crowded roads and highways. At the moment, not all roads, particularly those located outside of a city, have permanently installed traffic sensors. In this piece, we presented an original approach to the monitoring and reporting of traffic alarms that makes use of an Internet of Things cloud infrastructure. The purpose of the GSM/GPRS/GPS TK103 tracker-based device that is installed in vehicles is to collect geo-location and speed data in order to offer an OpenStreetMap portrayal of the current traffic situation in real-time. Following that, this data is sent to an OpenGTS server, where it is eventually stored in a SQL database. In addition, unstructured geolocation data that is received is parsed using a GeoJSONmicroservice, and this information is then put into a MongoDB distributed database. Another micro-service is responsible for analyzing the movement of cars in close proximity to those coming from nearby locations in order to notify drivers' mobile applications of potential abrupt traffic delays. The use of a 4G network connection for data transmission.Docker containers were utilized for deployment so that the OpenGTS server and the microservices may utilize a scalable Cloud-based architecture. We carried out a variety of tests in order to determine how successful the insertion and retrieval of information in MongoDB is, taking into account the known latency of the 4G network. The response times that were obtained suggest that our strategy is successful when applied in a practical environment. We would like to take a more in-depth look at the implications that our technology has for security.

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NOMENCLATURE

The paper proposes an Internet of Things (IoT) cloud-based system to tackle real-time traffic monitoring and accident prevention in Uttarakhand, India.

The system uses mobile traffic sensors installed in private and public vehicles to collect real-time data.

The data is processed using OpenGTS and MongoDB to allow prompt congestion detection, automated rerouting, and identification of potential accident hotspots.

A systematic analysis including pilot testing shows the effectiveness and efficiency of the proposed system in significantly enhancing road safety and traffic management.

The implementation of this technology is a major step towards modernizing the region's transportation infrastructure and could set a precedent for similar applications elsewhere.

The paper also provides details on the system design, architecture, and performance evaluation. Key abbreviations used include:

IoT - Internet of Things

OpenGTS - Open Source GPS Tracking System

MongoDB - Open Source Document-Oriented Database

V2V - Vehicle to Vehicle Communication

V2I - Vehicle to Infrastructure Communication

I2V - Infrastructure to Vehicle Communication

ITS - Intelligent Transportation System