# Chapter 13
# IoT Based Intelligent Transportation System (IoT-ITS) for Global Perspective: A Case Study

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**Abstract** Big data analytics helps in analyzing a huge set of data whereas IoT is about data, devices and connectivity. Internet of Things (IoT) involves connecting physical objects to the Internet to build smart systems and universal mobile accessibility advanced technologies like Intelligent Transportation System (ITS). IoT solutions are playing a major role in driving the global IoT in Intelligent Transportation System. Communication between vehicles using IoT will be a new era of communication that leads to ITS. IoT is a combination of storing and processing sensor data and computing using data analytics to achieve and assist in managing the Traffic system effectively. IoT based Intelligent transportation system (IoT-ITS) helps in automating railways, roadways, airways and marine which enhance customer experience about the way goods are transported, tracked and delivered. A case study on Intelligent Traffic Management System based on IoT and

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big data, which will be a part of, smart traffic solutions for smarter cities. The ITS-IoT system itself forms an eco-system comprising of sensor systems, monitoring system and display system. There are several techniques and algorithms involved in full functioning of IoT-ITS. The proposed case study will examine and explain a complete design and implementation of a typical IoT-ITS system for a smart city scenario set on typical Indian subcontinent. This case study will also explain about several hardware and software components associated with the system. How concepts like Multiple regression analysis, Multiple discriminant analysis and logistic regression, Cojoint analysis, Cluster analysis and other big data analytics techniques will merge with IoT and help to build IoT-ITS will also be emphasized. The case study will also display some big data analytics results and how the results are utilized in smart transportation systems.

**Keywords** Intelligent transport system · Internet-of-things · Data analytics

## 13.1 Introduction

The cities in India are aimed at achieving “smartness” by improving the economic structure an technology. The system aims to address the public with grievance redressal. Internet of Things (IoT) [1] links the objects of the real world to the virtual world, and enables anytime, anywhere connectivity for anything that has an ON and OFF switch. It constitutes to a world where physical objects and living beings, as well as virtual data and environments, interact with each other. The notion of IoT is to take a broad range of things and convert them into smart objects—anything from cars, watches, fridges and railway tracks large amount of data is generated as large numbers of devices are connected to the internet. So this large amount of data has to be controlled and converted to useful information in order to develop efficient systems. Big Data Analytics plays a major role in generating useful information from the generated data.

The term big data existed long before IoT arrived to carry out analytics. When the information demonstrates veracity, velocity, variety and volume, then it is interpreted as big data. This equates to a large quantity of data that can be both unstructured and structured, while velocity refers to data processing speed and veracity governs its uncertainty. The data from IoT devices lies in big data and this information is measured against it. Soon, IoT will touch each and every facet of our lives: smart homes, manufacturing, transportation, and consumer goods like wearables, smartphones and more.

The idea of internet of things (IoT) was developed in parallel to WSNs. The term internet of things was devised by Kevin Ashton and refers to uniquely identifiable objects and their virtual representations in an “internet-like” structure. These objects may range from huge buildings, planes, cars, machines, any sort of goods, industries, to human beings, animals and plants and even their specific body parts. One of the major evolutions of WSNs will be after they are integrated with IoT. This paper aims to develop an intelligent transportation system.

The Internet of Things (IoT) is fundamentally transforming the transportation industry. Next generation intelligent transportation systems will optimize the movement of people and goods, improving economics, public safety, and the environment. Smart transportation systems will automate our roadways, railways, and airways, transform passenger experiences, and reshape the way cargo and merchandise are tracked and delivered, creating substantial business opportunities for system integrators, independent software vendors (ISVs), service providers, and other solution providers.

With the acceleration of urbanization, motorization, the pace of modernization, the urban population increase, growing faster vehicles, urban traffic congestion and clogging growing, urban transport system overwhelmed, the consequent environmental noise, air pollution, energy waste and other factors plaguing today's transportation in major cities, has become a serious problem around the world now industrial countries and developing countries. So, faced with in today's world of globalization, information technology development trend, the traditional means of transportation technology and no longer meet the requirements of economic and social development, intelligent transportation is the inevitable choice for urban transport development, is a revolution in urban transport undertakings. Things appear to intelligent transportation industry breakthrough brings rare opportunities to bring new horizons for the development of intelligent transportation, smart transportation to provide a wider space for development, and therefore modern urban transport calling for "Internet of things". "The new generation of intelligent transportation" developments provides important technical support for the realization of real-time, efficient, accurate, safe, energy-saving intelligent transport objectives and provide technical support for the Internet of Things technology, networking technology will bring a intelligent urban traffic The new upgrade.

The growing population in the metropolitan areas in this modern age requires more smart services of transportation. Achieving smart and intelligent transportation requires the use of millions of devices equipped with Internet of things (IoT) [2] technology. For example, The Toronto Intelligent Transportation Systems Centre and Testbed, developed a system known as MARLIN-ATSC (Multi-agent Reinforcement Learning for Integrated Network of Adaptive Traffic Signal Controllers) [3] to improve traffic flow with smart signals that process traffic information locally. Tests of the system on 60 downtown Toronto intersections at rush hour showed a reduction in delays of up to 40%. The test also showed it cut travel times by as much as 26%.

Singapore has adopted an Intelligent Transport strategy and set of systems. It has one of the least congested major cities, with an average car speed on main roads of 27 km/h, compared to an average speed of 16 km/h in London and 11 km/h in Tokyo. The city uses an Electronic Road Pricing system where the tolls vary according to traffic flows. It has an Expressway Monitoring and Advisory System that alert motorists to traffic accidents on major roads. It also has a GPS system installed on the city taxis, which monitors and reports on traffic conditions around the city. Information from all of these systems is feed into the Intelligent Transport System's Operations Control Centre, which consolidates the data and provides real-time traffic information to the public.

## 13.2 Related Works

This paper [4] deals with developing an analysis environment for systems to analyse and optimize the Intelligent Transport System (ITS). This uses the phenomenon of the co-simulation that helps in modeling systems with high flexibility. The concept of virtual ITS is being implemented by selecting various components which run on different platforms. These components are simulated by using pre-existing packages such that all of the packages operate with same time stamp or in multiples of smallest time stamp. Thus the proposed system is cost effective by avoiding the need for the calculation in the real time. The integrated system analysis environment developed helps ITS with seamless integration of various models thereby assembling the existing structure that functions far better than the existing models. Thus the process of the system integration is streamlined and made ITS setup to be implemented throughout the country without any obstacles. The proposed application of co-simulation concept for ITS can be extended to incorporate timing, thus making it time-based simulation.

An efficient traffic light system is proposed [5] which uses genetic algorithm for evaluating the stochastic data thereby arriving at an optimized transport system. The data is processed, each traffic light is coded and then cumulative for each route is calculated to find the optimum state. The simulation is done based on the route length and average speed of the vehicle. The simulation helps to find the optimum state in which maximum vehicles can move with the proposed traffic lights. The simultaneous analysis of more objects using some statistical measure is given through multivariate analysis [6]. By this technique, there occurs simultaneous analysis on more than two variables. Various multivariate analysis techniques have been proposed which could be applied as per the necessity.

This paper [7] proposes a prototype of vehicle which is capable of interacting with the other roadside vehicles and also with the internal electronic device. The model also specifies the various components adopted in the proposed on-board unit. This also provides various applications that could apply this technique for efficient operations. The proposed work [6] gives an overview of the various requirements for designing an efficient ITS system. Based on the real world scenario, simulations are done using MATLAB to determine the accuracy of the proposed system. The observations show that the proposed environment helps in identifying the vehicle position in different environments. The algorithm is analyzed in terms of running time and also based on the accuracy of the results. The paper [8] proposes a new system which integrates Internet of Things with the proposed intelligent transportation system so as to provide better transportation. The system [9, 10] uses the sensors to monitor the environment which is then used by the monitoring system for informing the drivers regarding the positioning of the device and details pertaining to it. Thus the data is displayed as the current bus route to the passengers. This system determines the number of tickets obtained as it decides the efficiency of the proposed technique.

| Ref. No. | Publication year | Proposed technique | Traffic safety | Energy efficient | Merits |
|---|---|---|---|---|---|
| [11] | 2009 | Pollution-free transportation | No | Yes | Handles traffic in an efficient manner |
| [12] | 2014 | Pollution-avoidance transportation | Yes | Yes | Reduction in emission of $CO_2$ by using electric vehicles |
| [13] | 2015 | Green transportation | No | Yes | Traffic handling with sustainability is given importance |
| [14] | 2015 | Safe and sustainable transportation | Yes | Yes | Traffic congestion is handled efficiently |
| [15, 16] | 2016 | Green transportation | Yes | No | Proposes a pollution free technique which helps in vehicular movement |
| [17, 18] | 2016 | Collision-free transportation | Yes | No | Determination of braking response time and steering response time |
| [19, 20] | 2017 | Collision-free transportation | Yes | Yes | Safe system design with collision warning |
| [21] | 2018 | Congestion avoidance transportation | Yes | Yes | Time of arrival (TOA) based localization, using automatic braking for collision avoidance |

## 13.3 Smart Cities and IoT

Smart cities utilize multiple technologies to improve the performance of health, transportation, energy, education, and water services [22] leading to higher levels of comfort of their citizens. This involves reducing costs and resource consumption in addition to more effectively and actively engaging with their citizens. One of the recent technologies that have a huge potential to enhance smart city services is big data analytics. As digitization [23] has become an integral part of everyday life, data collection has resulted in the accumulation of huge amounts of data that can be used in various beneficial application domains. Smarter cities are based on smarter infrastructure. There are many ways that IoT can help governments build smarter cities [24]. One method is through optimizing services related to transportation, such as traffic management, parking, and transit systems. There is no single consensus definition of a smart city, but there is some agreement that a smart city is one in which information and communication technology (ICT) facilitates improved insight into and control over the various systems that affect the lives of residents.

Smart transportation, a key internet of things vertical application [25] refers to the integrated application of modern technologies and management strategies in transportation systems. These technologies aim to provide innovative services relating to different modes of transport and traffic management and enable users to be better informed and make safer and 'smarter' use of transport networks.

Intelligent IoT–enabled transportation systems improve capacity, enhance travel experiences and make moving anything safer, more efficient and more secure. The local police, emergency services and other government services can use these sensor networks with smart traffic management to gain citywide visibility to help alleviate congestion and rapidly respond to incidents. IoT based intelligent transportation systems are designed to support the Smart City vision, which aims at employing the advanced and powerful communication technologies for the administration of the city and the citizens.

Cities, as we all know facing with complex challenges—for smart cities the outdated traditional planning of transportation, environmental contamination, finance management and security observations are not adequate. The developing framework for smart-city requires sound infrastructure, latest current technology adoption. Modern cities are facing pressures associated with urbanization and globalization to improve quality-of-life of their citizens.

The expansion of big data and the evolution of Internet of Things (IoT) technologies have played an important role in the feasibility of smart city initiatives. Big data offer the potential for cities to obtain valuable insights from a large amount of data collected through various sources, and the IoT allows the integration of sensors, radio-frequency identification, and Bluetooth in the real-world environment using highly networked services. The combination of the IoT and big data is an unexplored research area that has brought new and interesting challenges for achieving the goal of future smart cities. These new challenges focus primarily on problems related to business and technology that enable cities to actualize the vision, principles, and requirements of the applications of smart cities by realizing the main smart environment characteristics. In this paper, the state-of-the-art communication technologies and smart-based applications are used within the context of smart cities. The visions of big data analytics to support smart cities are discussed by focusing on how big data can fundamentally change urban populations at different levels. Moreover, a future business model of big data for smart cities is proposed, and the business and technological research challenges are identified. This study can serve as a benchmark for researchers and industries for the future progress and development of smart cities in the context of big data.

Intelligent Transportation Systems are advanced applications that aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and smarter use of transport networks. Experfy deploys advanced analytics on a wide range of Intelligent Transport System technologies such as car navigation; traffic signal control systems; container management systems; variable message signs; automatic number plate recognition; speed cameras. Experfy also provides analytics for advanced applications that integrate live data and feedback from a number of other sources, such as parking guidance and information systems, weather information, and bridge de-icing systems.

In 2010, the European Union had defined Intelligent Transportation Systems (ITS) as systems "in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport."

Smart transportation includes the use of several technologies, from basic management systems such as car navigation; traffic signal control systems; container management systems; automatic number plate recognition or speed cameras to monitor applications, such as security CCTV systems; and to more advanced applications that integrate live data and feedback from a number of other sources. ITS technologies [26] allows users make better use of the transportation network and also paves the way for the development of smarter infrastructure to meet future demands. The evolution of intelligent transportation systems is providing a growing number of technology solutions for transportation managers as they seek to operate and maintain the systems more efficiently and improve performance.

According to the Intelligent Transportation Society of America, ITS technology makes it possible to:

- Use a navigation system to find the best route based on real-time conditions.
- Alert drivers of potentially hazardous situations in time to avoid crashes.
- Be guided to an empty parking space by a smart sign.
- Ride a bus that turns traffic lights green on approach.
- Detect and respond promptly to traffic incidents.
- Reroute traffic in response to road conditions or weather emergencies.
- Give travelers real-time traffic and weather reports.
- Allow drivers to manage their fuel consumption.
- Adjust speed limits and signal timing based on real-world conditions.
- Improve freight tracking, inspection, safety and efficiency.
- Make public transportation more convenient and reliable.
- Monitor the structural integrity of bridges and other infrastructure.

An example of the benefits of the implementation of smart transportation technologies can be found in Austria, where the country's Autobahn and Highway Financial Stock Corporation (ASFiNAG), turned to Cisco's Connected Roadways solutions to bring the "internet of things" to its roadside sensors [27]. The result is a highway designed to monitor itself, send information to drivers and predict traffic to ensure lanes stay clear of congestion.

By all accounts, the Internet of Things (IoT) and Big Data represents a huge opportunity for cost savings and new revenue generation across a broad range of industries. Researchers provided a primer on IoT and described how IoT impacts the manufacturing industry [28] in the first two briefs in the IoT series. This brief will highlight several examples of how IoT is being used to create smarter cites. In its most basic definition, the Internet of Things describes a system where items in the physical world, and sensors within or attached to these items, are connected to the Internet via wireless and wired network connections. The Internet of Things will connect inanimate objects as well as living things. IoT will connect everything from industrial equipment to everyday objects that range from medical devices to automobiles to utility meters.

## 13.4 Big Data and Its Challenges

When huge volume of data emerged and has to be managed at certain time and speed, it became necessary to evolve a new phenomenon namely Big data. Big data technologies [29] capture, store, process and interpret the data in a distributed environment. The following limitations of the Relational Database Management System [30] led to the beginning of big data.

- Data Volume increased exponentially and it turned out to be a challenge for RDBMS to handle such a huge data.
- To cater to this need, RDBMS increased the memory as well as the number of processors which resulted in increase in cost.
- Also nearly 80% of the data were in unstructured and semi-structured format and RDBMS cannot handle it.

## 13.5 V's of Big Data-An ITS Perspective

Big data exhibits special characteristics [31, 32] with varied dimensions. There are four dimensions of Big data which is described below.

The first dimension is the data size. This term is referred as volume in Big data terminology. Data which is generated and processed increases exponentially. The major sources of data include data from social media, online banking transactions, sensors in vehicles. This increasing data volume claims high scalable and reliable storage system. The tremendous increase in the number of vehicles paves way for the data to be processed with the help of bigdata analytics with impact on the IoT.

Variety Refers to data format that Big data supports. Various formats of data includes structure, semi-structure and un-structured format. Structured data refers to data organized in tables, in the form of rows and columns. Semi-structured data is the combination of structured and un-structured data. Xml data is semi-structured which does not fit into tables and contains tags which organizes fields within the data. Un-structured data has no definite structure, e.g.: Data from sensors of vehicles. The vehicular data is analyzed in terms of velocity and various parametric structures that helps in easy organization and implementation of smart transportation.

As the volume of data increases, the speed with which the data is generated also increases. In the big data era, data arrives so fast that it becomes difficult to capture and process it. For e.g.: Face book generates 3.3 million post and google gets 3.1 million searches in a minute. The velocity of the data in vehicular systems makes.

Veracity implies the abnormality and uncertainty in the data. This is due to inconsistency in the data. Data should be reliable so that when analyzed produces exact results.

## 13.6 Challenges Faced by Big Data Technology

Huge volume of data poses lot of challenges when dealt with, when some data could be stored in traditional tables, others which are un-structured such as videos and pictures could not fit into it. Though these data can be efficiently managed independently, major issues arises while integrating data from various sources [33].

The following are the major challenges.

- Data is heterogeneous in nature as data comes from multiple sources and so data has to be structured before performing analysis.
- Sometimes data may be incomplete or missing, which may create problem when taken for analysis, in such a case null values have to be inserted in the place of missing values, such that it does not affect the rest of the data and successful outcome is obtained.
- Managing huge volume of data is the biggest issue in the big data era. The more the data, longer is the processing time needed.
- The higher velocity of the big data introduces the challenge of processing the real time data at a faster rate in which it arrives.
- Data storage in big data should be in such a way that it is scalable at latter point of time, when the data grows exponentially. The data should not only be scalable but also be fault tolerant and trust worthy.
- Data privacy is a growing issue with increasing data volume. So stringent access control mechanism should be introduced in various stages of Big data life cycle. Data sharing should be restricted such that the available data provides the needed business knowledge. Even when the data is to be given for analysis, sensitive information should be protected and then delivered for processing.

## 13.7 s-ITS System Overview and Preliminaries

For an efficient Intelligent Transportation System, the components such as Central Server, RFID device, Sensors, Lighting control unit and EBOX II. Central Server plays a major role in providing resilience during any mis-functioning of the system.

RFID helps in communicating in data flow information between the cars to EBOX II. This RFID device has tags, antennas to communicate information and readers to decode the data.

## 13.8 Design Requirements of ITS System

- RFID tag operates on some specified frequency. The ITS System to be built is required to have ultra high frequency. This helps in reaching the good distance and recognize data for about 4–6 m.
- The energy needed for working of RFID device and lighting control unit is provided by extra chargers (Fig. 13.1).

## 13.9 Design Goals

The system considers the following parameters in designing a new ITS system.

- **Scalability**

The s-ITS system designed must cater to the growing data world namely bigdata. The information should be portable and it is ensured that the settings are remotely operated without any hindrance.

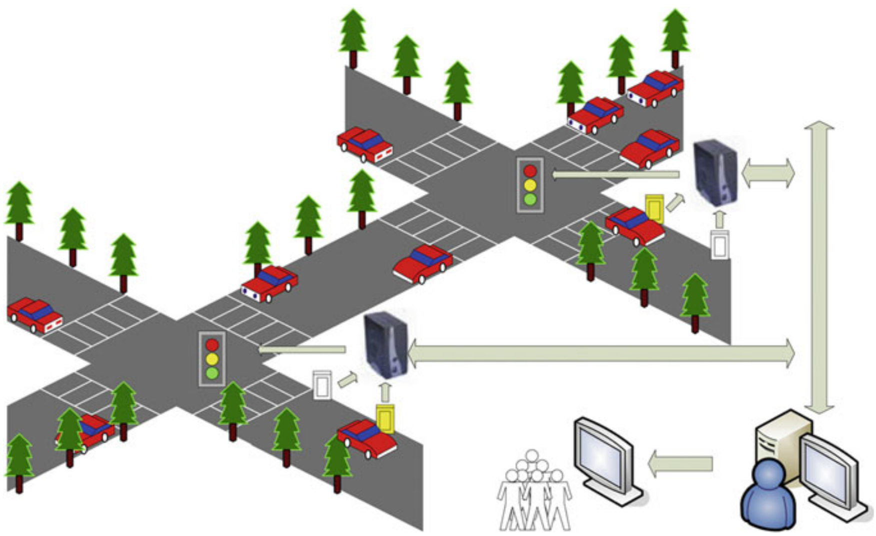

**Fig. 13.1** Proposed model- intelligent transport system

- **Reliability**

As the smart transportation system is designed to operate without any manual intervention by human, it is of utmost importance that the system must be reliable. It should also be designed to handle any unexpected situations in an efficient way.

- **User-Friendly**

The user need not be aware of the entire implementation. Rather, the user needs to know the initialization in a single click and the admin must also be able to manage the mishaps that occur in the server side.

## 13.10 Experimental Design

The proposed system smart intelligent transport system (s-ITS) involves the smart building of the intelligent transport system with the ability to tackle the real-time issues. The intelligent system is built to address the following modules (Fig. 13.2).

(a) Vehicular location Tracking
(b) Intelligent vehicle parking system
(c) Communication within a VANET
(d) Vehicular Big-data Mining.

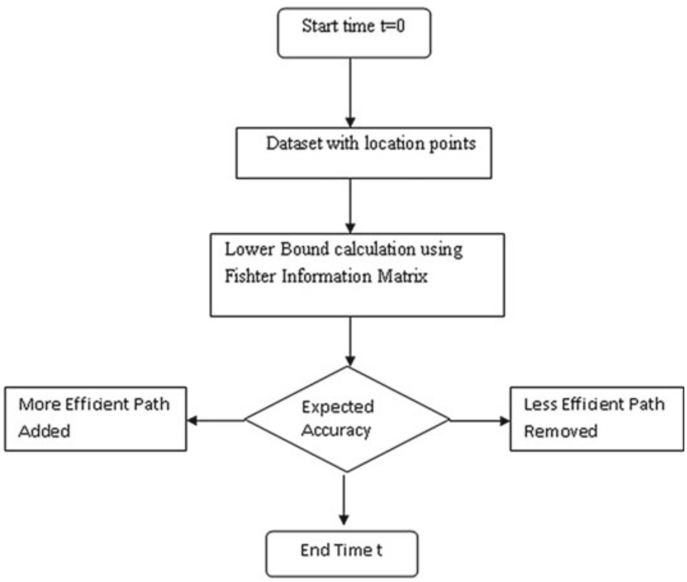


**Fig. 13.2** Flow of the s-ITS vehicle localization

The proposed algorithm helps in selecting those paths that provide maximum accuracy. With the lower bound value accuracy value as the benchmark, the model is checked for its performance. So if the model achieves the targeted accuracy than that of the lower bound, then it implies there are enough paths which are efficient an all other less connection paths are discarded. Whereas if the lower bound is more than the expected accuracy rate then it implies that there are no enough paths in the selected ones. Further the necessary routes are added to the set for effective vehicle localization.

**Pseuocode for Vehicle location Tracking by path sensing**

**Inputs:** $C_i^l$ represents the connections of a vehicle at time l.

$N_i^{l-1}$ represents the connections composed by the proposed algorithm at time l-1

$\beta(l-1)$ Represents the vehicle's position at time l-1.

D[K], location of the unit at the time k

$\alpha$, the expected accuracy.

Step1: $Z_i[k] = A\beta_i[l|l-1]$ which represents initial elements.

Step 2: $N_i^l = N_i^{l-1} \cap C_i^l$

Step 3:if $|C_i^l| > 5$ then I= fisher (D[k], $Z_i[k], \sigma_{ij\,2}$ )

Step 4: Else I=0.5 $\alpha^{-2}$ end if

Step 5:$\mu = \sqrt{Trace\{I^{-1}\}} - \alpha$

Step 6: if $\alpha$ <20% $\alpha$ *then*

Step 7: $N_i^l = N_i^l - M_i^l$

Step 8: for I $\epsilon N_i^l$ do

Step 9:Z= fisher(D[k], $Z_i[k], \sigma_{ij\,2}$)

Step 10:[b]=Trace{$I^{-1}\, Z\{I^{-1}$ }

Step 11:end for

Step 12:Elseif if $\alpha$ >20% $\alpha$ *then*

Step 13:if $N_i^l \cap C_i^l - D^k = \emptyset$ then

Step 14: $N_i^l = N_i^l - M_i^l$ else

Step 15: for I $\epsilon N_i^l \cap C_i^l - D^k$ do

Step 16: Z= fisher(D[k], $Z_i[k], \sigma_{ij\,2}$)

Step 17: [b]=Trace{$I^{-1}\, Z\{I^{-1}$ }

Step 18:end for

Step 19:$I_{max}$={j $\epsilon$ $N_i^l$[b]={max{b}}}

Step 20: $N_i^l = N_i^l + i_{max\ end\ if}$

Step 21:else

Step 22: $N_i^l = N_i^l$

Step 23:end if

The vehicle localization algorithm predicts the location of the vehicle at time l. This involves the storing of the predicted set and later measuring if the count of the predicted set is greater than 5. If so then fisher value is calculated. If less than 5 then fisher value is not calculated and it is ensure that new more connections are added. Then as per the flow the lower bound accuracy calculate from Fisher matrix is compared with the predicted value. If there is improvement in the predicted accuracy value then extra connections could be removed. Thus the proposed algorithm has the advantage of reducing the time period of the selection of paths for the vehicles as well as easy location estimation.

(b) **Intelligent vehicle parking system**

Sensors play a major role in this module. They help in collecting information about the geographic location of the vehicle, availability of the parking lot, Prior reservation details, position of the parking, details regarding the vehicle and current traffic information. Thus the big data plays a major role here as it involves the real-time application with the facility to provide an intelligent system for transportation.

The vehicle parking decision is made by the outcome factors like occupied or free factor. If the place is free and available for parking, then it is marked as free. Whereas, if there are vehicles in the location, then it is marked as occupied. The decision of parking is based on the application of the outcome value which will be updated over a period of time through sensors. The decision is then updated in the server. The features are compared against the given threshold value for final decision of the parking slot (Fig. 13.3).

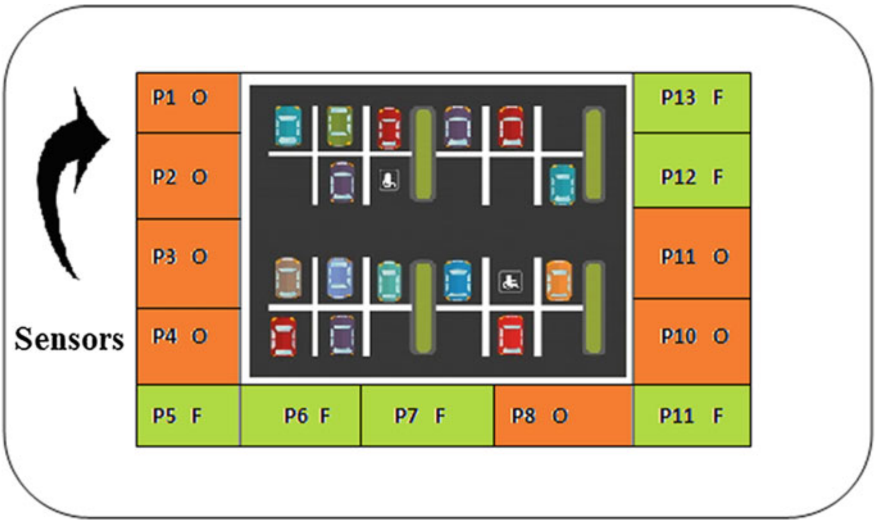


**Fig. 13.3** Parking scheme of s-ITS

(c) **Communication within a VANET**

With the help of the prior registration of the vehicle and its device, the sensors track the location of the vehicle and its status in the current traffic scenario. By using the sensor systems of IoT, the data is transferred and transmitted between the vehicles such that it helps in avoiding the traffic and also ensure safe journey.

(d) **Vehicular Big-data Mining**

The system built is made to inform ahead of the traffic condition, dangerous road situations as well as must be capable of handling the unforeseen accidents and situations with data so that it could be intimated ahead to vehicles for safe driving. It is of importance that the signals be communicated to the vehicles through the mining of the huge volume of previous similar data and also based on current traffic status.

## 13.11 Implementation

The implementation of the s-ITS involves ensuring that the proposed system achieves a smartness in transportation through the localization and by avoiding traffic through some bigdata techniques. In the example below, Chennai city is taken and the traffic levels in various roads are represented through different colors in the map. The various bigdata techniques and their application for ITS is depicted below (Fig. 13.4).

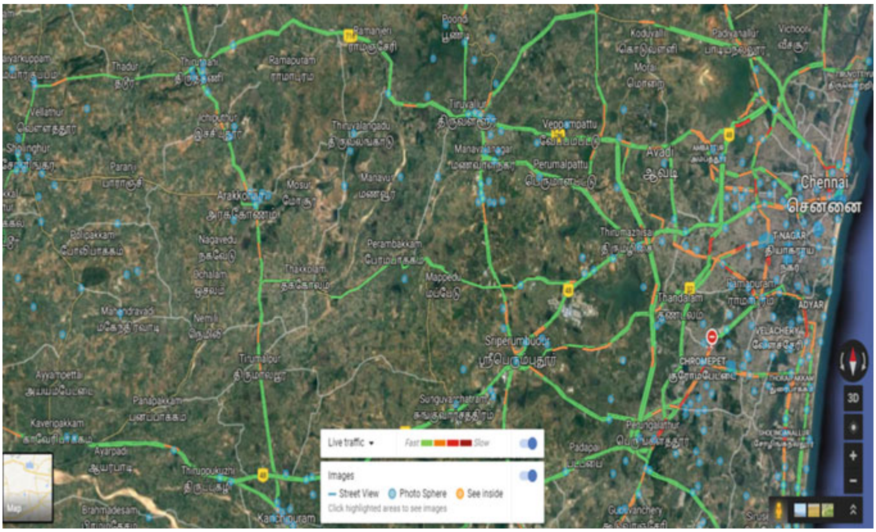


**Fig. 13.4** Map of Chennai for indicating traffic levels of s-ITS

## 13.12 Big Data Techniques in ITS

Multivariate analysis involves analyzing more than two variables at a time thereby delivering some useful results in a shorter period of time. Univariate is extended to hold more variables for analysis. In case of linear regression, two variables are analyzed, whereas in multivariate structure, more number of predictor variables are used.

## 13.13 Classification of Multivariate Techniques

The classification is based on variable's ability to get segregated into dependent and interdependent forms. Dependent form is one in which a variable is declared as dependent variable which is to be predicted by other variables which are independent variables. An interdependent form is one in which no variable is dependent or independent. The following flowgraph shows some of the multivariate techniques (Fig. 13.5).

- **Multiple Regression Analysis**:

The method of multiple regression aims to predict the changes in dependent variable in response to changes in an independent variable. This technique is found to benefit when the problem to be addressed involves a single dependent variable related to two or more independent variable. This is achieved by the method of least squares.

$$\underset{\text{(metric)}}{Y_1} = \underset{\text{(metric,nonmetric)}}{X_1 + X_2 + X_3 + \cdots + X_n}$$

This multiple regression can be applied to ITS, wherein the time (Dependent variable) at which the vehicle reaches the destination could be predicted by using the traffic in the route, speed of the vehicle (Independent variables)etc. This makes the prediction simpler and it can be depicted in a metric and nonmetric form as in the equation.

- **Multiple Discriminant Analysis**

This technique is suitable when total population could be divided into several groups based on a dependent variable which has several relevant classes. The main objective is to understand the differences between the various groups and to predict the likeliness of an object to any of the groups based on the independent variable.

$$\underset{\text{(nonmetric)}}{Y_1} = \underset{\text{(metric)}}{X_1 + X_2 + X_3 + \cdots + X_n}$$

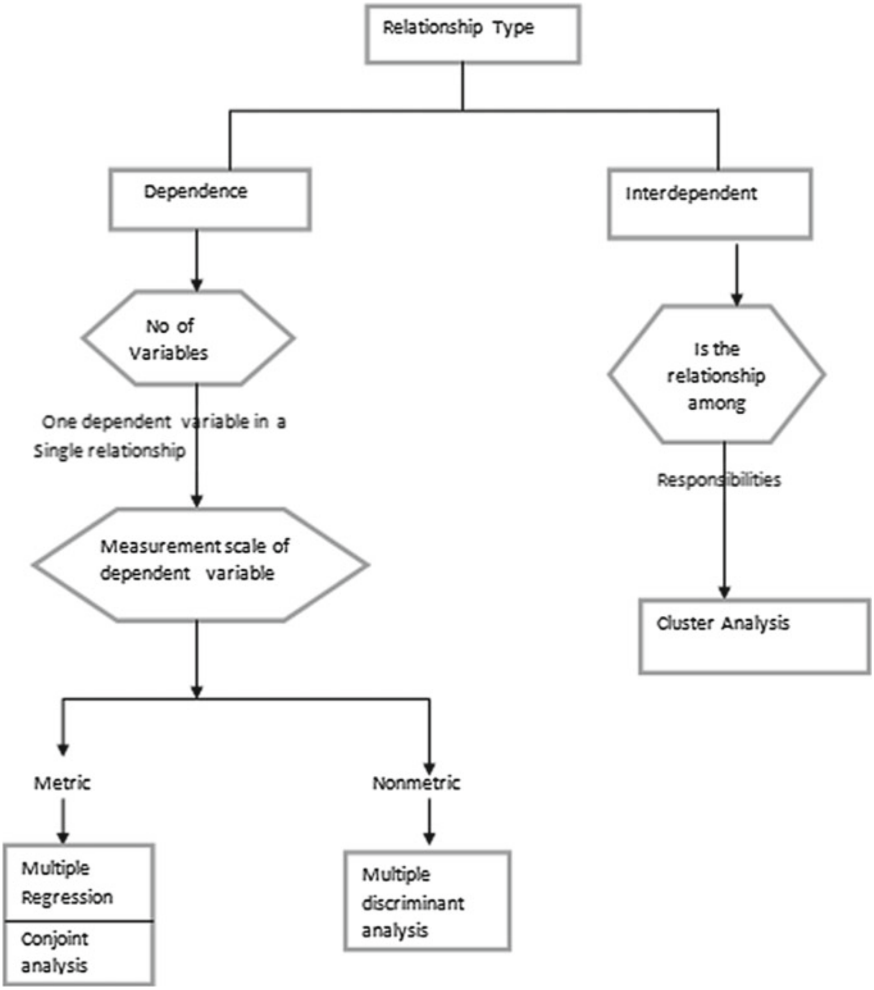


**Fig. 13.5** Classification of the multivariate techniques with relevance to s-ITS

Applying this technique to ITS, the best shortest routes that avoids traffic and helps in reaching the destination earlier are obtained. This involves usage of time factor and also the location based route map.

- **Logistic Regression**

The logistic regression model is the combination of multiple discriminant analysis and multiple regression. This is different from multiple regression as this

- **Conjoint Analysis**

This analysis paves way for both consumers as well as product researchers. When a product is designed with some attributes and parameters, the customers are only concerned about the certain parameters while they leave out the other parameters which do not fascinate them. Whereas the product researchers take keen note of all the attributes that decides the marketing of that product. When relating this to s-ITS, the users of the vehicular system are concerned only about the safe collision free travel. They intend to know the parameters and techniques that would aid them in safe travel without congestion. Whereas, the system is intended to consider various aspects of the vehicular movement and parameters that decide the uninterrupted travel with constant velocity. This is depicted as below

$$\underset{\text{(nonmetric)}}{Y_1} = \underset{\text{(metric)}}{X_1 + X_2 + X_3 + \cdots + X_n}$$

- **Cluster Analysis**

Cluster analysis involves grouping the values to some groups or clusters which determine the variations in the data elements. The process of clustering is done for a set of elements by finding the similarity of the similar objects. Once the similarity is identified, the elements are grouped into respective clusters. The final step is to profile the final variables. In s-ITS, the parameters related to vehicle motion are grouped based on their relevance in determining the various factors of ensuring the vehicular motion so that the transportation is made effective and collision-free.

## 13.14 Experimental Results and Discussion

The experimental results show that the proposed system outperforms the existing ITS techniques in terms of throughput and packet delivery. It serves best in case of delay and latency. The below graphs depict the various parameters and their relevance with respect to different network schemes for communication of data in the form of packets (Figs. 13.6 and 13.7).

The proposed system shows the varied delay in different network scenarios. The recent version of network namely Enc 802.11 p gives higher packet delivery ratio and lower delay.

The observations are made based on the time and distance factor with respect to the metrics RMSE and MAPE. The proposed s-ITS is compared with existing technique such as fuzzy control rule [2016 531] and also fuzzy rule based on Genetic algorithm to determine their effectiveness. The observation is done for the Chennai region mainly on peak hours and traffic prone regions to find the best

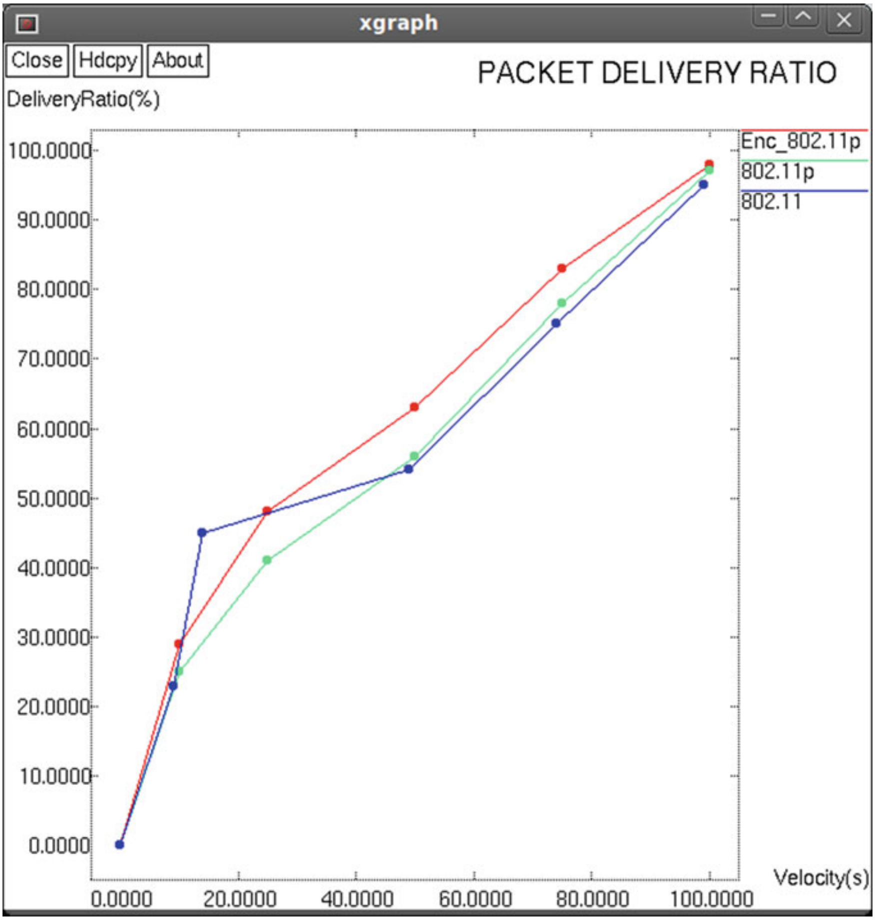


**Fig. 13.6** Packet delivery ratio comparison in various network environments

route. The proposed s-ITS helps in effective traffic monitoring as well as aid in easy parking as the vehicles are rerouted in case of traffic in a particular location (Fig. 13.8).

Analyzing the traffic condition further based on the parameters like vehicle speed, density and traffic volume, the current traffic is estimated and vehicles are rerouted to reach destination without further collision (Fig. 13.9).

The vehicle density is less with increase in distance for the proposed system as the new system resolves traffic without much trouble. Also the vehicles are diverted to the alternate path such that no traffic occurs. So the proposed system outperforms the other existing fuzzy based and VANET based systems by minimizing the vehicle count in a particular road without traffic.

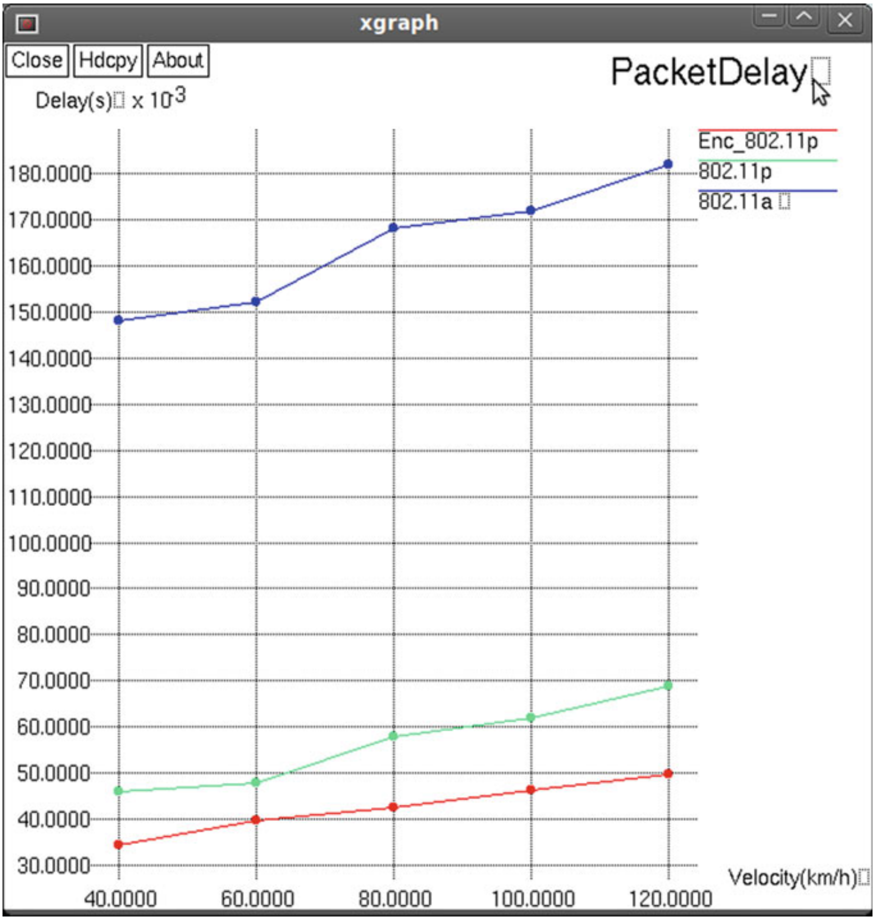


**Fig. 13.7** Comparison of packet delay in varied network environment

## 13.15 Conclusion and Future Work

The emerging paradigm namely Bigdata and IoT plays a major role in day-to-day applications. The technologies of bigdata aid in easy preprocessing and thereby providing pre-processed data to be processed in the next level. The traffic data which is processed is then subjected to IoT and bigdata techniques and a framework namely s-ITS is obtained. The proposed framework helps in location tracking of vehicles, smart parking and applying bigdata technology for designing efficient transportation system. The system helps in monitoring the vehicle's motion thereby determining the traffic in the particular area. The proposed system is evaluated for its performance in terms of packet delivery, network delay and it is found that the

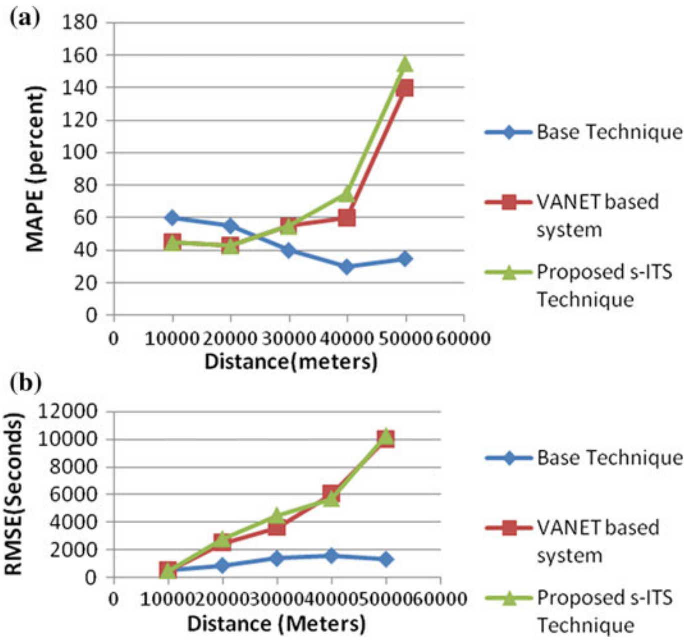


**Fig. 13.8** **a** MAPE values versus distance. **b** RMSE values versus distance

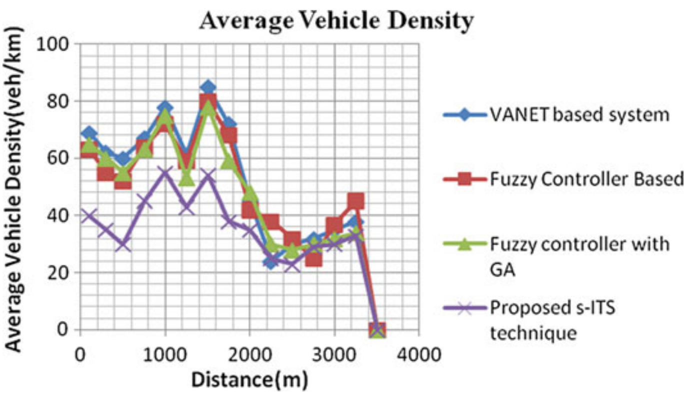


**Fig. 13.9** Comparison of vehicle density in various mechanisms

proposed s-ITS system performs better than existing conventional systems. It is also exhibited through MAPE and RMSE values.

The energy efficient mechanisms could be implemented in the ITS system and the system efficiency could be made more promising for dealing with the current road scenario. This could be the future work targeting the decrease in energy for effective transportation system which is smart and robust.

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