GPS Based Vehicle Tracking System

Thesis submitted in partial fulfillment of the requirements for the award of degree of

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in

Software Engineering

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CERTIFICATE

I hereby certify that the work which is being presented in the thesis entitled, "*GPS Based Vehicle Tracking System*", in partial fulfillment of the requirements for the award of degree of Master of Engineering in *Software Engineering* submitted in Computer Science and Engineering Department of Thapar University, Patiala, is an authentic record of my own work carried out under the supervision of *Dr. Parteek Kumar* and refers other researcher's work which are duly listed in the reference section.

The matter presented in the thesis has not been submitted for award of any other degree of this or any other University.

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This is to certify that the above statement made by the candidate is correct and true to the best of my knowledge.

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Abstract

Quality of life of people in India is degrading with the growing traffic congestion. Congestion leads to air pollution, decrease in accessibility and increased travel time. To overcome these problems number of vehicles has to be reduced and that can only be done by making public transport more reliable. To make public transport more reliable a system has to be proposed where the buses or auto rickshaws moving on same route could be tracked easily. Vehicle tracking system provides the passengers with the current location of the vehicle and gives the details of the estimated arrival time of the vehicle to the passenger. The system helps the passengers to make better travelling decision as passengers can decide if should wait for the vehicle or not in accordance to the estimated arrival time. From this system passenger can also determine if the vehicle has been missed or yet to come. The system provides the basic information which is necessary to make day to day life more efficient.

GPS based vehicle tracking system is the proposed system which can be categorized into two areas, firstly that uses GPS for real time locations and another is the prediction system which includes the information from the collected data. Real time location of the vehicle can be usefully transferred through Internet. Real time location of the transit gives a very broader idea of the arrival time of the vehicle. But this information is of no use for an outsider who does not know the traffic pattern between the current location of the vehicle and the traveler. Prediction system considers the traffic pattern. After testing it has been observed that integrating the two systems gives the correct results.

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Chapter 1

Introduction

1.1Introduction to GPS based vehicle tracking system

Vehicle tracking system provides the passengers with the current location of the vehicle and gives the details of the estimated arrival time of the vehicle to the passenger. This system helps the passengers to make better travelling decision as passengers can decide if should wait for the vehicle or not in accordance to the estimated arrival time. From this system passenger can also determine if the vehicle has been missed or yet to come. The system provides the basic information which is necessary to make day to day life more efficient.

For enhancing public transport it has to be made more reliable for which various concepts have been suggested. Intelligent transport systems are developed to make transportation easier and comfortable. Intelligent Transport System is route that is tested to mitigate traffic congestion models. There are various concepts that are included in it. Some of them are providing the travelers with the reliable information like real time passenger information system, pre trip in3formation systems, automatic vehicle location system, vehicle arrival notifications, timed transfers and determining priority of road to vehicle at intersections. Other concepts are about providing comfort, improving stops and number of passenger information systems.

Global Positioning System (GPS), Wireless communication systems and other systems have made public transport more reliable in developed countries by providing more information, for example, when will the transit vehicle arrive. Another most important information system is the travel time information system. However, this information cannot be extracted directly. Reliable travel time information system is important because it increases the ridership and increases the satisfaction of transit users. This decreases the congestion as number of vehicle reduces. Many metropolitan areas of developed countries have already come up with successful real time vehicle arrival systems on highways but still there are difficulties in the provision of real time vehicle arrival time information on urban streets because of the stochastic nature of the

urban traffic. Application of such a system in developing countries is even worse considering the lack of collected data and undisciplined traffic. Hence, to come with better vehicle arrival systems a good algorithm that can predict the arrival time of the vehicle with reasonable accuracy is required.

GPS based vehicle tracking system is the proposed system which can be categorized into two areas, firstly that uses GPS for real time locations and another is the prediction system which includes the information from the collected data. Real time location of the vehicle can be usefully transferred through Internet. Real time location of the transit gives a very broader idea of the arrival time of the vehicle. But this information is of no use for an outsider who does not know the traffic pattern between the current location of the vehicle and the traveler. Prediction system considers the traffic pattern. Integrating the two systems gives the correct results.

1.2Need for the GPS based vehicle tracking system

- Quality of life of people in India is degrading with the growing traffic congestion. Congestion leads to air pollution, decrease in accessibility and increased travel time. In developed countries still many people use their private vehicles. In developing countries also the degree of vehicle ownership is increasing at a faster rate. Many concepts have been applied for the mitigation of congestion. One of them is to expand and improve the public transport system. A good public transport system is very important for the economic growth of the country. With good and reliable public transport satisfaction among the travelers increases which decreases the number of private vehicles. A good public transport system improves the quality of life providing better mobility, accessibility, social cohesion and secures the environment. To make a transportation system reliable android application is made as it is very easily available and user friendly.

- Public transport can be impractical for people who need to adhere to strict schedules. The variations from the official vehicle schedule are understandable and unavoidable. But along with this if there is lack of communication regarding delay of the vehicle then traveler might be wasting time. If the vehicle is late, will make the travelers late and if the vehicle is early than its time will even make travelers late because they might miss the

vehicle. Even if the vehicle is on time, travelers have no way to know the information about the vehicle and ends up adopting alternative modes of transportation.

- With the increasing use of smart phones it has become very easy for people to stay in contact. Initially business was conducted only during business hours and preplanned locations. With the advances in recent year meetings have become impromptu. Because of these advances more precision is required in scheduling activities with more accuracy.

- These technologies have improved making business run more efficiently by making commuters who use public transport reach on time. The lack of certainty that vehicle travelers face applies not only to business world but also to everyone. Students need to reach on time for their classes, commuters traveling to go social get together. This technology helps the transit users know the potential delay in the vehicle schedules so that they can plan accordingly and increase the efficiency. Employees can notify the managers or the clients about the delay and reschedule the meetings. Students can also inform about their delay to the respective group members.

1.3 Techniques for vehicle tracking system

Vehicle tracking system can be broadly classified into real time location based system and the prediction system. Real time location based system uses the current location and speed of the vehicle to calculate its arrival time and prediction system takes into consideration the traffic pattern on the route to calculate the arrival time of the vehicle.

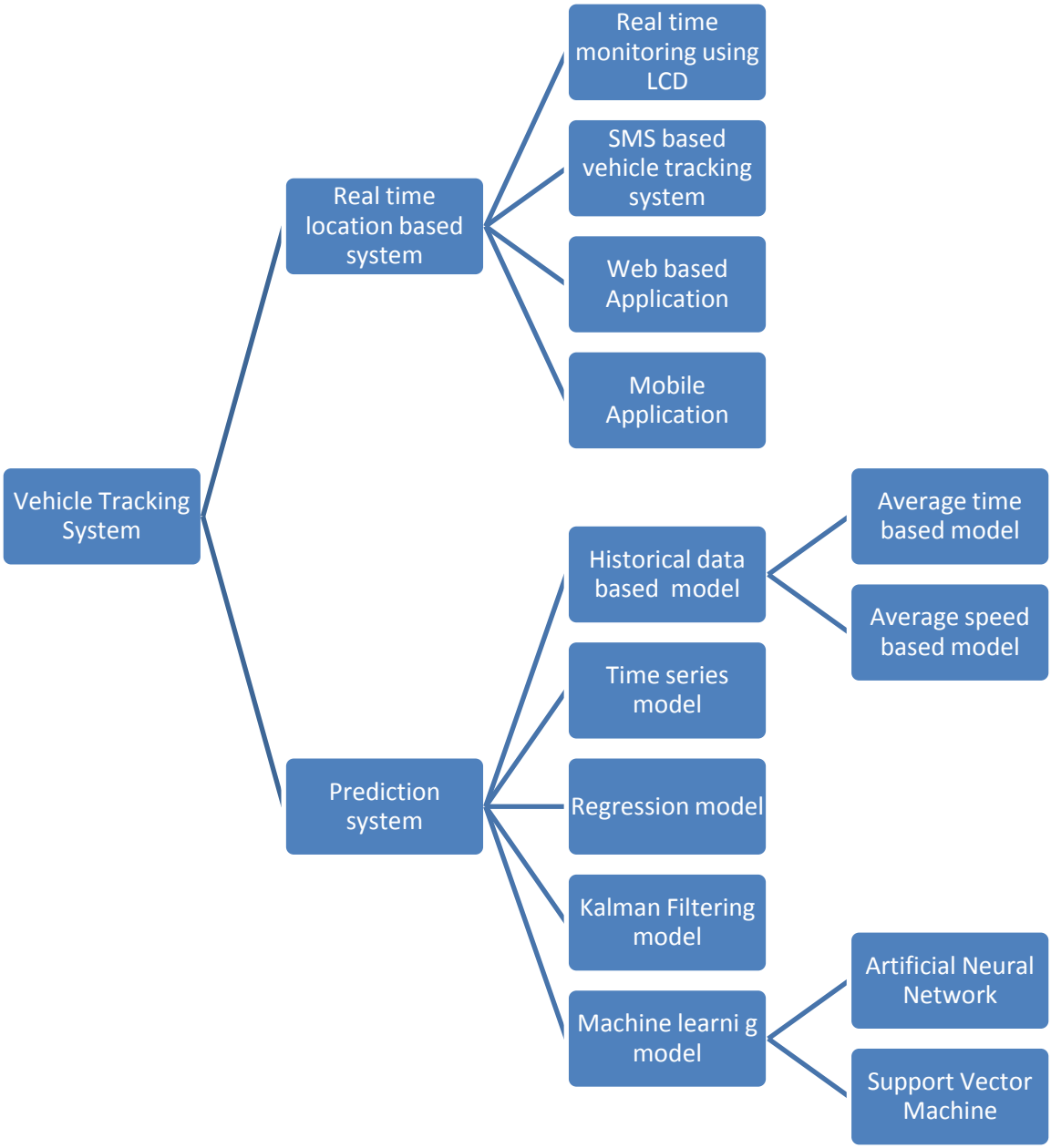

Figure 1.1 Techniques for vehicle tracking system

Real time location based systems can also be standalone systems that displays the arrival time of the transit vehicle on the LCD screens that are placed on every stop, through SMS facility, web based application or by using android application using GPRS (General Packet Radio Service). Real time location based models are illustrated below.

i. Real time location based systems that displays the arrival time of the vehicle on LCD screens that are placed on every stop uses RF (Radio Frequency) transceivers. As the vehicle enters the range of reception location is displayed on the LCD screen along with the vehicle number.
ii. SMS (Short message service) is used over the GSM networks to transfer the vehicle location coordinates. The location information is sent to the central server over the GSM networks using SMS and stored in the database. User sends the request and receives the information through SMS.
iii. Through the web based application users can track the vehicle graphically using the web based systems also enables users with different operating systems platforms to easily reach the details with the help of internet access.
iv. Vehicle tracking system using Android application has inbuilt GPS service provided by the Smartphone to get its GPS coordinates. These coordinates are transferred to the central server. Users can retrieve information through android application.

Another type of vehicle arrival time system is based on prediction system. It is based on the large amount of collected data. Prediction systems are broadly classified into the following:

i. Historical data based model uses the data from the previous journeys on the same route, same time and same day of the week with traffic conditions that follow the consistent pattern. This model is either based on average travel time or average travel speed.
ii. Time series model is based on the theory that either the factors acting from outside remain constant or can be measured if they vary with time.
iii. Regression model finds the variable which depends upon the set of independent variables like speed be the dependent variable which depends upon the independent variables like volume of traffic, day and time.
iv. Kalman filtering model considers the mathematical form of the linear state space equation and manage the traffic variations with time dependent variables.
v. Artificial Neural Network (ANN) model captures the complex non linear relationship between arrival time and other non dependent variables.

vi. Support Vector Machine (SVM) is the combination of regression and classification which are the methods of supervised learning.

1.4 Technologies

GPS based bus tracking system is required which tracks the real time location of the bus and this information is used effectively by the commuters to make better travelling decision. System and technology is growing even in nanoseconds. GPS is growing its popularity in day to day life applications. In this era of IV Generation Smartphone and palmtops have become a valuable part of the human beings. We often listen to the words Android and Maps. Android has made life easier and comfortable. Data mining technology is nearly being used in every environment and organization to predict the upcoming values.

1.4.1 Global Positioning System

Global Positioning Systems (GPS) are used to track the transit vehicle's location that is employed by various agencies. The major point of concern is how reliable are the results from GPS. GPS is the one of the most reliable and widely used for getting the current location. It is operated by United States of Department of Defense. The idea behind the working of GPS is that a receiver calculates the time a pseudo code takes to get from GPS Satellite to that receiver on earth surface. This time is approximately 0.1 seconds in practice. From this distance between the GPS satellite and the receiver can be calculated as the speed of sending code is known and time is measured, which gives the distance (X). The Satellite imaginarily places the receiver somewhere on the surface of a sphere with radius (X). Figure 1.2 (a) shows the setup of the arrangement. Then the same process is carried from the second satellite. This narrows the possibilities of existence of the receiver as it can be present only at intersection of the two virtual spheres. Intersection of the two spheres is an elliptical region where the receiver is possibly present. Figure 1.2 (b) shows the arrangement. By carrying out the same process for the third satellite, the probable locations are further reduced to just two points as illustrated in Figure 1.2 (c).

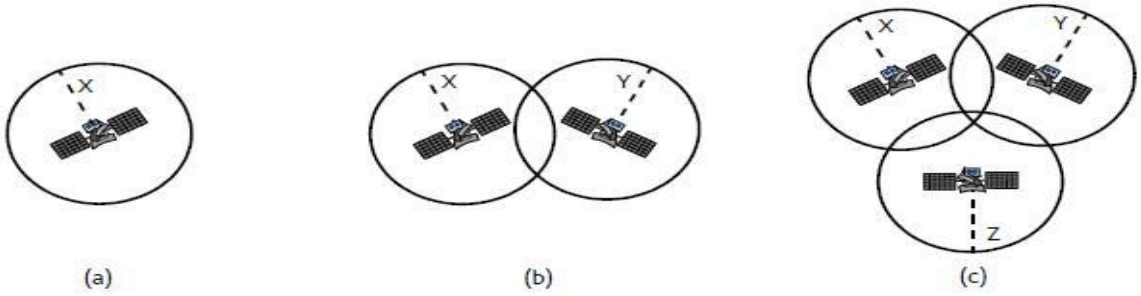

Figure1.2: GPS position computation using (a) one satellite (b) two satellites (c) three satellites.

One of the two points is ignored because either it is moving with unrealistic speed or it is much far from the surface of the earth. Measurements from the fourth satellite are counted if three dimensional positions is required *i.e* longitude, latitude and altitude. Figure 1.2 explains the 2-dimensional system.

The accuracy of the standard GPS facility is satisfactory, but there are few applications where much higher accuracy is required. For standing upto such higher accuracy differential GPS was developed. Errors caused due to delays when signal passes through the troposphere and the ionosphere are corrected in the differential GPS for higher accuracy. GPS gives longitude and latitude in following 3 conventions:

- Degrees minutes seconds: 40° 27′ 46″ N 79° 48′ 56″ W
- Degrees decimal minutes: 40° 16.767′ N 79° 158.933′ W
- Decimal degrees: 40.436° N 79.782° W

The system implementation uses Decimal degress representation.

Following are the sources of errors that might arise:

- Disturbances in the atmosphere slow down the speed with which the radio waves travel.
- In the absence of clear Line of sight (LOS) like underground subways, clouds correct results might not be collected.
- Skyscrapers bounce off the radio waves which gives the wrong results.
- Satellite might also send corrupt location data, misreporting the position.

Following are the methods of correction:

- By using Differential GPS (DGPS) hardware receiver's inaccuracy can be easily calculated. The signal correction information is broadcasted by the station for that area.
- Advanced systems which have higher accuracy are deployed for the area where GPS enabled devices is present and estimates the distance to the base station.
- Signals between the adjacent antenna service providers are interpolated with which device is always connected.

1.4.2 Android

Android application is proposed for the system as Android Smartphone consists of GPS system, with the use of which the current location of the transit vehicle and the passenger can be easily tracked. GPS system in the Smart phones can be easily used with appropriate security permissions. Android is developed by Google and is an open source operating system for mobile devices. One of the major features provided by Android is the set of Android applications (apps) provided through Android market that enables the users to extend the functionality. Android applications have made life much easier and faster. Applications are made very user friendly which makes it very popular. These apps are developed by professionals and a group of hobbyist programmers using enhances form of java. Android provides a lot of documented help for new developers.

The Android Software Development Kit (SDK) is a set of tools and APIs (Application Program Interface) that facilitates the development of Android application.

The Android SDK Manager provides an excellent feature to install API components according to the different versions of the Android OS with ease. Another key feature of SDK is that it provides the developers with Android emulator which ensures the developers to deploy their code and test its working on different virtual phones with different specifications.

To develop Android apps, set of tools are provided in Android SDK. Only after downloading and installing Android SDK these tools can be used from Eclipse IDE (Integrated development environment) through ADT plugin (Android development tools) or from command line. Google developed ADT plugin with a purpose of developing Android applications in Eclipse. Eclipse makes it very easy for all the Android developers to create the android projects and debug the programs whenever needed. Text editors cannot be used for large programs as it cannot highlight wrong spellings.

1.4.3 Prediction System

Data Mining is a concept of analyzing the collection of data and discovering the patterns in the large data sets including the methods in common of artificial intelligence, statistics, machine learning and database systems. Basic idea behind data mining is to extract information from the data and change it into understandable structure so that it can further be put into efficient use. Root of prediction systems is the data mining. Well structured data can be efficiently used by applying machine learning, statistical analysis, fuzzy logic, parallel grid computing *etc*. Data mining is all about processing large collection of data and determining the trends so that some information of interest could be obtained. Different techniques could be applied to get the relationships between the data.

In accordance with the problem system data is collected and machine learning concepts are applied to train the data to react to similar situations accordingly. Analysing the data from different perspectives so that it could efficiently used to get the speed of the vehicle on the basis of segment and the volume of traffic on it on different timings of the day and different days of the week.

Following are the different techniques used in data mining:

- Association: In order to identify the patterns a simple correlation between two or more items is established. Strong rules are discovered in databases on the measures of interestingness.
- Classification: It is the process of generalizing the given known structure so that it could also be applied to new data. Stored data is used to identify data in predetermined classes.
- Clustering: It is process of grouping the similar data without knowing the known structures in the data. It is the process where correlating results or data under similar conditions are clustered together.
- Regression: It is a process of identifying mathematical model between the dependent variables and the independent variables.
- Sequential Patterns: Data is mined to access the trends and behavior patterns. It tracks the occurrences of regular events to gain further benefits.
- Prediction: It is nearly used in every business. It is the collection of different data mining

techniques. Its main idea lies in the concept that by analyzing past events predicting the future can be easier.

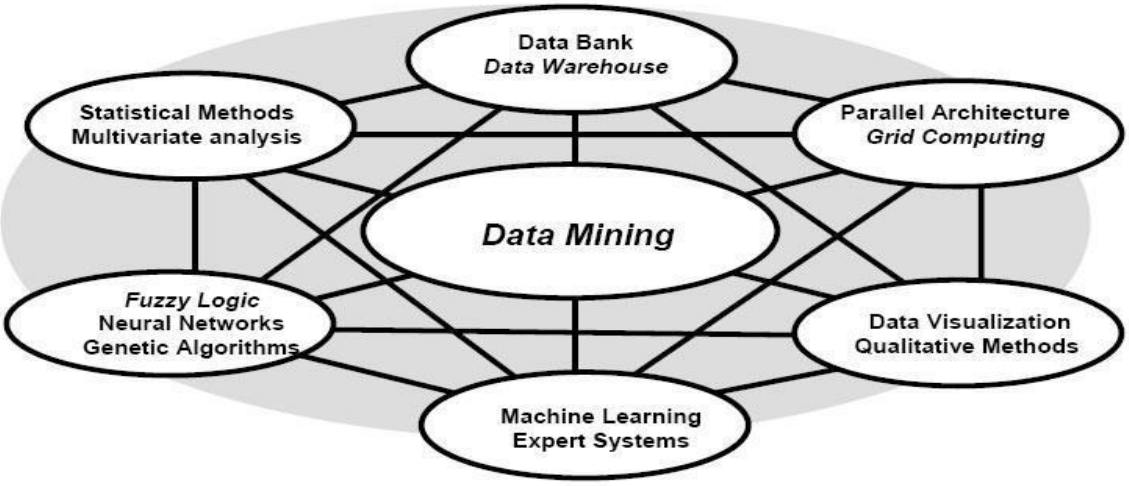

Figure 1.3: Applications and domains of data mining

1.5 Thesis Outline

This thesis has been divided into 6 chapters.

- Chapter 1 includes the introduction to GPS based vehicle tracking system. It also covers its applications and challenges.
- Chapter 2 describes the different approaches to get Vehicle arrival time like only GPS based, only prediction based or the combination of the two. It describes the various ways to get interface like LEDs, SMS, web or Android application. Also it explains hardware based systems using transmitters. It explains Historical based, Machine learning based, Support vector machine *etc.*
- Chapter 3 presents the problem statement, objectives and methodology for developing GPS based vehicle tracking system.
- In chapter 4, GPS based vehicle tracking systemhas been proposed. Algorithms to get the speed of the vehicle and the distance have been discussed. It also explains how the data collected can be efficiently used to get more reliable predictions.

- In chapter 5 results of the system have been discussed.
- Chapter 6 gives the conclusion and the future scope of the work done in the thesis

Chapter 2

Literature Review

2.1 Overview

Vehicle tracking system has been a part of Intelligent Transport system since 1970s but were hardware based which used sensors. Software based solutions which based their results by adding data mining techniques came in late 1990s. Adding traffic pattern increased the reliability. In 2000s GPS was started being used to track the real time location of the vehicle. Although the GPS was used even much before this but for aid of visually impaired.

Real time location based systems can also be standalone systems that displays the arrival time of the transit vehicle on the LCD screens that are placed on every stop, through SMS facility, web based application or by using android application using GPRS (General Packet Radio Service). Real time location based systems that displays the arrival time of the vehicle on LCD screens that are placed on every stop uses RF (Radio Frequency) transceivers. As the vehicle enters the range of reception the circuit gets active and its location is displayed on the LCD screen along with the vehicle number [1]. SMS (Short message service) is used over the GSM networks to transfer the vehicle location coordinates. The GPS receiver at the vehicle computes the longitude and latitude of the vehicle coordinates. This information is sent to the central server over the GSM networks using SMS and stored in the database. User sends the request and receives the information through SMS [2]. Through the web based application users can track the vehicle graphically using the web based systems also enables users with different operating systems platforms to easily reach the details with the help of internet access [3]. Vehicle tracking system using Android application uses the inbuilt GPS service provided by the Smartphone to get its GPS coordinates. These coordinates are transferred to the central server. Users can retrieve information through android application where users select the route number, vehicle number and receive the arrival time of the vehicle with respect to the user's current location instead of the stop [4].

Another type of vehicle arrival time system is based on prediction system. It is based on the large amount of collected data. Historical data based model uses the data from the previous journeys on the same route, same time and same day of the week with traffic conditions that follow the consistent pattern. This model is either based on average travel time or average travel

speed as given by Williams and Hoel (2003). Historical average travel time model use the historical average travel time by combining various inputs. Historical average speed model use the average speed of vehicles over segments to predict travel times [5]. Chien *et al.* (2002) stated time series model is based on the theory that either the factors acting from outside remain constant or can be measured if they vary with time [6]. Regression model finds the variable which depends upon the set of independent variables like speed be the dependent variable which depends upon the independent variables like volume of traffic, day and time as stated by Chien *et al.*(2002). Yang *et al.*(2005) used Kalman filtering model that considers the mathematical form of the linear state space equation and manage the traffic variations with time dependent variables [7]. Chen *et al.* (2004), Ramakrishna *et al.* (2006), Jeong (2004) came up using A system was proposed where advanced Artificial Neural Network model to dynamically predict the vehicle arrival time was used [8].Artificial Neural Network (ANN) model that tends to capture the complex non- linear relationship between the arrival time and the other variables that are independent [9]. ANN model was developed that outperformed the existing Multilinear regression model and historical data based models [10]. SVM and SVR (support vector regression) have outperformed time series analysis and statistical learning in Chun-Hsin *et al.* (2003). SVM have better generalization and gives global minima for data [11]. Bin *et al.* (2006) explained SVM as Neural Network algorithm to predict arrival time of the vehicle [12].

2.2 Real time location based system

Real time location based systems are used to track the current location and speed of the vehicle. Many real time tracking systems have been developed. Understated are some of them.

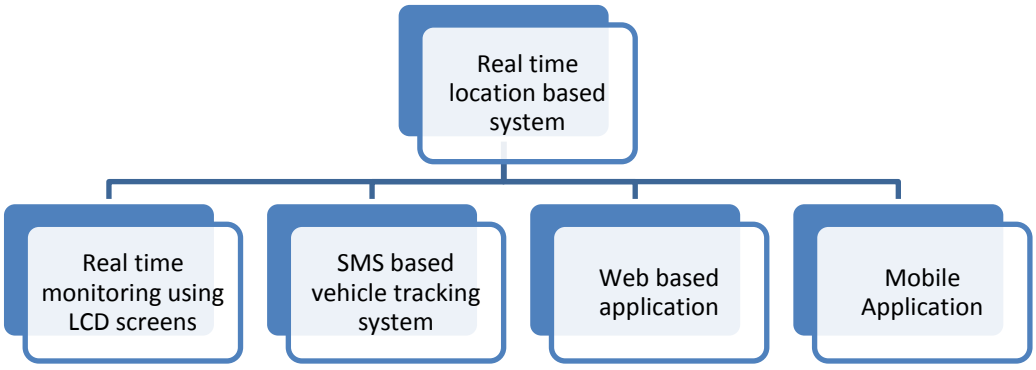

Figure 2.1: Various Real time location based systems

2.2.1 Real time vehicle monitoring system using LCD screens

The goal of the GPS based vehicle tracking system is to give a product that enables the passengers to decide whether to wait for the vehicle or take alternate transport. LCD screens were placed on the vehicle stops of the city that displays the vehicle number and the routes of the vehicle that are near the stop along with the time it will take to reach the stop. Vehicle routes will be illustrated on the map imposed on Plexiglas cover. LEDs are used to depict approximate geographic positions on this map where all stops are also marked. Following are the major modules of the system. Following are the major components of the system:

i) Transmitter module: GPS module is mounted on each vehicle and is able identify its location when any three GPS satellites triangulate and measure distance to the receiver. Information from all the satellites that triangulate is compiled to determine the location of the vehicle. Data from the GPS module is passed to the PIC microcontroller 18F4520 using UART serial link where processing is done to get the longitude and latitude. Transmitter polls a signal through a RF (Radio frequency) transmitter.

ii) Receiver Module: Receiver unit at each vehicle stop contains RF receiver and PIC microcontroller 18F4520 which receives the data through the RF receiver. To interpret the data programmable logic is applied. C/C++ is used for processing the data and the data is then sent to the LCD screens.

iii) Control module: This is a centralized system where GPS data from all the vehicles is collected to plot the locations of the vehicles on the map. After processing the data from the receivers, LEDs are illuminated corresponding to the coordinates received.

Figure 2.2 illustrates the architecture real time vehicle monitoring systems using LCD’s

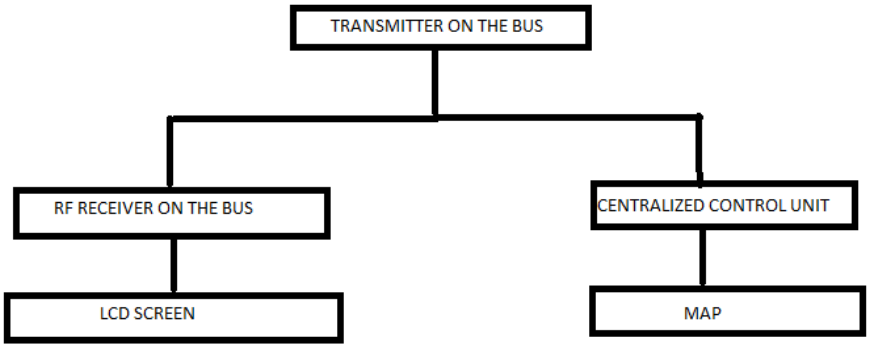

Figure2.2: Architecture of LCD based system

2.2.2 SMS based vehicle tracking system

Following are the major components of the system:

i) Vehicle module: GPS device is installed over the tracking vehicle. GPS works in any weather condition, anywhere in the world, 24 hours a day. GPS antenna is connected to the right jack to make sure it receives the signal. GPS device is turned on and tuned to receive signals from satellite. Device is capable of receiving longitude and latitude coordinates of the location.GPS data is regularly sent to the server using SMS service over the GSM networks. For this purpose SIM card is inserted to connect to the GSM networks. Server analyses the data.

ii) Server module: It manages and analysis the GPS data and manage the queries from the users. Initially a setup message is sent from the server to the vehicle module to set the time interval at which GPS data is sent. SMS enabler acts as the interface between the vehicle module and the server. PC suit is installed at server side. SMS enabler receives the SMS from the vehicle module and extracts the longitude, latitude values from the entire message and stores in the database.

iii) User module: Users send SMS to the server to retrieve real time location of the vehicle. Server side application processes the user's request and fetches the location name from the database for the corresponding vehicle number and sends a reply to the user. On server side initially user message is validated if its in a valid format with valid vehicle number. After this, request is processed and receives a reply from the server. There are two ways to send SMS from a computer to a phone. Firstly, by connecting a GSM modem to a computer, by applying AT commands GSM modem sends the SMS. Secondly, by connecting computer to the SMS center (SMSC) to send SMS using a protocol. SIM (Subscriber identity module) card is inserted in the GSM modem that is connected to the computer.

Figure 2.3 illustrates the architecture of the SMS based real time vehicle location system in which the following are the sequence of steps:

a) Server module sends requests to vehicle module to set up the time interval.
b) Vehicle module sets the time interval and sends the GPS information at regular intervals and stores in the database.
c) User requests the current location from the server module.
d) After verification, server module sends the location of the vehicle to the user.

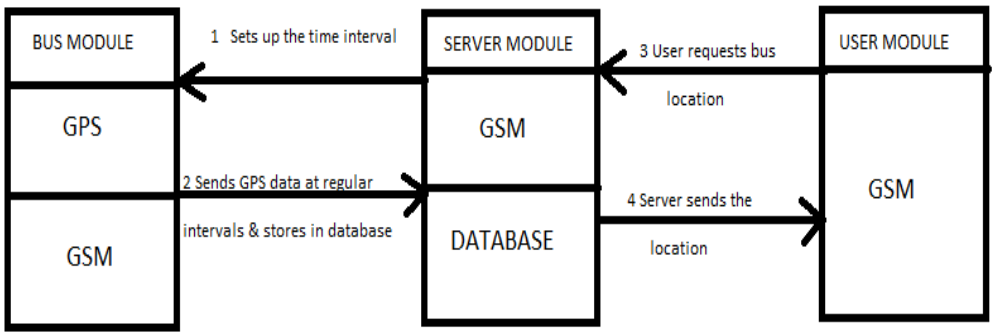

Figure2.3: Architecture of SMS based real time vehicle location system

2.2.3 Web based application

Web based application not only queries about the real time location of the vehicle but also can track the route on the map through the web application with the embedded Google-map and interacts with the database server for the track details. Web based application also enables users with different operating system platforms to easily query the real time location of vehicle using the internet access. The coordinates of the vehicle to be tracked is acquisitioned from the satellite using GPS receiver. Coordinates are sent to the server using GPRS service over GSM networks as a HTTP packet. Following are the major components of the system:

i) Web design: Overall functionality of the system is eased using various web application languages. Objectives of the web application are to define and manage all users' accounts and vehiclees account. Receiving the GPS coordinates and storing them in database corresponding to

the vehicle number. Replying to the client's request to get real time location of a particular vehicle number and displaying the route on the electronic map.

ii) Communication – Vehicle and server: GPS device on tracked vehicle queries the coordinates, satellite responds with string of data with longitude and latitude coordinates, speed, and time. Details are separated from the received data and the set of data along with the vehicle number are sent through the GPRS to the path defined in the URL using HTTP get method.

iii) Track Browsing: Map page consists of the embedded Google-map, two drop down lists for selection of vehicle number, route type. Through this page of application users and vehicle drivers can view track on map. By selecting vehicle number, route type and date, location will be displayed. For static tracking all locations in the track table corresponding to the vehicle number, route and date will be displayed on the map using colored markers and the lines connecting the markers from the start position to the last position. Whereas for the simulated tracking markers are added one by one at a time gap, say after 2 seconds of duration.

2.2.4 Mobile Application

Getting real time location of the vehicle has become very easy with the rapid increase in the use of programmable smart phones with built in GPS facility. The massive influx in the use of Android has made the system very user friendly. It has been observed that by using Android phones the acceptance to the system has increased enormously. Location Based services (LBS) are used by Android to get the real time location of the vehicle.

Following are the major components of the Vehicle tracking system using Android application:

i) Vehicle Tracker system: This is the android application that is installed on the smartphone that is placed on the vehicle that is to be tracked. This application provides the driver with the GUI where driver starts the tracking by selecting the vehicle number, Route number and clicks on "BEGIN TRACKING". With this web service gets to know that the vehicle with that vehicle number and route number has begun its journey. Once the initiation is completed Vehicle tracking system sends the location data (GPS coordinates) of the vehicle to the web service periodically after 6 seconds. With these frequent submissions web service is able to plot the vehicle on the maps correctly on the mobile application or the web application.

ii) Web Service: This service collects the information from all other systems like Vehicle tracker system, Web Application and Mobile Application. It keeps all the data and uses it in the most

efficient way. It provides ability to for multiple platforms to work together within or around the system.

iii) Web Application: This system provides the users with an interface where all the routes are present, with all the vehiclees on those routes. The system allows the users to select the route and the vehicle on that route. With this Web service provides the users with the current location of the vehicle on the Google Maps. The site is continuously updated by making AJAX calls to the web service to update the web map accordingly.

iv) Mobile Application: This system is installed by the users on their programmable Smartphone from the Android market. The application provides with user friendly interface where user selects the route number and the vehicle number from the drop down lists. With this request at web service is generated along with GPS location of the passenger. Location of passenger is tracked using Location Based Services. In response to this web service sends the detailed information in which the passenger might be interested in. The detailed information includes the vehicle's current speed, Distance between the current locations of the vehicle and the passenger and the time it will take for the vehicle to reach the passenger's location, the estimated time to reach the final destination.

Reference points are plotted along the routes and these points are put in correspondence to the coordinates on the Google Map. Sometimes the current GPS coordinates of the vehicle does not matches with the coordinates on the same route of the Google Map. In result of this when the vehicle's current location is mapped on Google Map it might be shown on the road but near it. To overcome this problem reference points are plotted along the route in corresponds to the Google Maps. With this GPS locations generated by the mobile devices are associated with its nearest reference point.

2.3 Prediction system based models

Data Mining is a concept of analyzing the collection of data and discovering the patterns in the large data sets including the methods in common of artificial intelligence, statistics, machine learning and database systems. Basic idea behind data mining is to extract information from the data and change it into understandable structure so that it can further be put into efficient use. Some of the data mining based vehicle tracking systems has been illustrated below.

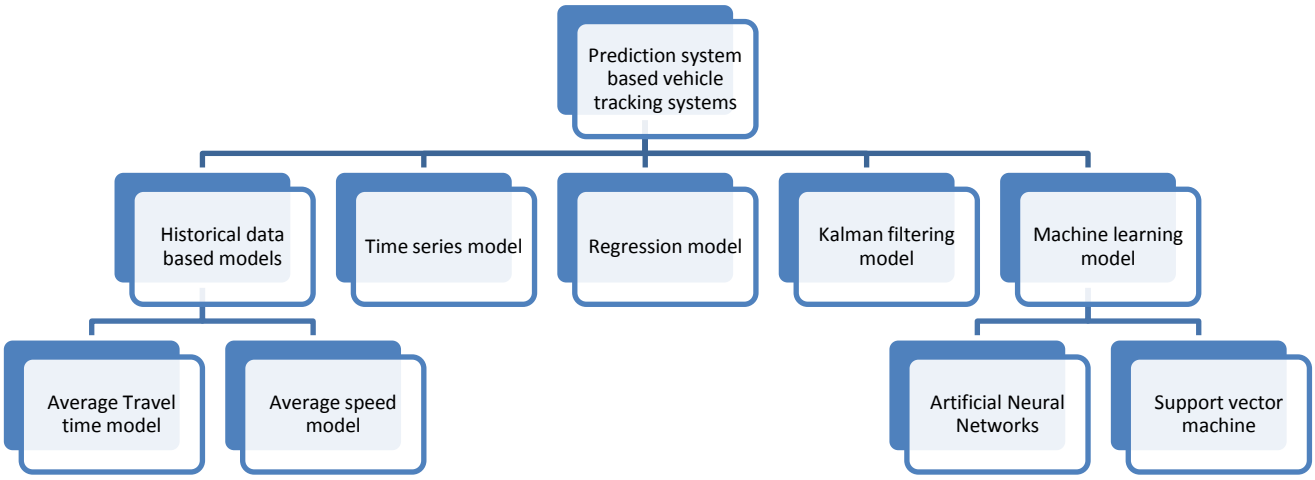

Figure 2.4 Various prediction system based vehicle tracking systems

2.3.1 Historical Data Based Models

This category of models predicts the future and the current vehicle travel time using the historical travel time of the earlier journeys under similar conditions. In such models traffic conditions are taken are stationary. Williams and Hoel (2003) stated that the consistent daily and weekly patterns of the traffic could be efficiently used to find the expected historical averages under the similar conditions like time and day of the week. The system said that the same could also be used to forecast the future traffic conditions under similar conditions like day of the week and the time of the day. Hence, such a system is used where the traffic pattern is relatively stable like rural areas.

Lin and Zeng (1999) developed four algorithms for the GPS data based vehicle arrival time system. The algorithms were based on historical data which was collected from the area with relatively stable traffic conditions like Blacksburg which is the rural area of USA. Different assumptions were used on input data in the four algorithms. It was claimed that the system outperformed several algorithms. Major inputs in the developed algorithms were Schedule information, Vehicle location data, waiting time at the time stops and the difference between the

scheduled and the actual vehicle arrival data. In these developed algorithms the traffic congestion and the dwell times were not considered as the system was developed for the vehicle in rural areas where the traffic is minimum. The performance of these systems was evaluated on the basis of the robustness, precision and stability. The difference between the predicted time and the actual time was used to calculate the precision of the system. The system was checked if the it would occasionally give the predicted time that is far off from the actual time. This was the measure of robustness. The system was checked if it provides the output which changes from time to time. This was the measure of stability. The algorithms were tested on the real time data and fourth algorithm was based on the inputs that were earlier mentioned and showed the best performance.

Historical data based models are most often used in combination with recently observed data to give real time information. Although variety of historical data models were introduced for the vehicle arrival time prediction but can be broadly classified into average travel time models and the average speed models.

2.3.1.1 Using Average Travel Time

Average travel time prediction model uses historical average time in combination with other inputs to give estimated arrival time of the vehicle. Jeong (2004), Shalaby and Farhan (2004), Ramakrishna *et al.* (2006), Vanajakshi *et al.* (2009) researches mostly used for comparison purpose. And in almost every research this was outperformed by respective main models. However this also outperforms some models like multilinear regression model as given by Jeong (2004), Ramakrishna *et al.* (2006).

Shalaby and Chung (2007) using explanatory variables developed Expected time of arrival (ETA) model. The stated model used input from two categories: previous few days historical data and the operational data of the current day. An additional feature of operational data was incorporated into the model to lessen the risk of overestimated arrival time that may result in missing of the vehicle. In the developed model most important constraint was the size of the historical data that is to be used in the model. The developed model was deployed on school vehicle. School vehicles run over the route only once in a day and the routes are also revised every year. Due to these the ETA system was chosen to apply on relatively smaller size historical data. As the Vehicle routes and the stops are fixed, ETA model uses the travel time between the

stops from the historical trends and the other correlated variables. In operational conditions weather conditions and schedule adherence were incorporated. Due to the stable conditions dwell time was not used in operational conditions. The performance of the system was evaluated from the data collected using real world operational school bus on which GPS based vehicle tracking system was installed. As mentioned in the research the proposed model showed consistently lower levels of error in the prediction system than the regression and the moving average approaches. Sufficiently reliable service was provided using the operational strategy in which 95 to 100% students did not miss the vehicle. The system was developed to get tolerable time of 162- 177 seconds. As discussed earlier, to develop a dynamic travel time prediction algorithm real time travel time can also be used along with average travel time.

2.3.1.2 Using Average Speed

To predict the travel times many models uses average speed of the vehicles over the route segments. These models are applicable where data collected from GPS system is used.

The distance between the links is calculated using the GPS technology. To estimate vehicle position and time to travel generally uses map matching techniques which can be established using Geographic Information System (GIS) software.

Weigang *et al.* (2002) developed a model that was implemented in SITCUO Information System for Urban Vehicle Transportation, in Brasilia. The developed system used the GPS information. The system comprised of three algorithms with one main algorithm and two sub algorithms. Main algorithm calculates the predicted arrival time and the two sub algorithms calculate the speed of the vehicle and the position of the vehicle. Following were the steps used in the system.

1) Route of the vehicle is divided into segments *i.e,* subroutes. These subroutes were first degree equation in plane. As the vehicle moves its position and the speed is sent to the control center. It is highly unlikely that the position of the vehicle will match the lines on the graph that shows the route. Due to this vehicle position is matches to the nearest point on the graph.

2) If the vehicle is stationary then its time to reach the vehicle stop will be infinite. To overcome this problem speed from the historical data was used. Hence the unique collaboration of the real time speed of the vehicle and the speed predicted from the historical data was done.

The results of the proposed system were satisfactory. 8% of the mean error between the estimated time and the actual time was found in the developed system. These errors could be further reduced if the number of points in the graphs were increased.

The similar model has later been developed with slight modifications by Sun *et al.* (2007). The proposed system efficiently combined the real time data that is retrieved using GPS receivers with the average speeds along the route segments from the historical travel speed data collected over temporal and spatial variations of traffic.

Weigang *et al.* (2002) stated that estimated average speed would mainly depend on its historical average speed when the vehicle is far from the station. Whereas Sun *et al.* (2007) stated that current speed of the vehicle is the major factor influencing the average speed of the vehicle over the route. The system comprised of two main components. The first component was the real time vehicle location tracker system which processes the GPS data and also projects the location of the vehicle on the electronic map. Also obtains the distance to each vehicle stop. The second component was the prediction system to find the predict the time to downstream vehicle stop in real time on the basis of the other component. To ensure stability, regularity and robustness the system was developed as a finite state machine. To evaluate the performance of the proposed system a case study on a real vehicle was conducted. The results of the implementation were satisfactory and the performance was perfect in predicting the travel direction. However on deploying it was found that the model performance was low during peak hours. This was so because during peak hours there were high variations in traffic conditions and thus speed is reduces when congestion increases. This system showed better accuracy than the algorithm proposed by Weigang *et al.* (2002).

Mostly, historical data based models uses large amount of data. But in practice it might not be available especially in the case where traffic varies stochastically. These systems are not used in areas where traffic pattern varies largely like in large cities or where dwell time varies greatly. The accuracy is calculated by finding the similarity between the historic patterns and the real observation.

2.3.2 Time Series Model

These models are based on the theory that exogeneous factors either remain constant or can be measured, if they vary in time. In this model it is assumed that traffic pattern remains consistent.

Chien *et al.* (2002), research says that the similarity between the historical traffic patterns and the real times gives the accuracy of the system. Variations in the relationship between real time data and historical data and changes in the historical travel time, are the major reasons of inaccuracy in the predicted results. This model is not used for predicting travel time of the vehicle. However, It has been used in predicting traffic volume and link travel time. It might also be used in combination with other models like Kalman filtering as stated by Al-Deek *et al.* (1998), Thomas *et al.* (2010).

2.3.3 Regression Model

Mathematical function is defined by a set of independent variables that predicts the dependent variable as used by Chien *et al.* (2002). These models work efficiently under unstable conditions unlike the historical data based models. Regression model considers the simultaneous effects of various independent factors that affect the dependent variable. Data collected by automatic passenger counter (APC) used to predict the arrival time by a set of multilinear regression model in a system proposed by Patnaik *et al.* (2004). Various independent factors like number of stops, distance, alighting passengers and weather descriptors were used in the system. However, this approach is efficient and reliable only if such equation between these factors could be established. Jeong (2004) and Ramakrishna *et al.* (2006) developed multilinear regression model but with different sets of independent inputs. Studies explain that other models outperforms the regression models. From the mathematical function established between the independent variables explains which variable is of greater impact. For example, Patnaik *et al.* (2004) explained that weather conditions was not important factor in their proposed system. Ramakrishna *et al.* (2006) proposed a system where it was discovered that intersection delays and the dwell times are less important factors. Regression models also explains the directly or inversely proportionality of the independent variable on the dependent variable. regression models are less applicable as factors affecting the ouput are highly correlated.

2.3.4 Kalman Filtering Model

Kalman filtering models uses sophisticated mathematical representations like linear state space equations and has the capability to accommodate traffic variations with time dependent

parameters (e.g. Kalman gain). Chen *et al.* (2004), Wall and Dailey (1999), Chien *et al.* (2002), Vanajakshi *et al.* (2009), Yang (2005) researches tell that it is exclusively used for predicting vehicle arrival time. Main objective is to get the estimation about the current state of the system. It has the strength to filter noise as suggested by Kalman (1960), Lesniak *et al.* (2009), Thomas *et al.* (2010). It forms the basis for predicting future values by improving estimates of variables.

Yang (2005), Wall and Dailey (1999) proposed an algorithm by integrating real time data with historical data for predicting the arrival time of the vehicle. Data source was from Seattle, Washington. The system had two major components: prediction and tracking. Kalman filtering was used for tracking and statistical estimation for vehicle arrival time prediction. As the system included both the real time location data along with the historical data, it was assumed that other variable like mentioned in Tu (2008) were implicitly included in the data statistics. Due to this independent variable like dwell time was not explicitly used. Empirical results showed that the results of the proposed algorithms were satisfactory and flexible enough to handle adverse conditions. Also, produced the results that were useful for the travelers. The system was checked with highaccuracy and notified with less than 12 % error ,*i.e.*, if the predicted time 20 minutes, 72 % of the vehicles would arrive between 18 and 22 minutes. The system was deployed using a web application to provide users with estimated arrival time of the vehicle.

Shalaby and Farhan (2004) described a system using Kalman filtering technique. Data source was from the four vehicles in downtown Toronto which were installed with AVL (Automatic vehicle locator) and APC (Automatic Passenger counter). Data was collected during weekdays in May 2001. Four fifth of the data was used for developing the model and rest for testing. Two Kalman filtering algorithms were developed. One for predicting the arrival time and another for calculating dwell time. In the system as the historical average model, time recurrent neural networks, regression model was developed dwell times between the links were also included. Distance between two references points were defined as a link. Each link included 2 to 8 vehicle stops. Dwell times were only considered at reference points, not at each vehicle stop. For real time model, predicted time of vehicle arrival and other information like departure time at the check points were updated at the check points. The route included 27 vehicle stops but 6 check points. Hence, the information updated 6 times. It was claimed that Kalman filtering

models performed better than historical average techniques, regression models in terms of precision, stability, accuracy, performance and ability to show its dynamic nature.

Chien and Kuchipudi (2003) used Kalman Filtering model for predicting vehicle arrival time. The developed system used real time and prediction system as two components. Kalman Filtering model was used because of its capability of continuously updating variable with new observations. The study focused on comparison between link based travel time prediction and path based travel time prediction system. Results showed that during peak hours path based prediction was better than link based prediction due to larger sample variance and smaller variations in travel time. The advantage of applying historic average data on link based system is more but at the cost of accuracy in congestion situations.

Yang (2005) concentrated on observing and working under congestion after special events like concerts, matches. A case study was conducted after the graduation ceremony using Kalman filtering techniques. GPS system were installed on the transit vehicles to get the real time data and the predicted arrival time was evaluated from the previous time instant. The performance was evaluated on the basis of mean absolute relative error. The results shown were satisfactory. Prediction error was observed to be 17.6 %. Such high error rate was also acceptable as the system developed included many uncertain factors like weather, traffic, delay time at the signals.

Vanajakshi *et al.* (2009) developed a system using Kalman filtering algorithm under stochastic traffic conditions in urban areas of the city Chennai, India. The motivation for basing the system was that data is collected in such studies from homogeneous lane disciplined traffic, either directly or from the simulation models. The important and unique feature of the system developed was the discretization was performed over space instead of time. Such feature was efficiently used to consider the conditions like accidents in the previous subsection. The results were promising. The system outperformed the average approach over 8 days out of 12 days.

Kalman filtering algorithms give better results for providing dynamic travel time estimation.

2.3.5 Machine Learning Models

Machine Learning methods have the following advantages over statistical methods:

1) These handle the complex relationships between the variables that have the impact on prediction.

2) These models have the capability of handling the non linear relationships between the predictors and also the noise data as given in Ricknagel (2001).

3) These models could also be used for vehicle arrival time prediction where the traffic processes are implicitly handled as suggested by Hoogendoorn and Van Lint (2008).

However, these provide the location specific solutions that require efforts in input and model selection for each application like instance correlation analysis, trial and error procedures or genetic algorithms. Results from one position are not transferrable to another due to location specific situations (traffic control, geometery *etc*). Support Vector Regression (SVR) and Artificial Neural Networks (ANN) are presented under this category.

2.3.5.1 Artificial Neural Network Model

Chen *et al.* (2004), Jeong (2004), Chien *et al.* (2002), Park *et al.* (2004), Ramakrishna *et al.* (2006) developed models using ANNs which are gaining popularity in vehicle arrival time prediction systems as it has the capability to solve complex non linear relationships. ANNs are inspired from the data processing capability of human brain. ANNs are constructed with multiple layers of processing units called as artificial neurons. These neurons contain linear or non linear functions. Synaptic weights are used between these highly interconnected neurons. Processing of information is done either in forward direction or feedback direction. These are connected in partially or fully connected topologies. To map the input- output relationships synaptic weights are adjusted automatically through a learning process as developed by Hagal *et al.* (1996). Chien *et al.* (2002) proposed an advanced Artificial Neural Network model to dynamically predict the vehicle arrival time. Back propagation algorithm was used in the system. The system was inspired from the fact that ANNs take long learning which makes it hard to apply online. As a result a new system with adjustment factor was introduced that enabled it to modify predicted vehicle arrival time with new values of real value of data. New inputs like traffic volume and passenger count are done using Corridor Simulation Model (CORSIM). It was observed that Automatic Passenger Counters (APC) has to be integrated with Vehicle arrival systems to practically deploy it. In this system dwell time was not considered. Results were checked using

simulation model. The results were satisfactory and results claimed that the system worked well for both single and multiple stops.

Chen *et al.* (2004) came up with a concept of predicting vehicle arrival time based on data collected from Automatic Passenger Counter (APC). ANN was used to prdict the arrival time of the vehicle between time points whereas Kalman filtering technique for dynamically handling estimated arrival time using current location of the vehicle. The system was trained using various input variables like day, time of the day, segment number, weather conditions. The dynamic algorithm using Kalman filtering algorithm was integrated with recent vehicle location information. Real time APC was also used along with explicitly considered predicting variables. The system showed promising results in handling variations in estimated time along the route of the vehicle. It was also concluded that dynamic algorithm outperformed ANN because it also included the latest location information.

Jeong and Rilett (2004) developed an ANN model and outperformed the existing Multilinear regression model and historical data based models. Historical data based showed better performance than multilinear regression. Authors tested l2 and l4 training functions and prediction system chose the best out of the available. The system developed had many advantages as it included dwell time, traffic congestion, schedule adherence as predicting variables.

Ramakrishna *et al.* (2006) developed a model which used both Artificial Neural Network (ANN) and Multiple Linear Regression (MLR) model for estimating arrival time of the vehicle using location information. The model was deployed to a case study which included a route in Chennai, India. The research proved that performance of ANN was better than Multiple Linear Regression Model.

To conclude it can be said that ANNs has the capability to handle the complex non linear relationships between estimated arrival time and independent variables. ANNs has been proved to perform satisfactorily for estimating the arrival time of the vehicle. These models are most useful when it is nearly impossible to form a mathematical function to get relationship between inputs and outputs. Although the process of learning and testing is slow and delicate to get the optimal solution as given by Hagal *et al.* (1996), still possible to do training off-line and adopting ANNs to real time conditions provided the inputs are carefully chosen.

2.3.5.2 Support Vector Machines

Support Vector Machiness (SVMs) is a set of supervised learning methods that are used for Regression and classification. Wheras, other machine learning techniques like ANN have been studied thoroughly. The applications reported in transport engineering of Support vector machines are very less. Chun-Hsin *et al.* (2003) showed that Support Vector Regression (SVR) and support vector machine have proved their success in statistical learning and time series analysis. Support vector regression performs better for time series analysis as support vector machines have the ability of generalization and also guarantees global minima for training data.

Chun-Hsin *et al.* (2003) proposed a model for the estimation of the vehicle arrival time on highways or freeways. The results were compared to other baseline predictors and it was conclude that support vector predictor can lessen the root mean squared errors and the relative mean errors.

Bin *et al.* (2006) proposed new algorithm for predicting arrival time of vehicle using support vector machine as a artificial neural network. The system came up with a fact that support vector machine is not amenable to the problem of overfitting as the traditional ANNs were. Support vector machine is trained through optimization process. The system was based on the theory that predicted arrival time is based on the travelling time of the current link and the latest travelling time of the next link. Separate models were also introduced which included weather conditions and time of the day as input variables. The model explained was tested on offline data of the route. The model also exhibited many advantages over ANN based model. The authors indicated that on large size problems when support vector machine is applied, a larger computation time will be involved. In addition to this functions and models to select the input predictors and identifying the parameters is of major concern and needs further research.

Chapter 3

Problem Statement

GPS based vehicle tracking system provides an opportunity to the traveler to track the current location of the vehicle and get the time it will take to reach the transit traveler. The system not only estimates the arrival time of the vehicle in accordance to real speed of the vehicle but also takes into consideration traffic on the route. This system helps the passengers to make better travelling decision as passengers can decide if should wait for the vehicle or not in accordance to the estimated arrival time. From this system passenger can also determine if the vehicle has been missed or yet to come. The system provides the basic information which is necessary to make day to day life more efficient. The system can be used for tracking the school vehicle.

Android is at its pick of success not only amongst the youth but entire community. Android Application that meets the user's need has become a key idea with the rapid growth and huge advances in Android. Android device has become a powerful device which provides much more than basic facilities. Therefore, aim is to provide an android application which locates the real time location of the vehicle on the map and gives the arrival time of the vehicle to the passenger.

3.1 Objectives

For GPS based vehicle tracking system following objectives have been framed.

- To understand the working of the GPS based vehicle tracking system and the models and the methodologies that have been used.
- To propose GPS based vehicle tracking system which estimates the arrival time of the vehicle at the passenger side using the android architecture.
- To develop the system under client server architecture where vehicle module periodically sends the location data to the server side where arrival time of the vehicle is estimated and sent to the passenger module.
- To not only base the system on real speed of the vehicle but also integrate the data mining techniques to on the traffic dataset to compute the predicted speed of the vehicle.
- To test and validate the proposed GPS based vehicle tracking system.

3.2 Methodologies

To obtain the objectives as mentioned in section 3.1 following methodologies have been adopted.

- Literature survey has been carried on the basis of existing approaches like systems based on real time location based vehicle tracking system and different prediction systems for predicting traffic and calculating arrival time of the vehicle.
- For GPS based system in android architecture entire developing environment with Android SDK and ADT tools are downloaded and installed.
- Vehicle module periodically sends its location information at the server side. Passenger sends its request for particular vehicle tracking to the server side. Server side compute the time it will take to reach from vehicle's current location to the passenger's current location.
- For taking into consideration the traffic, its pattern is observed from historically collected datasets and applying mining techniques. For applying data mining techniques entire route is divided into segments of 100 meters and pattern is observed individually at different time and day of the week.
- Testing and validation is done at Thapar vehicle tracking system which has been carried out as a part of the case study of the thesis.

Chapter 4

Implementation

4.1 Architecture of the Proposed System

The idea of the proposed system is to track the vehicle and get the arrival time of the vehicle on the basis of speed with which the vehicle is moving and the average velocity from the historical trends under same day and time of day conditions. The architecture of the proposed plan is as shown in figure 4.1.

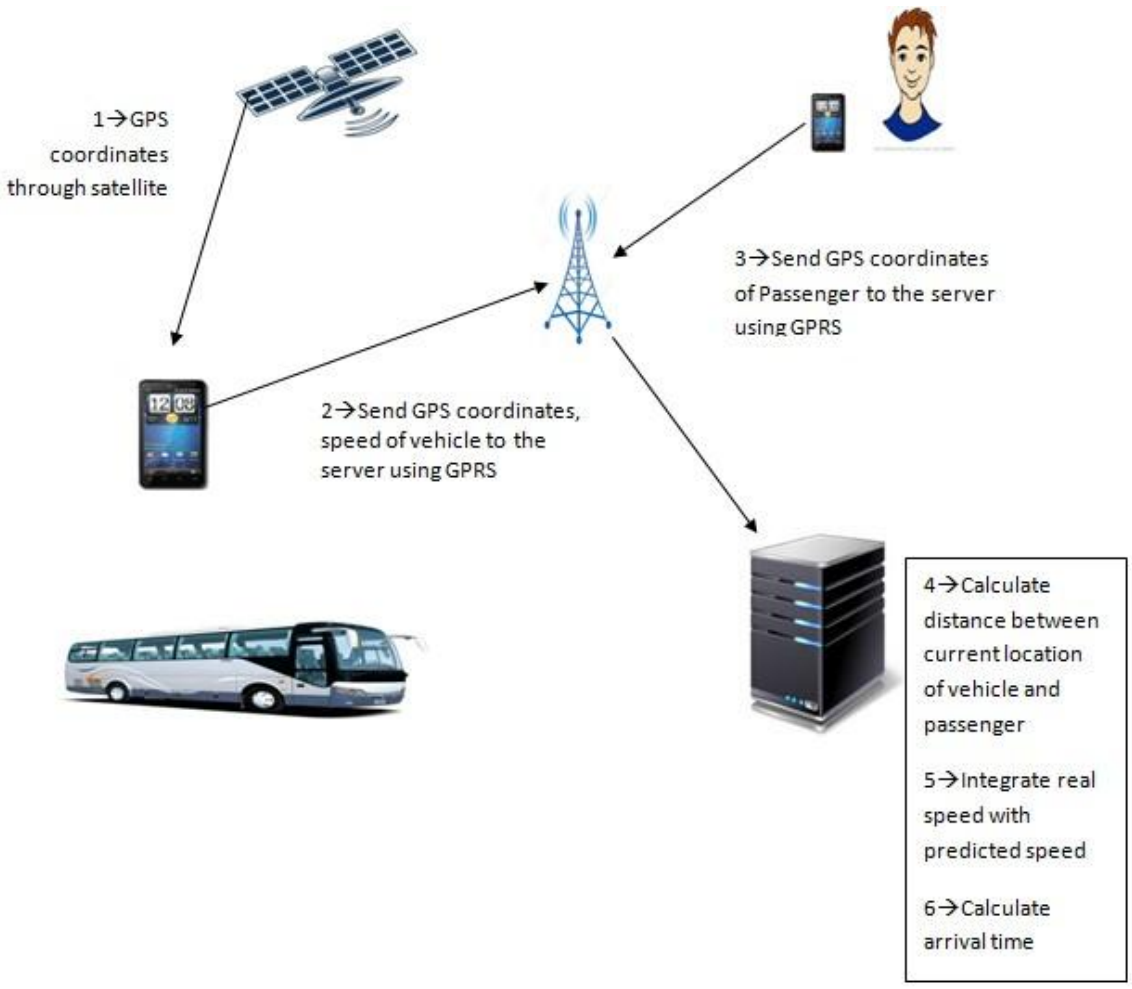

Figure 4.1: Architecture of the proposed system

The proposed system is based on the client server technology, which consists of two types of client side application and the server side. The drawbacks of both the parts have been taken into account during development. Two client side applications are vehicle module and passenger module. Android application is to be developed for client sides as android applications are at its peak and user friendly. The proposed system is divided into following two subsystems.

- GPS based system that tracks the current location of the vehicle and the passenger to calculate the distance between the same. Also tracks the real time speed of the vehicle.
- Prediction system that calculates the average velocity of each segment from the data that captures the historical trends of traffic on the basis of different attributes like segment, day, time, volume of traffic and crossings in the segment.

4.1.1 GPS Based System

GPS based system accounts for GPS based current coordinates of the vehicle and the passenger and the real time speed of the vehicle**.** GPS based system is further divided into following three modules.

- Vehicle Module (Module 1) gets the current GPS coordinates in terms of Latitude and Longitude of the vehicle. Also calculates the speed with which the vehicle is moving.
- Server Module (Module 2) takes the information from Module 1 and Module 3 to find vehicle and Passenger's exact location on the route and distance between the two.
- Passenger Module (Module 2) finds the current location of the passenger in terms of Latitude and Longitude and sends request to the server for the arrival time of the particular vehicle.

4.1.1.1 Vehicle Module

Vehicle Module is the client side of the android application. This application is installed on the Android platform smart phone which is placed on the vehicle whose position is to be tracked. The Requirement for this application is GPS and GPRS. In the beginning of the route, vehicle driver initializes the application with the route number, direction and the vehicle number. Once

this initialization is done it initializes the server side with this route number and vehicle number. This application uses Location based services (LBS) to get the current GPS location of the Vehicle. Location services automatically maintain the user's current location, so application has to retrieve it as needed. Accuracy of the location depends on the location permissions that have been requested and the location sensors that are currently active for the device. Once the tracking has been initiated Vehicle module submits its coordinates frequently, every 6 seconds to the server. These frequent submissions are used to track current location of the vehicle on the route. Mathematically module 1 is represented as follows:

System S=Android Application for vehicle module

System $S_1 = \{S_1', I, \delta, O\}$ …(4.1) In (4.1) system is represented in the form of input, transition function and output.

$S_1' = \{GPS, GPRS\}$ …(4.2)

In (4.2) Vehicle module uses GPS and GPRS to communicate with the server.

I = {Vehicle Route, number} …(4.3)

In (4.3) Vehicle number and Vehicle route is entered by the driver to initialize the system at server side.

$\delta \rightarrow$ {Function to determine current GPS location using Location based services} …(4.4)

In (4.4) Using location based services GPS location of the vehicle and the speed with which the vehicle moving is calculated.

O = {Latitude, Longitude, Speed} …(4.5)

In (4.5) the output is the location in terms of longitude, latitude and the speed is sent to the server side.

4.1.1.2 Passenger Module

This module is a client application. This android application is installed by the passenger who wants to track the location of the vehicle and get its arrival time. The basic requirement of this application is the GPS and GPRS. This application uses Location based services to get the passenger's current GPS coordinates. These coordinates are sent to the server side where it is

coordinated with the nearest vehicle stop because the vehicle will stop only at vehicle stops. The arrival time is predicted with respect to the distance between the vehicle's current location and the passenger's nearest vehicle stop. The passenger selects the Vehicle number from the drop down and request is sent to the server. After processing server sends the arrival time also passenger can locate the vehicle's current location on the map. Mathematically the module can be represented as under:

System S_3=Android Application for Passenger Module

System S_3={S_3', I'', δ'' , O''} …(4.6)

In (4.6) Passenger module is represented in the form of input, transition function and output.

S_3' = {GPS, GPRS} …(4.7)

In (4.7) Passenger module uses GPS and GPRS to communicate with the server.

I'' = {Vehicle Route, Vehicle number} …(4.8)

In (4.8) Passenger enters the vehicle route and the vehicle number of the vehicle whose location is to be tracked.

δ'' →{Function to determine current GPS location using Location based services and sent to web service} …(4.9)

In (4.9) Using location based services GPS location of the passenger is calculated.

O''={Distance, Arrival Time of vehicle} …(4.10)

In (4.10) the output is the vehicle arrival time and the distance between the vehicle and the passenger.

4.1.1.3 Server Module

This module is the server side of the android application where most of the processing is done. Web service is used that facilitates the submission and request of information to the database server. MySQL server 5.6.23 is used where tables for all the routes are present. Each table comprises the *Coordinating point, Latitude, Longitude, Distance and Direction*. Points are set up along the route at the distance of 100 meters or at the vehicle stops, whichever is closest. These coordinating points are essential for easy calculation of the distance between the vehicle and passenger and results in increase in accuracy. Google maps were used to plot the location of the

vehicle, but sometime plotting the real time GPS generated coordinates were inconsistent with the Google map road structure. To overcome this problem Coordinating points were inserted along the route. Vehicle's current real time coordinates are sent to the server where it is matched with the nearest coordinating point laid on the Google map. This increases the accuracy in the depiction of the real time location of the vehicle on the map at passenger side application. Also calculation of the distance has become more efficient. When database is prepared, along with each coordinating point number and respective coordinates, its distance from the next coordinating point is depicted. If distance between coordinating point 1 and 5 is to be calculated then using database query *Distance* from the coordinating point 1 to 4 is added. With the use of coordinating points it can also easily be found if the vehicle has been missed or still to come[13]. Also by using the *Direction* of the vehicle as major component, the size of the database is reduced to half. Instead of creating different tables for routes from coordinating point 1→ 35 and 35 →1, only one table could be used for both.

System S_2 = Server side

System $S_2' = \{S_2', I', \delta', O'\}$ …(4.11)

$S_2' = \{$ Internet, Database server$\}$ …(4.12)

$I' = \{$ Longitude, Latitude, Speed, Route, Vehicle number$\}$ …(4.13)

$\delta' \rightarrow$ Cal

Let, $F(M) = \sum_{i=1}^{n}$ Cal …(4.14)

In (4.14)

Cal = {R, Dist, V_a} [R = Routes, Dist = Distance, V_a = Average velocity] …(4.15)

In 4.15

R = {R1, R2, R3, ……..,Rn} …(4.16)

In (4.16) set of routes are represented where GPS based vehicle tracking system is deployed.

R1 = {Source, L1, L2, L3,……..,Ln} …(4.17)

where L1,L2,L3…….Ln are intermediate Geographical points

In (4.15) Dist = {D1, D2, D3,……,Dn} …(4.18)

In (4.18) D1, D2, D3……Dn are distances between the geographical points

In (4.15) V_a= Average velocity

Time = Dist / V_a …(4.19)

O' →{Dist, Time, average velocity of the current segment} …(4.20)

In (4.20) Distance, Time and the average velocity is the output.

4.1.1.4 Distance calculation formula

The distance between two is calculated as the sum of the distance between the two coordinating points and the distance between the vehicle and it's nearest coordinating point. Distance between the two coordinating points is easily and efficiently calculated from database. While the distance between the vehicle and its nearest matched coordinating point is calculated using Haversine formula. Haversine formula calculates the distance between the two pairs of longitude and latitude considering in mind the spherical shape of the earth. Haversine formula ignores the ellipsoidal effects and gives computationally and mathematically exact results. Haversine formula is illustrated as in (4.21).

$$distance = Radius * c \quad \ldots(4.21)$$

In (4.23) radius = radius of earth, 6371 km

$$c = 2 \times b \ \tan^{-1}(\sqrt{b}, \sqrt{(1-b)} \quad \ldots(4.22)$$

$$b = \sin^2\left(\frac{lat}{2}\right) + \cos(lat1) * \cos(lat2) * \sin^2(\frac{lon}{2}\ ) \quad \ldots(4.23)$$

Here in (4.21)

lat=difference in latitude= lat2-lat1

lon=difference in longitude= lon2-lon1

4.1.2 Prediction System

Data Mining is a concept of analyzing the collection of data and discovering the patterns in the large data sets including the methods in common of artificial intelligence, statistics, machine learning and database systems. Basic idea behind data mining is to extract information from the data and change it into understandable structure so that it can further be put into efficient use. Root of prediction systems is the data mining. Well structured data can be efficiently used by applying machine learning, statistical analysis, fuzzy logic, parallel grid computing *etc*. Data mining is all about processing large collection of data and determining the trends so that some

information of interest could be obtained. Different techniques could be applied to get the relationships between the data.

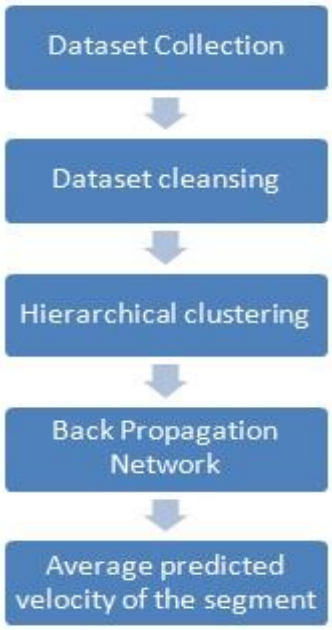

Figure 4.2: Architecture of the prediction system

Working of the proposed prediction system as shown in figure 4.2 is illustrated as follows:

i. Data from the field is collected. Attributes like Day of the week, time of the day, volume of traffic, number of crossings and average speed were considered for each segment.
ii. Invalid data like Null values or wrong coordinates are removed.
iii. Clustering is done on the data. Hierarchical clustering is used as it gives better results in case of the proposed system.
iv. Back Propagation Neural Network is applied on each cluster. By applying BP Neural networks system is better trained. This further gives us better results.
v. When Input stream is fed, particular cluster is recognized.
vi. For this cluster average speed is calculated. This speed is called predicted speed.

4.1.2.1 Hierarchical Clustering

Clustering is the process of grouping the similar data without knowing the known structures in the data. It is the process where correlating results or data under similar conditions are clustered together. Following are the steps conducted in hierarchical clustering:

Strategies for hierarchical clustering are as follows:

- Agglomerative: It is a "bottom up" approach. Each observation starts with a single object and pairs up objects or clusters as moves up in hierarchy.
- Divisive: As the name suggest it is a "top down" approach. All the objects are in one cluster and the clusters are split iteratively as moves down the hierarchy.

For the implementation of GPS based vehicle tracking system, Agglomerative technique is used. The following steps are taken for hierarchical clustering on the given dataset.

i. Let $X = \{x_1, x_2, x_3, ..., x_n\}$ be the set of data points.
ii. Begin with the disjoint clustering having level $L(0) = 0$ and sequence number $m = 0$.
iii. Find the least distance pair of clusters in the current clustering, say pair (r), (s), according to $d[(r),(s)] = \min d[(i),(j)]$ where the minimum is over all pairs of clusters in the current clustering.
iv. Increment the sequence number: $m = m + 1$.Merge clusters (r) and (s) into a single cluster to form the next clustering m. Set the level of this clustering to $L(m) = d[(r),(s)]$.
v. Update the distance matrix, D, by deleting the rows and columns corresponding to clusters (r) and (s) and adding a row and column corresponding to the newly formed cluster. The distance between the new cluster, denoted (r,s) and old cluster(k) is defined in this way: $d[(k), (r,s)] = \min (d[(k),(r)], d[(k),(s)])$.
vi. If all the data points are in one cluster then stop, else repeat from step 2.

In agglomerative hierarchical approach, initially each object exist as a cluster and then combining of clusters takes place at each step. Following are the combining methods

- Single Linkage (Minimum Distance)
- Complete Linkage (Maximum Distance)
- Average Linkage (Average Linkage)
- Centroid Method

- Ward's Method

In the proposed system single linkage combing method is used. In general splits and merges are conducted in greedy manner. Agglomerative clustering has the complexity of $O(n^3)$. Least complexity is $O(n^2 logn)$. Due to this reason for large data it becomes slow. Divisive clustering has complexity of $O(2^n)$ which makes it even worse.

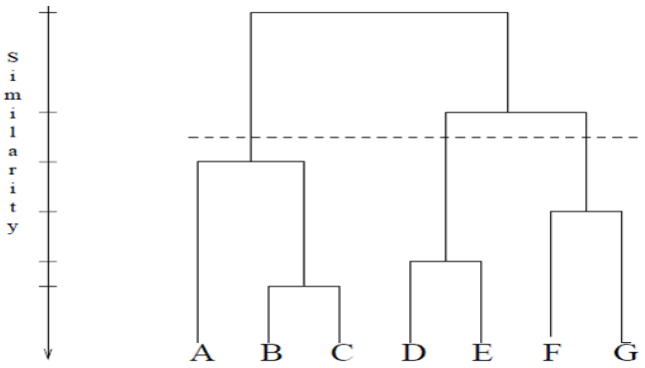

Figure 4.3: Showing how cut is introduced at a gap

4.1.2.2 Artificial Neural Network (ANN)

Average learning time for Artificial Neural Networks is very high. To overcome this problem Back Propagation (BP) Neural Network is opted. BP neural networks consist of three layer main layers, input layer, hidden layer(s) and output layer. Each layer consists of A,B and C nodes respectively in each layer. The W_{ab} are the synaptic weights from input to hidden layers and W_{bc} from hidden to output layer. In this system adaptive neural networks which consists of many neural networks is used. The number of neural networks is equal to the number of clusters centers. Each cluster H is associated with the H^{th} back propagation (BP) network. For every cluster learning data is fed to each H^{th} Back propagation neural networks (BPN).

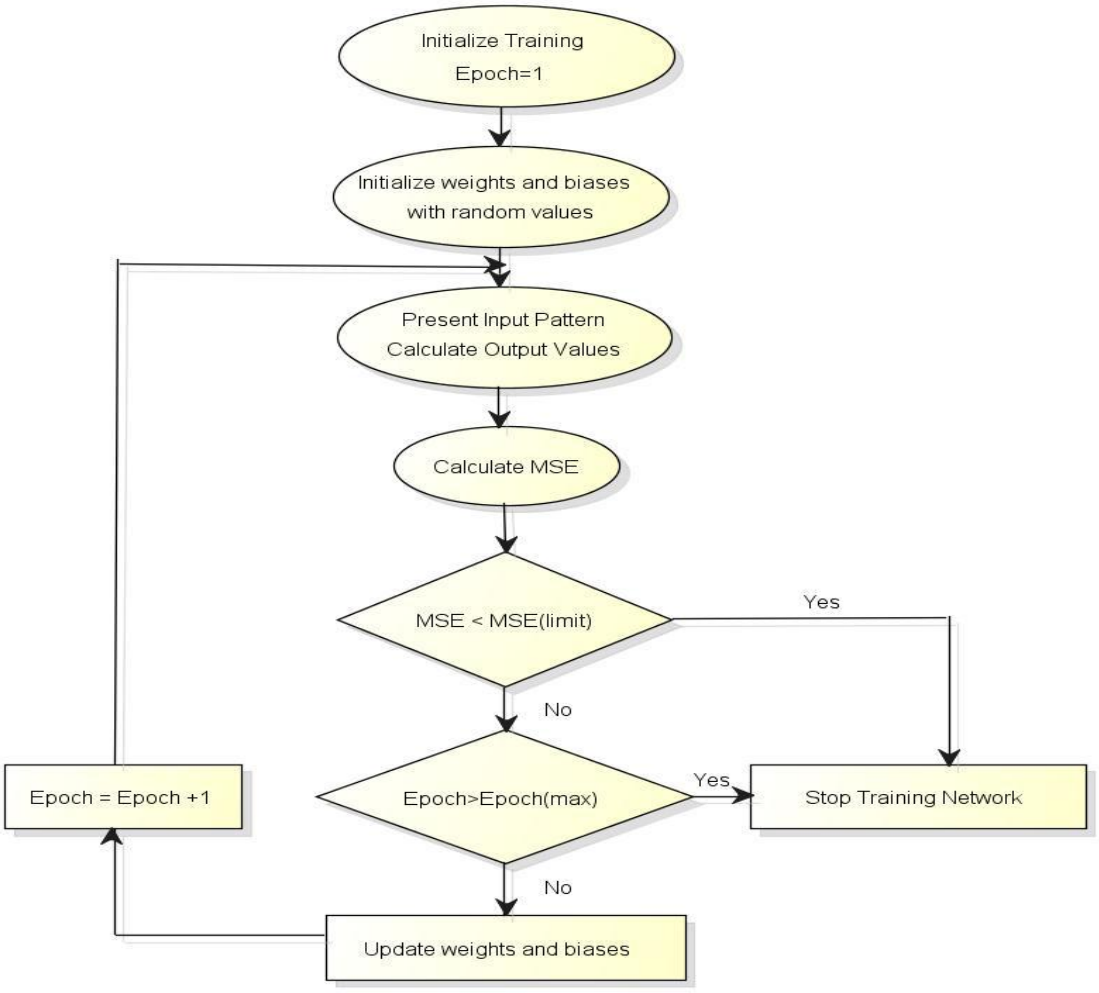

Figure 4.4: Working of Back propagation network

Following steps are done for each Back Propagation Neural Network:

- All the weights are initialized to some small number somewhere between(-1 to 1).
- Give the input pattern for which the output is calculated. This is called forward pass. But the output observed is much different from the one that is targeted as the weights taken were random.
- Calculate the error for each neuron, where error is calculated as difference between actual and target value.

  $Error = Target - Actual$ …(4.24)

- Error is used to change the synaptic weights in accordance to the way that reduces the error. This will bring each neuron towards its target value. This is called reverse pass. This process is carried in loop until error becomes minimal.

Principle of BP Neural network is motivated from Widrow—Hoff delta learning rule where weight adjustment is done by mean square error of the output to the input.

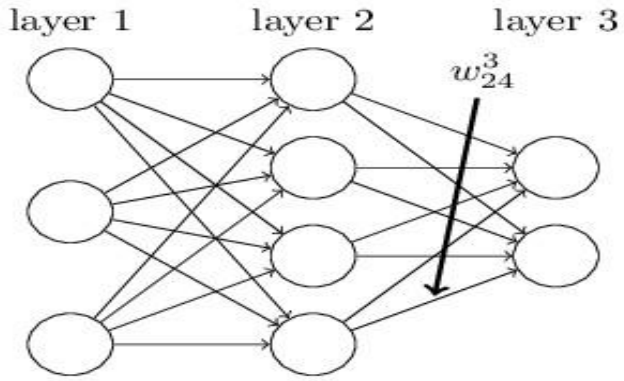

Figure 4.5: Showing Neural network

In Figure 4.5 layer 1 is the input layer, layer2 as hidden layer and layer 3 as output layer. Also w^{l}_{jk} is the weight from the k^{th} neuron in $(l-1)^{th}$ layer to j^{th} neuro in the l^{th} layer.

4.1.3 Arrival Time Prediction

Vehicle arrival time depends on average speed of each segment and the real time speed of the vehicle. Because of the variation in traffic conditions, the travel speed of the vehicle is around the average speed of the route segment. To take into account the variations in real time speed due to traffic, average speed of each segment is obtained using the traffic prediction system explained earlier.

This thesis concentrates on finding the velocity of the current segment on the basis of real time speed of the vehicle which fluctuates at high rate and speed from the prediction system which calculates the speed from historical trends on the basis of day of the week, time of the day, volume of traffic in that segment and number of crossings in that segment. The average velocity of the segment in which it is currently present is given by a formula as given in (4.25)

$$V_f = \frac{d_1 + d_2}{\frac{d_1}{V_{real}} + \frac{d_2}{V_{average}}} \quad \ldots(4.25)$$

Here

V_f → calculated speed for the current segment

V_{real} → Real time velocity of the vehicle from the GPS information

$V_{average}$ → Average velocity of the current segment from the prediction system

d_1 → Distance from the current location of the vehicle to the to the end of the current segment, *i.e.,* Distance in the current segment that is still left to be travelled by the vehicle as shown in figure 4.7

d_2 → Distance from the beginning of the current segment to the current location of the vehicle, *i.e.,* the distance in the current segment that is already travelled by the vehicle as shown in figure 4.6

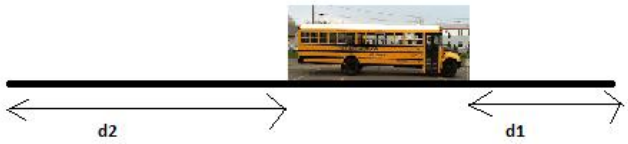

Figure 4.6: Distances as in (4.25)

This formula captures that if the vehicle is near the end of the current segment, *i.e.,* $d_1 << d_2$ then V_f is close to $V_{average}$ else if vehicle is near the beginning of the current segment, *i.e.,* $d_1 >> d_2$ then V_f is close V_{real}.

Arrival time of the vehicle is calculated as the sum of the time taken to travel each segment. Arrival time is calculated using the formula as given in (4.26).

$$T = \frac{D_i}{V_f} + \frac{D_{i+1}}{V_{i+1}} + \frac{D_{i+2}}{V_{i+2}} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots + \frac{D_k}{V_k} \quad \ldots(4.26)$$

Here

T → Arrival time of vehicle

D_i → Distance of current segment

D_k → Distance of destination segment

D_{i+1}, D_{i+2} ……D_{k-1} → Distance of intermediate segments

V_f → Calculated speed of the current segment from equation (4.25)

V_{i+1}, V_{i+2}……V_{k-1} → Predicted speed of intermediated segments

V_k → Predicted speed of destination segment.

4.2 Algorithm for the GPS Based Vehicle Tracking System

i. Get the location and the speed of the vehicle using Location based services and periodically update the server side.
ii. Get the location coordinates of the passenger using Location based services (LBS).
iii. Find the nearest coordinating point to the vehicle using haversine formula
iv. Find the nearest coordinating point to the passenger using haversine formula using Algorithm 4.21
v. Calculate the distance between the two coordinating points using entries in the database.

$$\sum_{i=a}^{b} Distance_i \quad \ldots(4.27)$$

where a= nearest coordinating point to the vehicle

b= nearest coordinating point to the passenger

vi. Add the distance between the vehicle and its nearest coordinating point. This is calculated using Algorithm 4.1

$$Distance = \sum_{i=a}^{b} Distance_i + Distance_{ac} \quad \ldots(4.28)$$

where $Distance_{ac}$ is distance between the vehicle and its nearest coordinating point

where $Distance_{ac}$ is distance between the vehicle and its nearest coordinating point

vii. Find the segment number in which the vehicle is present.
viii. Find the day of the week and the time.
ix. Segment number, day and time are given input to prediction system which finds the volume of traffic and the number of crossings from the database.
x. Input stream (Segment number, day, time, volume and number of crossings) are given as input to clustering Algorithm 4.4
xi. From Hierarchical clustering, cluster number is retrieved.
xii. For that cluster the average speed is found which is called predicted speed.

xiii. Using 4.26 calculate the vehicle arrival time.

Chapter 5

Results and Discussions

5.1 Case Study

A case study has been carried on the proposed system to test its working. A case study has been carried in the campus of Thapar University, Patiala, India. The campus has an area of more than 250 acres. The university has a policy of go—green where the pollution free campus is maintained. No vehicles are allowed inside the campus. As the campus is distributed over large area it makes it difficult for the students to travel inside the campus. To overcome this problem and for the testing of the proposed plan two auto rickshaws were installed in the campus that travelled over one particular route. This route extended from boys hostel – girls hostel- various academic blocks- boys hostel. Two auto rickshaws had a gap of 20 minutes. The route covers the length of 1.5 km.

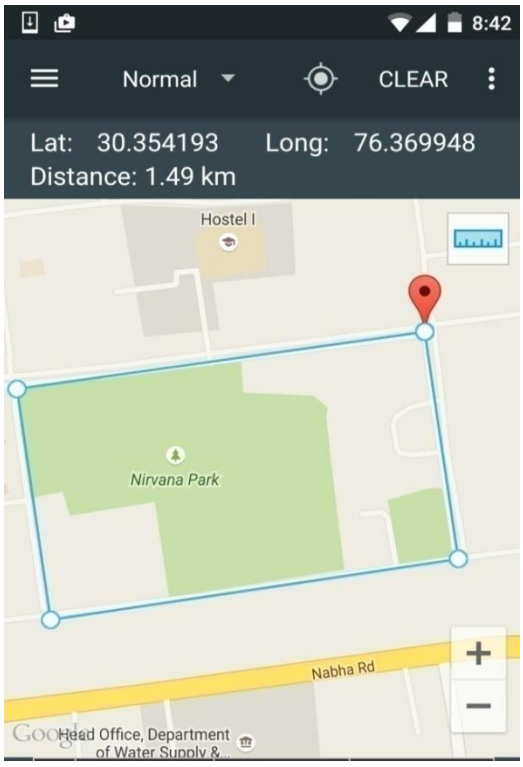

Figure5.1: Route covered in the case study

Figure 5.1 shows the route covered in Thapar University, Patiala, India where the system is used. This route is divided into segments of 100 meters using coordinating points. 15 coordinating points are inserted.

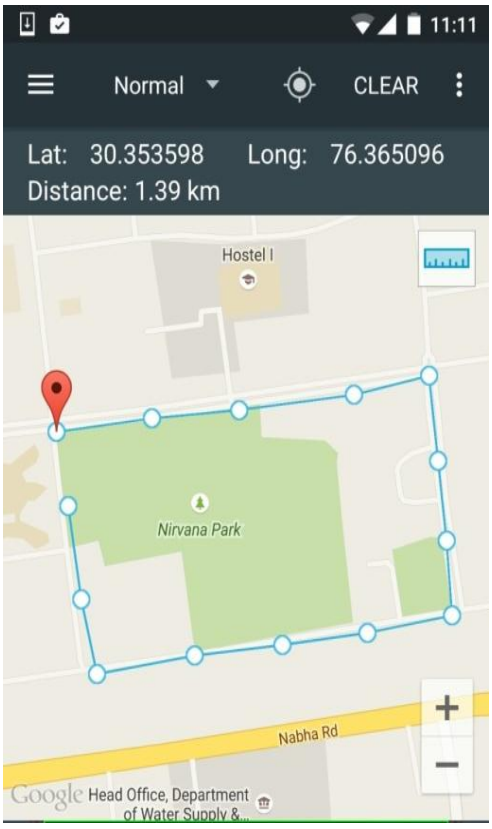

Figure5.2: Coordinating points on the route.

Figure 5.2 shows the coordinating points laid down on the route at a distance of 100 meters. Two different types of android apps are developed. One to be installed on the smartphone that is placed on the auto rickshaw and another to be installed by the students. For both the applications the basic requirement is the availability of the internet and GPS should be enabled. Thapar University provides wi-fi facility to its students in the campus. This fulfils the basic need of the proposed system. An application at the end which is installed on the auto rickshaw initialize by entering the auto number and clicking on start button. Whereas, on another client end which is installed by the students provides an interface where student enters the auto number and can get the arrival time.

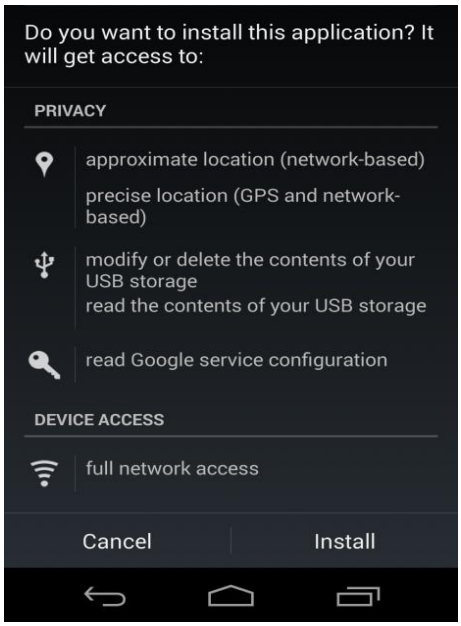

Figure5.3: Permissions that are asked before installing the applications

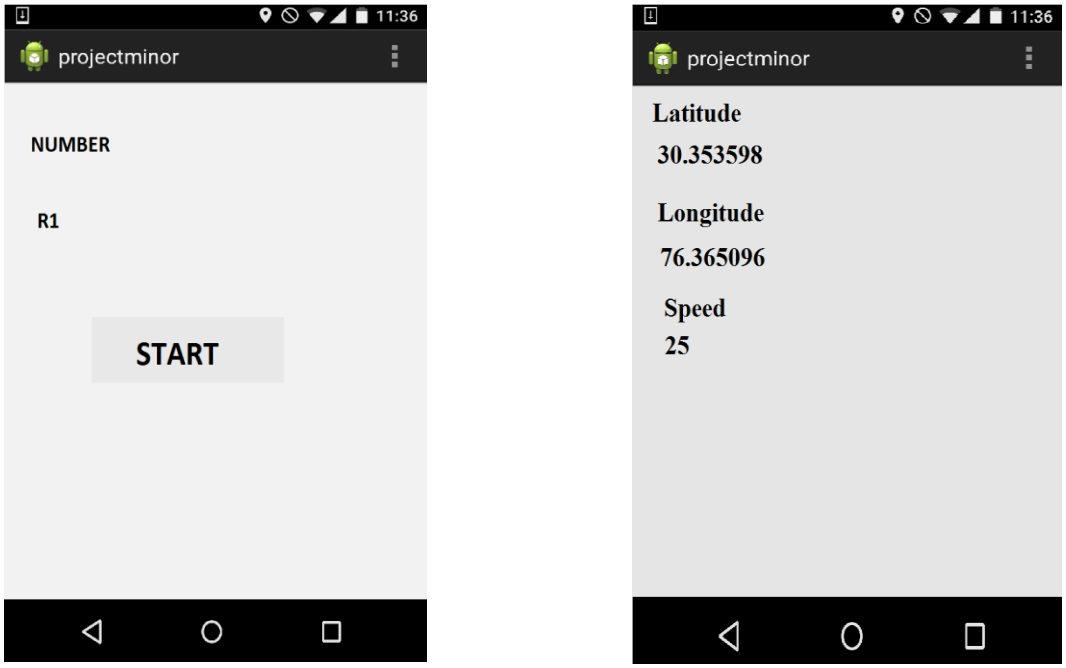

Figure5.4 (a) shows the first interface and (b) shows the next interface that comes up at a module installed at auto rickshaw side.

Figure 5.3 shows the permissions that are asked for when the android application is downloaded. Figure 5.4 (a) gives the first interface where the driver initializes the route and figure 5.4 (b)

gives the second interface at vehicle module where the coordinates of the vehicle and the real time speed of the vehicle is shown.

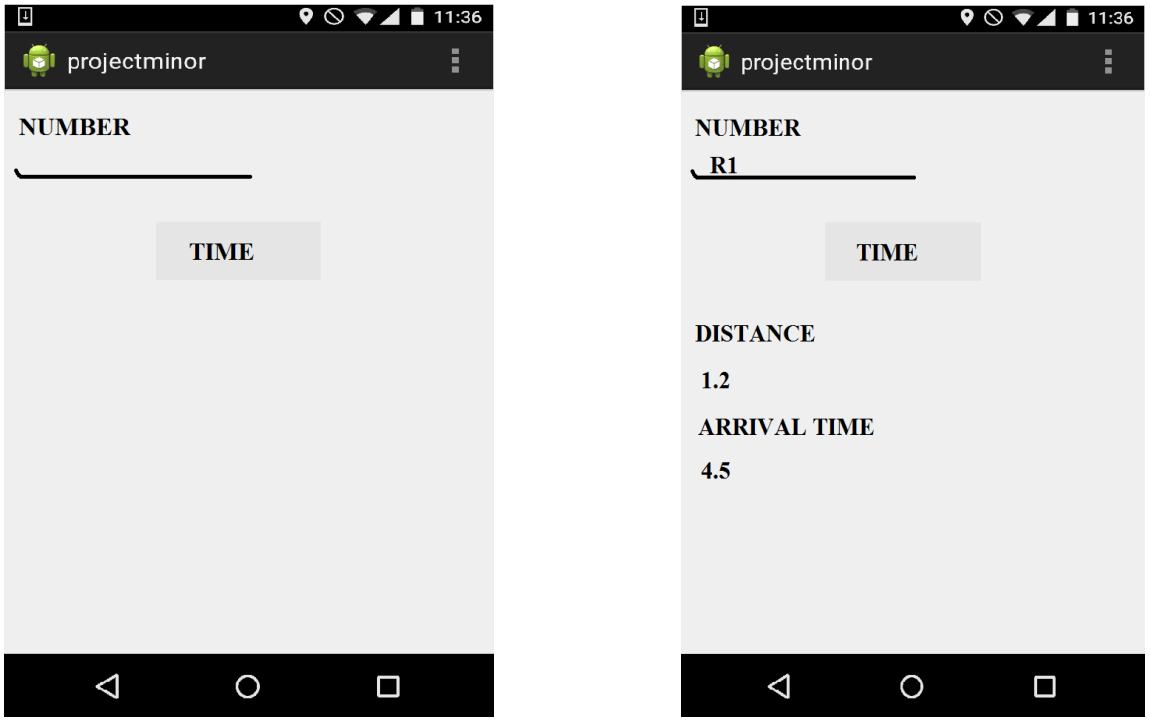

Figure5.5 (a) Shows the first interface and (b) shows the second interface at the module installed at student side

Figure 5.5 (a). shows the interface where the student enters the auto number that is to be tracked. whereas, figure 5.5 (b). shows the result which comprises of the , time to arrival and distance between the current location of the student and the auto rickshaw.

There are two types of clustering algorithms: hierarchical and non hierarchical. In non hierarchical there comes K means, EM, Cobweb. Hierarchical clustering is chosen as it performs better for the given dataset. Hierarchical clustering generally works well for small dataset. For the given dataset it outperforms the other clustering techniques. After doing Hierarchical clustering Back Propagation Neural Networks are applied to further train the dataset. By applying BP Neural Networks it improves the relationship between the input and the output by giving synaptic weights to the relationships.

Hierarchical clustering is also important because it can clearly distinguish clusters on the basis of segments or time of the day where more traffic management has to be done. Although no vehicles are allowed in the campus but pedestrians are the major population which occupies the road. Hierarchical clustering is very useful as it helps in concluding which segment needs management, time of the day where time to travel takes the most or which crossing needs to be managed.

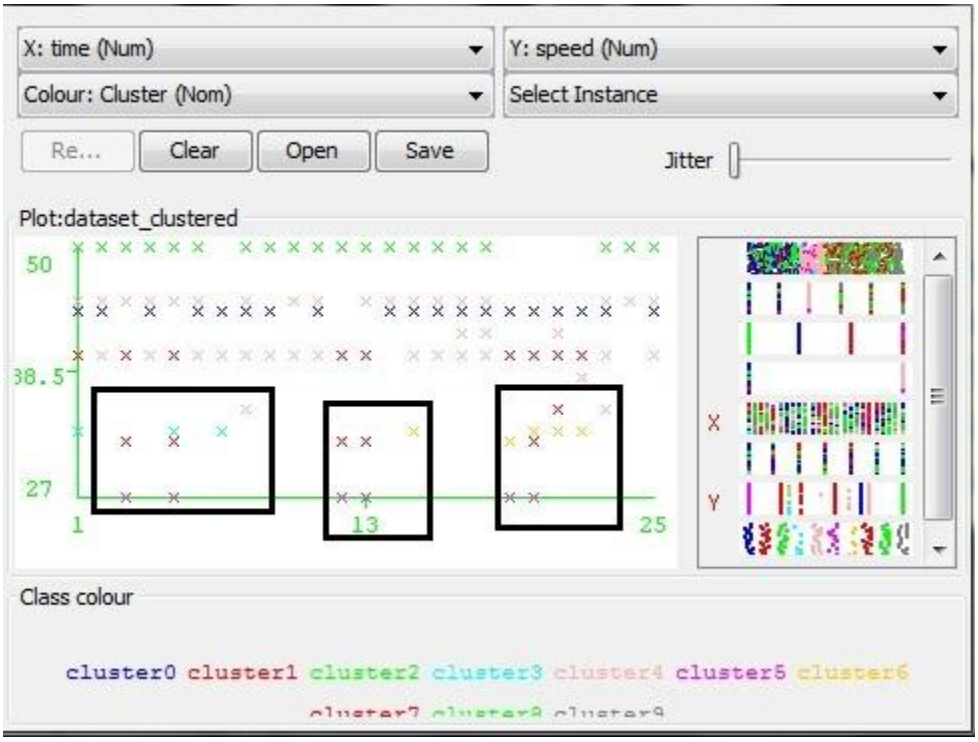

Figure 5.6: Graph between the speed and the time of the day

Figure 5.6 illustrates the relationship between the time of the day and the speed. Where X axis are 1 to 25 where time from 7:45 am to 8:15 pm have been divided into slots of half an hour. Y axis speed varies from 27km/hr to 50km/hr. The graph shows that the highlighted area is more high congestion time where management is required. On observing it is found that the system correctly identifies the time where congestion is high is during commencement of the classes, lunch time and at evening at the time when classes end.

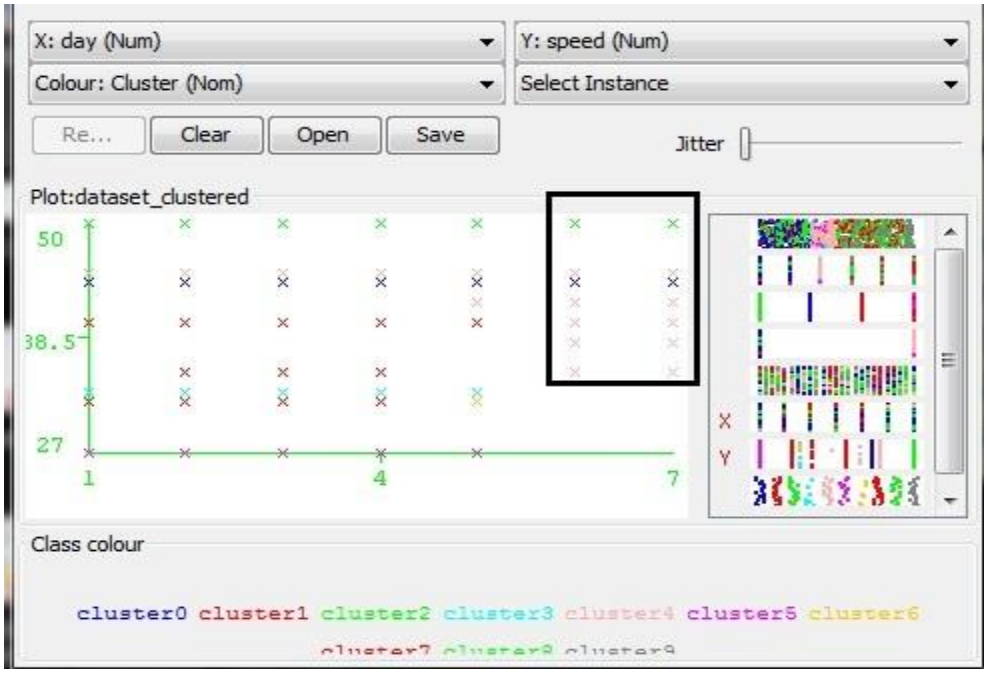

Figure 5.7: Graph between the day of the week and the speed

Figure 5.7 illustrates the relationship between day of the week and the speed. The highlighted portion depicts that during weekend less congestion is there and vehicle moves with high speed. This correctly determines the behavior as there are no classes on weekends congestion is less.

Figure5.8: Graph between the speed and the number of crossings

Figure 5.8 illustrates the graph between number of crossings in the segment and the speed of the transit vehicle. The highlighted portion describes that the when the crossing in the segment is one the congestion is more and speed of the transit vehicle is low. Thus, conclusion can be made that crossings need to be managed.

In the following figure 5.9 describes the graph between the volume of traffic and the speed. The graph clearly illustrates that as the volume of traffic increases the speed decreases. Volume of traffic is the nominal value for the amount of vehicles or pedestrians.

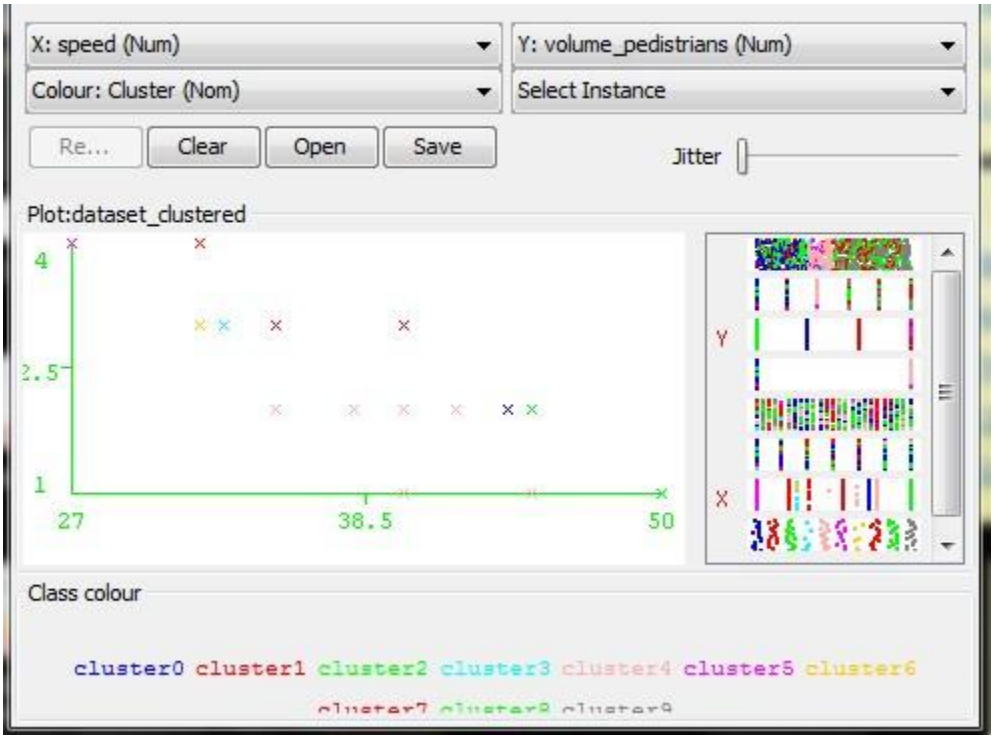

Figure5.9: Graph between the speed and the volume of traffic

Figure5.10: Visualizes the Hierarchical tree

Figure 5.10 illustrates the hierarchical tree drawn from clustering on the given dataset. This tree can be further studied to make important decisions like the area where congestion is high and needs to be managed, the time when congestion is the most, the day which is the vehicleiest *etc.* If this system is applied to actual environment covering small area then this system can be successfully deployed.

Back propagation Neural Network is applied on each cluster for improved learning and better results. Following are the results compared using different clustering algorithms.

Table 5.1: Comparative analysis for different clustering algorithms for a given dataset

CLUSTERING ALGORITHM	CORRECTLY CLASSIFIED(%)	INCORRECTLY CLASSIFIED(%)
K-Means	98.617	1.383
Hierarchical	99.451	0.549
Cobweb	95.619	4.381

From table 5.1 it can be concluded that hierarchical clustering algorithm shows the maximum accuracy. Also efficient use of hierarchy tree can be made to make important decisions to make transit systems more reliable.

Chapter 6

Conclusion and Future Scope

6.1 Conclusion

The system aims at reliable transportation in the city by providing passengers with the real time location of the vehicle. The system also gives the details of the estimated arrival time of the vehicle to the passenger. This system helps the passengers to make better travelling decision as passengers can decide if should wait for the vehicle or not in accordance to the estimated arrival time.GPS based vehicle tracking system not only works on the real time position and the real time speed of the vehicle but also considers the traffic pattern on the road. This traffic pattern plays very important role in evaluating the arrival time of the vehicle.

The basic idea behind the proposed system is to track the vehicle and get the arrival time of the vehicle on the bases of speed with which the vehicle is moving and the average velocity from the prediction system. The proposed system is divided into 2 subsystems. Firstly GPS based system that tracks the current location of the vehicle and the passenger to calculate the distance between the two. Also tracks the real time speed of the vehicle. Secondly the prediction system, which calculates the average velocity of each segment from the data that captures the traffic pattern on the basis of different attributes like time of the day, day of the week, volume of traffic, average speed in the segment and number of crossings.

The route is divided into segments to overcome the problem of ambiguity when displaying the location of the vehicle on the Google maps. The concept of dividing the route makes the distance calculation easier also the prediction system is applied on the route segments. Also by using the Direction of the vehicle as major component, the size of the database is reduced to half. Instead of creating different tables for routes from coordinating point 1→ 15 and 15 →1, only one table could be used for both. To cover the stochastic nature of the traffic, data mining is included in the proposed plan. A case study has been carried in which the system is deployed in the campus of Thapar University. The dataset is small. Hierarchical clustering is performed over the dataset which outperforms the other clustering algorithms. Back Propagation Neural Network is applied over each cluster for better learning and training of the model. Hierarchical clustering performs well in the given dataset. Hence it is concluded that hierarchical clustering outperform other clustering algorithms if the route covered is small. Hierarchical

clustering produces the hierarchical tree which makes it easy to conclude which segment at what time and which day is most congested and needs the management.

The system was tested in the campus of Thapar University as explained in case study. The system was tested 50 times at different locations of the route, different timings and different days. The proposed system shows an error of 12% ,*i.e.*, out of 50 times 44 times correct arrival time was predicted.

6.2 Limitations and Future Scope

Following are the limitations of the proposed system and the future scope to resolve these limitations:

i. The working of the system entirely depends upon the availability of the internet. The passengers should have smartphones with the availability of the internet in it. To overcome this problem LCDs or LEDs could be deployed at each vehicle stop which displays the required information.

ii. The working of the system is highly dependent on the coordinates provided by the GPS. Many android applications and many other important systems are working on the grounds of coordinates provided by the GPS. To overcome this problem Transmitters could also be deployed over the vehicle and the stops but this is very less efficient way.

iii. Hierarchical clustering performs well on small dataset as it is time consuming. Hence the system could be applied over small routes. To overcome this problem other efficient algorithms could be used.

iv. There is no means of communication from the user end to vehicle application. The application can be further enhanced with the facility to help the isolated people or people work in dangerous and remote locations.

v. The error of 12% can further be improved by using better hybrid algorithms

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List of Publications

Research Paper Accepted

Leeza Singla and Parteek kumar, "GPS Based Vehicle Tracking System", in IEEE International Conference on Computer, Communication and Control, MGI Indore, INDIA. September 10 -12, 2015.

Leeza Singla and Parteek Kumar, " Bus Tracking System Using GPS", in Third International Symposium on Women in Computing and Informatics (WCI-2015), August 10-13, 2015, Kochi, Kerala, India

Video URL

A video describing the “GPS Based Vehicle Tracking System” has been uploaded at www. youtube.com . The URL of the same is as follows:

https://www.youtube.com/watch?v=7MD2beXewlc&feature=youtu.be