

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



الرحيم الرحمن الله بسم

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Gazipur-1704, Dhaka, Bangladesh

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



Project report title

TRAFFIC UPDATE

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Certification

This is to certify that this project entitled “Traffic Update” is a true work of Jakaria Al Meharab (114439) & MD. Abir Hasan (114408) who was successfully carried out the work project under the supervision of Mr Md. Moniruzzaman. This project count as our final year project which put an end to our four years program as B.Sc in Computer Science & Engineering at Islamic University of Technology (IUT) Dhaka, Bangladesh.

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Acknowledgement

Thanks to Allah (SWT), the most gracious and the most merciful.

The satisfaction that accompanies the successful completion

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Dedication

This project is dedicated to our parents who brought us into
This world, and whose loves remain in our heart forever.

Abstract

We are in the age of big changes, particularly the technology revolution and this has affected all aspect of our life. This modern day revolution, at the global level, has manifested itself in the form of many innovations and breakthroughs and giant leaps in internetworking technology. With this changes, we have new opportunities, people can now transcend the barriers of time and distance with the internet's speed. This has completely change our living style, and every sector got changed and most of the traditional activities are going on now online.

Over the last few years the transportation problem of Dhaka City has visibly been deteriorating steadily. Citizens constantly complain about the unbearable twin problems of traffic jam and air pollution. Democracy watch decided to address this problem through an opinion poll covering around eight hundred households randomly selected from several purposively selected neighbor hoods of the city, representatives of middle and lower income areas.

“Traffic Update” is an online based windows mobile app that will change our old habit to go to the road and wait so long to get a vehicle. The aim of this project is to save precious time of people.

This project has three major parts, the admin part for managing the whole system, the owner of a specific vehicle company who can track its all vehicles and the user who can a particular vehicle or a group of vehicles through map.

Traffic accidents are now a very serious and growing problem and the safety situation is very severe by international standard. The problem of road accidents costing the community in the order of US\$ 800 million (nearly 2% of GDP) each year. The other serious deficiencies resulting from ad-hoc planning are sectorial bias improper modal mix, un-integrated system, serious institutional weakness, limited role of the private sector etc. The current deficiencies have produced an unsustainable trend of transport development, which is characterized by misallocation of resources, adverse impacts on the environment and lack of competition. The current disturbing trends in transport development indicate the need for guidelines to make such development environmentally and to create a transport system that can meet the growing demand for transport services. In this paper characteristics of transportation and consequent mobility, safety and environmental effects are discussed. The purpose of the present paper is to conceptualized a vision and identify supporting policies for sustainable transport development. The authors also make an attention on key transport issues and possible options for ensuring sustainable transport development in Bangladesh.

TABLE CONTENTS

1. Introduction	9
1.1 About TRAFFIC UPDATE	11
1.2 Objectives	12
1.3 Scope	14
2. Feasibility Study	15
2.1 Technical feasibility.....	15
2.2 Economic feasibility.....	15
2.3 Operational feasibility.....	16
3. CURRENT SYSTEM	17
3.1 Road Traffic Management System - The Current Scenario.....	17
3.2 Overview of Bangladesh Transport System.....	18
4. Problem Definition.....	19
5. Characteristics of the Proposed System.....	24
6. Data Flow Diagram.....	26
7. Use case diagram.....	27
8. ER Diagram.....	28
9. Technologies used.....	29
10. Hardware Specification.....	30
11. Database Design	31
11.1 About the Database.....	31
11.2. Database Tables.....	32
12. Interfaces	37
12.1 Log in the app as user or admin	37
12.2 Log in.....	38

12.3 Menu.....	39
12.4 Profile.....	40
12.5 TRAFFIC UPDATE.....	41
12.6 TRAFFIC UPDATE (cont.).....	42
12.7 TRAFFIC UPDATE (cont.).....	43
12.8 TRAFFIC UPDATE (cont.).....	44
12.9 TRAFFIC UPDATE (cont.).....	45
12.10 TRAFFIC UPDATE (cont.).....	46
12.11 TRAFFIC UPDATE (cont.).....	47
12.12 TRAFFIC UPDATE (cont.).....	48
11. FUTURE SCOPE AND ENHANCEMENT.....	49
12. CONCLUSION.....	50

Chapter 1

Introduction

Traffic Congestion is one of the main serious global problems in both developed, undeveloped and developing countries.

With Bangladesh's huge population and current infrastructure, frequent traffic jams waste valuable fuel and time and makes travel very unpleasant and difficult. Furthermore, it makes the existing public transport very inefficient and most importantly adds unbearable and unsafe levels of noise and hazardous air pollution to an already unregulated country. The noise levels and pollution cause stress in most people and lead to many life-threatening medical conditions such as cardiovascular diseases and blood pressure related ailments.

Traffic congestion changes during the day, and planning for trips is becoming impossible. Not only do commuters lose valuable time stuck in traffic, they have to leave early in hopes of making up for or altogether avoid a traffic jam. Conversely they have to wait for others trapped in the congestion, which greatly affects the daily productivity. This is something that affects everyone irrespective of their social or economic status. The current infrastructure also poses great problems for the elderly and youth. With the constriction of cars and other vehicles, old and young people lack independence and means that their escorts also waste valuable time. Walking constitutes a major mode of travel among the low-income majority. However, this majority of pedestrians are consistently ignored in the planning of transport. As a result of the unplanned and overwhelming traffic situation, people prefer walking and started using bicycles also, which have become efficient transport systems but risk their lives on the dangerous

streets. Almost 80% of all traffic fatalities in the city of Dhaka alone involve pedestrians being hit by a fuel based vehicle. Private cars, a mere 4% of the total vehicles on the roads, represent vehicles which take around 70% of the road space. Public Transportation needs to be stressed in any future policy. Although, the change to Compressed Natural Gas (CNG) cars saved over 4000 premature deaths in 2009, their cheap price has spiked the total numbers of cars on the streets though the recent prices hikes of CNG may have affected the spike. This has led to a decrease in the amount of natural gas available for other purposes.

1.1 About TRAFFIC UPDATE

With Bangladesh's huge population and current infrastructure, frequent traffic jams waste valuable fuel and time and makes travel very unpleasant and difficult. This problem is much serious for pedestrian, especially in large cities like Dhaka. Traffic Updates are not available everywhere and all the time. So it will be more convenient for people to get traffic update in mobile within a minute. TRAFFIC UPDATE is a GPS based system that helps to find out a vehicle's global position. A person from anywhere can get the update of vehicle through this app. A person can also get his/her current location from the app. It keeps the records of user's recently visited place.

Each car will be equipped with a GPS-enabled mobile phone. The GPS unit will contain some software that will send signals carrying data on the vehicle's speed and location to the central server for that area. With all vehicles in an area sending signals to the central server, there will be ample data to compute the traffic conditions of that area. Once computed, the results will be uploaded to the Internet in form of images (graphs or charts). This information can be viewed by anyone on his/her cell phones or any other device able to browse the Internet. The best thing about this model is that both drivers and the traffic police can view the traffic conditions in real-time with a delay of only few milliseconds.

1.2 Objectives

Our main focus is to solve the user's problem not to change the full traffic system. We will try to reduce people's waiting time on the road for desire vehicles not wasting time of the people in a vehicle.

Keep records of the recently visited place and time of the users.

To make a bond between the vehicles company and the users. For instance, a cab company that is using a vehicle tracking system can tell a customer exactly where the nearest cab is and give a realistic estimate on how long it will take to reach a cab.

Hence our main goals are:

Keep records of user's recently travelled information

Through our app user can see his or her recently travelled information at any time. Suppose at any time he or she needs to know the place that he has recently visited but could not remember it or he forget the address that he has visited. Then he can easily find it out through our app.

Dynamically update present location

User's current location is automatically updated via TRAFFIC UPDATE. So, if someone wants to know the place he is currently staying can easily get the information about the place.

Available vehicle information at any time

At a particular time how many vehicles are in a particular area user can get this info via TRAFFIC UPDATE app. However user can select a

particular vehicle to know its current position. Also user can select a group of vehicles to their present location.

Active and Passive GPS tracker system

TRAFFIC UPDATE is based on active and passive GPS tracking.

Several types of vehicle tracking devices exist. Typically they are classified as "passive" and "active". "Passive" devices store GPS location, speed, heading and sometimes a trigger event such as key on/off, door open/closed. Once the vehicle returns to a predetermined point, the device is removed and the data downloaded to a computer for evaluation. Passive systems include auto download type that transfer data via wireless download. "Active" devices also collect the same information but usually transmit the data in near-real-time via cellular or satellite networks to a computer or data center for evaluation.

Many modern vehicle tracking devices combine both active and passive tracking abilities: when a cellular network is available and a tracking device is connected it transmits data to a server; when a network is not available the device stores data in internal memory and will transmit stored data to the server later when the network becomes available again.

Historically, vehicle tracking has been accomplished by installing a box into the vehicle, either self-powered with a battery or wired into the vehicle's power system. For detailed vehicle locating and tracking this is still the predominant method; however, many companies are increasingly interested in the emerging cell phone technologies that provide tracking of multiple entities, such as both a salesperson and their vehicle. These systems also offer tracking of calls, texts, and web use and generally provide a wider range of options.

1.3 Scope

This project is not limited to a particular town, nor a city, nor a country or a continent but it is for all over the world. It can be apply anywhere in the world. People can move from one place to another with their records via TRAFFIC UPDATE. It is capable of making life easier than before. The traffic system of third world country like Bangladesh is getting worst day by day. So, it will be very helpful to overcome this worst situation.

Chapter 2

Feasibility Study

The Feasibility Study outlines the work to be accomplished, sizes the project, identifies any key issues that need to be addressed before a project is undertaken and determines whether the target species can be successfully managed at the project site. It gives an indication of whether the project will be successful, or not.

The Feasibility Study asks three questions:

- Why do the project?
- Can the project be done?
- What will the project take?

To answer these three questions we have to consider the three followings:

2.1 Technical Feasibility

To use this system, people will not need anything else an internet connection and a smart phone. Nowadays smart phone users are increasing day by day. So, these two are available almost everything in the world at low cost.

2.2 Economic Feasibility

Our app needs GPS tracker that will be attached to every vehicle. The price of this device is approximately 45\$. Actually it is not a big deal for the company that runs this system. User only need an internet connection and a smart phone. And nowadays these two are available almost everything in the world at low cost.

2.3 Operational Feasibility

Since nowadays almost everyone uses internet it will be very easy for them to download the app from the windows store and install it within a minute. Interface of this app is so user friendly that no one can face any complexity to use this app.

Chapter 3

Current System

At present, most road traffic monitoring systems use sensors and video cameras to check the speed of vehicles and to take snapshots of vehicles that violate signals. However, the cost of this equipment has restricted the current video camera-based road traffic monitoring systems to certain very important areas and important highway intersections - where there are greater possibilities of traffic congestion and accidents.

3.1 Road Traffic Monitoring System – The Current Scenario

The government is willing to cut down the costs of the "sensor and video camera based road traffic monitoring system" so that it can implement it widely. To achieve this, it has permitted several research groups and telecom companies to come up with a model- both practical and cost effective- covering large areas (not only certain portions of the city and highway intersections). There are several research projects going on, some using government grants and some on their own – conducted by telecom giants such as Nokia, UTStarcom, and others.

The common point in all these researches is that almost all of them are considering GPS-based road traffic monitoring system to bring down the overall costs of maintenance because the costs of the GPS devices are low and are showing a further downward trend. Almost every person with a vehicle has a GPS device or can afford a GPS device for vehicles, which means that the stage is already set. We just need to put the different components in place so that the desired GPS-based road traffic monitoring system can be put into place.

3.2 OVERVIEW OF BANGLADESH TRANSPORT SYSTEM

The transport system of Bangladesh consists of roads, railways, inland waterways, two seaports, maritime shipping and civil aviation catering for both domestic and international traffic. Development and maintenance of transport infrastructure in the country is essentially the responsibilities of the public sector. The public sector is involved in transport operations in road, inland water transport (IWT) and ocean shipping alongside the private sector. In the road transport and IWT sub-sectors, the private sector is dominant. In ocean shipping, however, public sector still predominates, although the private sector has considerably increased its role in this sectoring recent years. Recently private sector has also been involved in domestic air transport and railway in a very limited scale. Bangladesh witnessed rapid growth of transport since independence. The overall annual growth rate has been nearly 8.2 per cent for freight transport and 8.4 per cent for passenger transport. Even then, the transport intensity of the Bangladesh economy is considerably lower than that of many developing countries.

Chapter 4

Problem Definition

This chapter discusses about the problems we usually face in the existing system. The transport sector in Bangladesh is characterized by weak public and private institutions, and low level of investment. The problems are discussing below.

During office hours

In Bangladesh before or after office hours the roads become very busy & if someone wish to go somewhere they have to wait for a long for the desired vehicle. It creates a huge mental & physical problem.

Railway management

Another main transportation system in our country is railway system. So if anyone desire to use train for journey he needs to reach the railway station before half an hour of the train's schedule. But Railway System in Bangladesh is not well organized in perspective of time. So people have to wait for a long time for the train.

Highway journey

Another focusable problem is that anyone want to go long-way journey in our country the system is maintained like people gets the update of the

vehicle from the counter . But it is possible to get the vehicle update from mobile within a minute.

Traffic jam (Too Long)

Traffic jam is one of the most irritating problems in Bangladesh. It has taken a very serious shape in Dhaka city. This problem is the result of rapid growth of population and the increasing number of vehicles. If a person wants to go somewhere by public bus he or she have to wait for a long time in the bus stoppage.

Poor Quality of Transport Services

The transport sector in Bangladesh is characterized by weak public and private institutions, and low level of investment. It operates in a physical environment of high levels of risk, and socio-political context of extreme poverty and frequent man-made disruptions. The general quality of services at all levels and by all modes has been poor. The overcrowded buses, trains and water transports, with poor safety and security records, and unreliable service operations are quite common in Bangladesh. In freight transport, excessive cost, time, pilferage, etc., are some of the common problems. These problems are further complicated by vested interests from both within and outside the transport sector itself and the socio-political environment of the country. Road accidents, air pollution due to vehicle emissions, hazardous vehicle driving/operations, overloading, etc. are some of the most common phenomena, in transport sector, particularly in the urban areas. These phenomena have actually developed due to lack of enforcement of existing rules and regulations with regard to transport operation in the country. While overloading of buses, rash driving of trucks, unworthy vehicles are supposed to be stopped by law enforcing agencies

visa, traffic police, very little effective measures are actually taken in this regard.

Unaware of the Regional Role of the Transport System

As indicated earlier, Bangladesh has been developing its national transport system, essentially with an inward looking strategy. In the context of the globalization process which is currently underway, it has been observed that worldwide economic dynamism has been driven to a significant extent by economic exchange on an increasing scale among economies situated in the same region/sub-region. Despite her strategic location in the sub-region comprising the countries/areas which are the close neighbors, such as Nepal, Bhutan and North-East India, Bangladesh has not been planning and developing its transport system with a regional perspective in mind.

Development Trend Not Sustainable

There is a growing interest in sustainable development, which requires us to be more sensitive to environmental and social constraints, including indirect and long-term impacts. It emphasizes intergenerational equity and long-term ecological viability. Sustainability has significant implications for transportation planning, since transport activities tend to be highly resource intensive, have numerous external costs, and frequently distribute impacts inequitably. Sustainable development focuses on improved access to facilities and to using each mode for what it does best. Improvement of access and distribution of linked production and storage activities can substantially reduce the necessity of movement and/or reduce trip length resulting in lower demand for transport infrastructure and services, less energy consumption and reduction of external costs. Pricing policy for the transport sector of the country poses a serious problem for the proper functioning of the transport sector. Although pricing policy should ideally be based on cost recovery principle, in reality it is not commensurate with the cost of providing transport services. Fare and rates in all the transport sub-

sectors are fixed at a level much below the combined cost of transport. This leads to substantial losses in all the transport sub-sectors and in turn puts strains on the total allocations meant for the different sectors of the economy. Although the transport is a service sector and the public transport is provided depending on the principle of public service obligation (PSO), the practice of providing unlimited subsidy from Govt. exchequer is creating problem for other sectors of the economy too, and is therefore not sustainable.

Transport System Not Fully Integrated

Integrated system development which has now become a major issue in modern sustainable transport development, has particular significance for Bangladesh with her acute resource scarcity. Thus there is an urgent need for an optimum mix of modes and minimization of consumption of resources. However, such a mix cannot be achieved if one looks at a mode in isolation from others. Thus although rail and water transport is generally more efficient than road transport because of their higher energy efficiency and better labor productivity, this fact by itself cannot ensure greater use of these modes. In most of the cases they alone cannot provide door-to-door services. Because of their higher terminal costs they are also not suitable for short trip length or where intensity of demand is too low to justify higher capacity modes. These inherent characteristics of different modes require that to improve overall efficiency each mode should be used for what it does best in an overall transport chain. Reflecting a fundamental change in the traditional way of looking at transportation of goods and people, a mode is increasingly considered only as a link in the chain and the whole issue of transportation from the origin to ultimate destination is considered. In Bangladesh, each mode of transport operators on its own without any initiative to establish efficient logistic chains between O-D involving different

modes as necessary. Thus an integrated system involving different modes, as appropriate from the origin to ultimate destination is needed.

Lack of Urban Transport Policy

Bangladesh has no urban transport policy as yet. As such there is no clear decision as to which modes of transport and facilities, the urban areas should encourage. In the past urban transport received little attention, as investment went more in infrastructure development for inter-urban linkages and for opening up links to rural growth centers. The 4th Five Year Plan of Bangladesh (1990-95) indicated that urban transport problems, will be tackled, particularly in the metropolitan areas with emphasis on land use and water management system. Government therefore, undertook a study “the Greater Dhaka Metropolitan Area Integrated Transport Study (DITS) (1992-94), funded by UNDP. In line with the findings of the study, World Bank formulated a project – “Dhaka Urban Transport Project”, to address in the short-term, urgent policy issues, infrastructure bottlenecks and traffic management constraints, and in the longer term, to focus on planning, institutional and policy action. Based on another recommendation of the World Bank for strengthening coordination mechanism, Greater Dhaka Transport Planning and Coordination Board (GDTPCB) was established. The Board has recently been renamed as Dhaka Transport Coordination Board. While efforts are underway to improve urban transport situation in Dhaka, similar initiatives need to be taken to address urban transport problems in other cities, and before that there is an urgent need for setting urban transport policies of Bangladesh. Generally speaking such a policy should aim at developing an integrated, balanced and environmentally sound urban transport system in which all modes (motorized and non-motorized) can play their roles efficiently.

Chapter 5

Proposed System

This chapter discusses about our app.

Our project “Traffic update” is a user friendly app. Windows phone user can use it and will get a present traffic situation of the road. To make this app we take two basic distinct work.

- Tracking the vehicles. Several types of vehicle tracking devices exist. Typically they are classified as "passive" and "active". "Passive" devices store GPS location, speed, heading and sometimes a trigger event such as key on/off, door open/closed. Once the vehicle returns to a predetermined point, the device is removed and the data downloaded to a computer for evaluation. Passive systems include auto download type that transfer data via wireless download. "Active" devices also collect the same information but usually transmit the data in near-real-time via cellular satellite networks to a computer or data center for evaluation.
- Traffic Update vehicle tracking devices combine both active and passive tracking abilities: when a cellular network is available and a tracking device is connected it transmits data to a server; when a network is not available the device stores data in internal memory and will transmit stored data to the server later when the network becomes available again.

- Vehicle tracking has been accomplished by installing a box into the vehicle, either self-powered with a battery or wired into the vehicle's power system. For detailed vehicle locating and tracking this is still the predominant method.
- The Vehicle Tracking Kit is designed to read the GPS information from an existing database and display it within a web application. In order to receive live coordinates from an actual GPS device need to write a custom program that will interface directly with GPS Tracking Device. How this program works will depend heavily on what type of GPS Device it is and what sort of communication capabilities it has. We need real time data so GPS Device is portable and has a cellular connection it may post via HTTP to a web page or via TCP/IP or UDP.

Chapter 6

Data Flow Diagram

This data flow diagram (DFD) shows the graphical representation of the "flow" of data through this system.

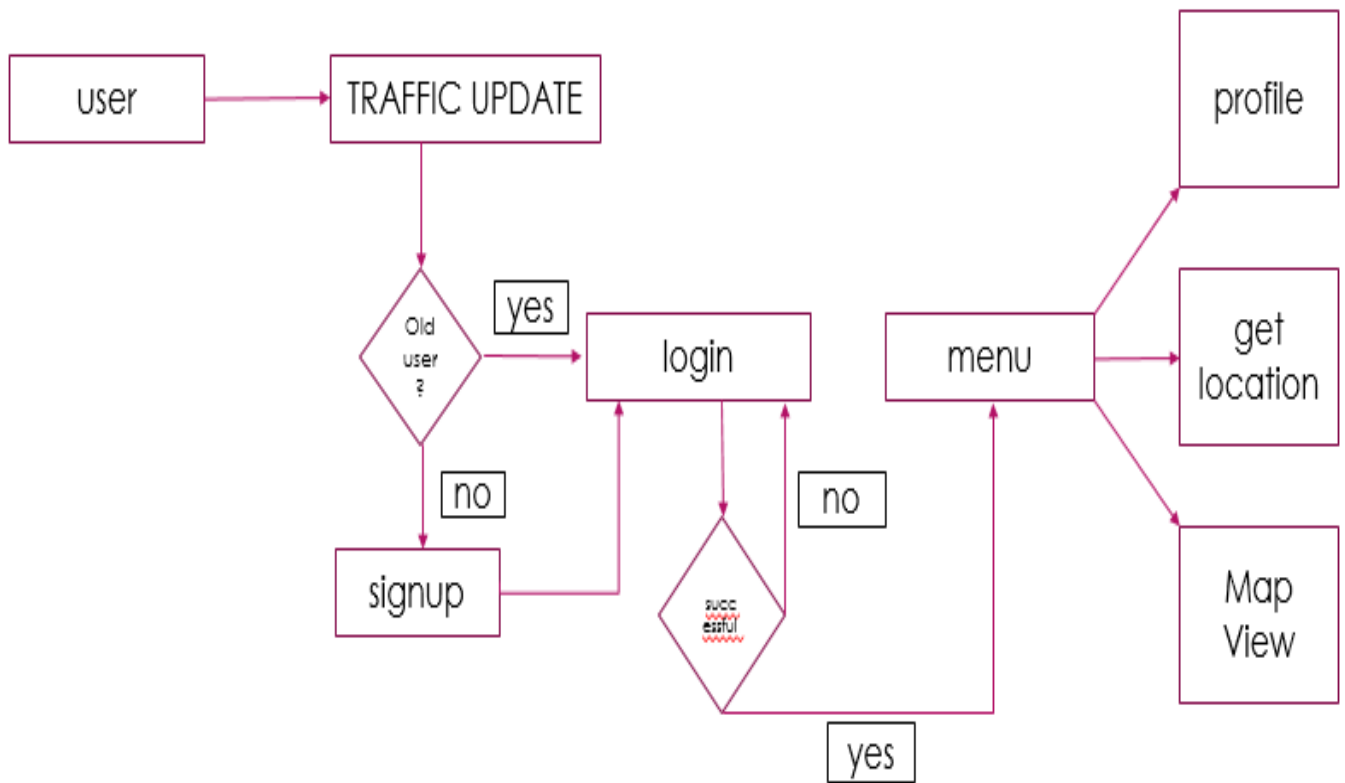


Figure: 1. Dataflow Diagram

Chapter 7

Use Case Diagram

This use case diagram shows the simplest representation of user's interaction with the system that shows the relationship between the user and the different use cases in which the user is involved.

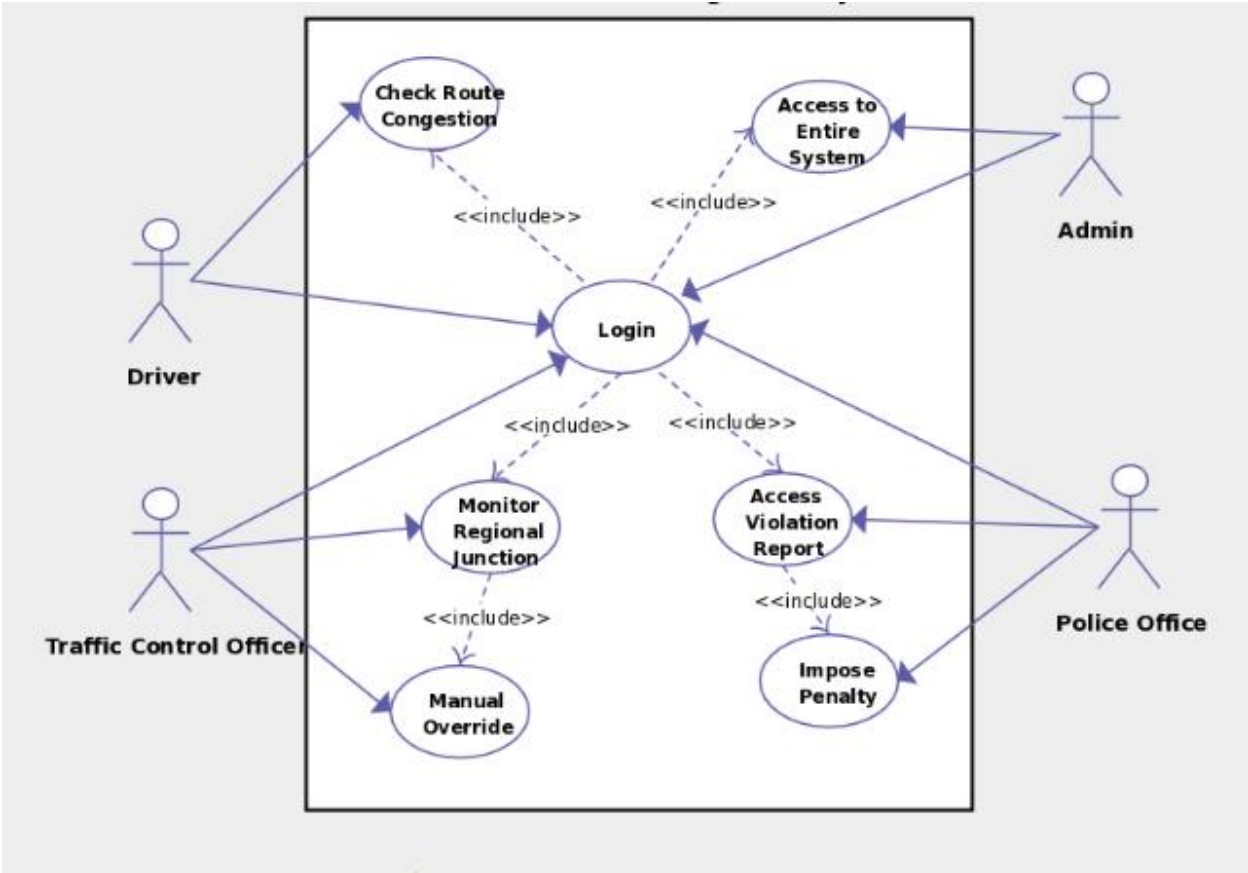


Figure: 2. Use Case Diagram

Chapter 8

ER Diagram

This ER Diagram shows the relationship between people, objects, places, concepts or events within this system.

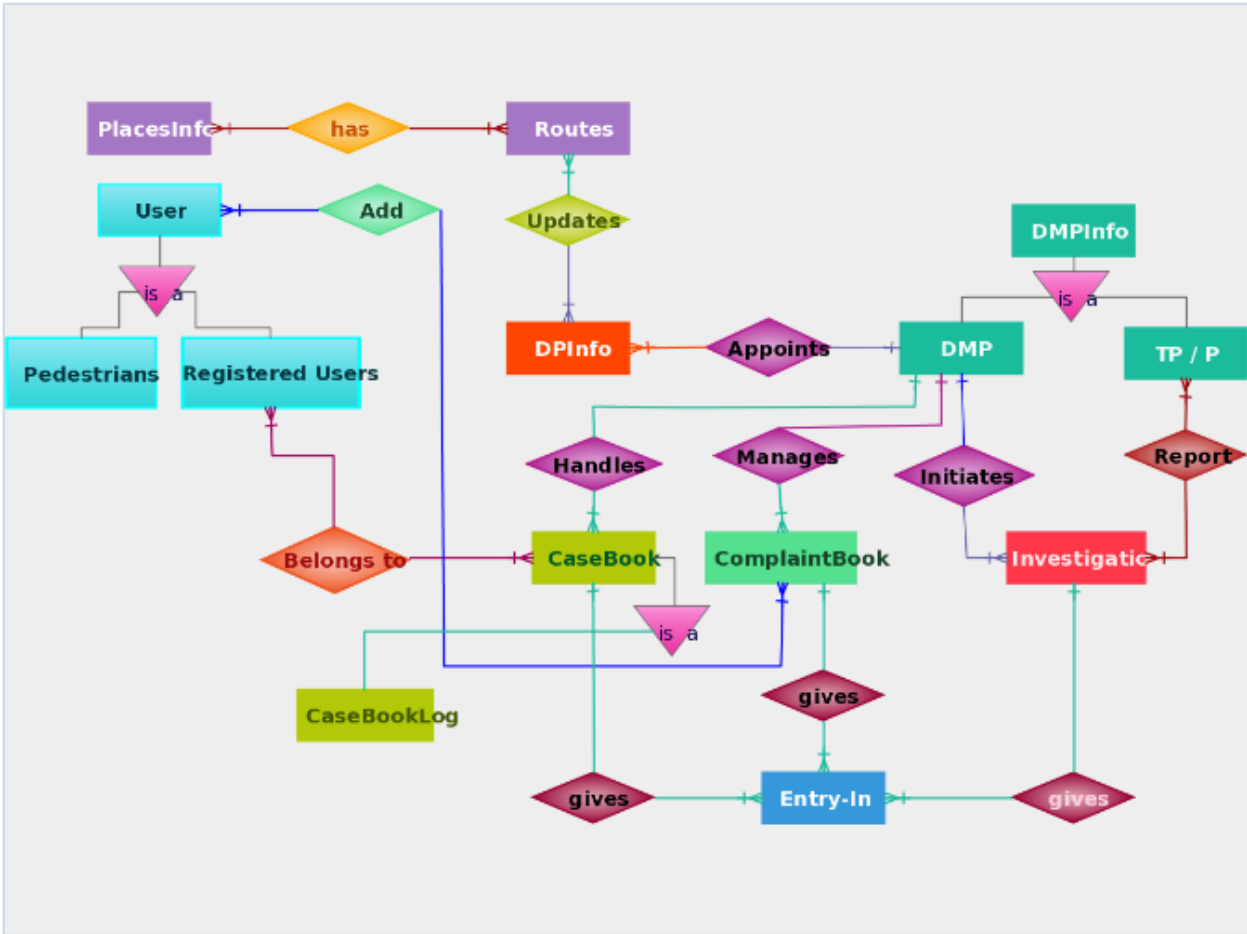


Figure: 3. ER Diagram

Chapter 9

Technology Used

Platform

- Windows Phone

Language

- C#
- PHP
- JavaScript (Json-Parsing)
- SQL
- HTML

Tools

- Adobe DreamWeaver CS5
- Microsoft Visual Studio

Database Server

- phpMyAdmin

Chapter 10

Hardware Specification

We need GPS tracker in every vehicle to track them. Other than that there is no restriction to the hardware with which we want to use this app. Any windows phone that has internet connection can easily use the app TRAFFIC UPDATE.

Chapter 11

Database Design

11.1 About the Database

The database is the structure which will contain all the data of the website and will make the operations of the system efficient.

Here is a brief description and composition of the database design:

- MySQL server 5.1.
- Querying language: SQL
- Name of the database: **traffic_update**
- Number of tables: **05**

11.2 Database Tables

In this section we will give the role of every table of the app.

Table 1

Name: user_info

Purpose: It stores the user information.

Structure:

Table field	Type	Length
UserID	int	11
Username	varchar	100
Age	varchar	50
Gender	varchar	50
Contact_no	varchar	100
Password	varchar	100
IMEI	varchar	100
Profile_picture	varchar	10000
Email	varchar	40

Table 2

Name: object_location

Purpose: It stores the users current location.

Structure:

Table field	Type	Length
UserID	int	11
Latitude	varchar	50
Longitude	varchar	50
EntryDate	varchar	50

Table 3

Name: group_user

Purpose: There are different types of vehicles groups. It stores the vehicles group information.

Structure:

Table field	Type	Length
Group_name	varchar	50
Admin_name	varchar	50
Group_catagory	varchar	50

Table 4

Name: latest_location

Purpose: It stores the current longitude and latitude of the vehicle.

Structure:

Table field	Type	Length
UserID	int	11
Username	varchar	255
Record_dateline	dateline	
Latitude	varchar	50

Table 5

Name: trackers

Purpose: It stores a particular vehicles location.

Structure:

Table field	Type	Length
PointID	int	11
RunnerID	varchar	255
Latitude	varchar	50
Longitude	varchar	50
Time	varchar UTF 8_general_ci	255

Chapter 12

App Interfaces

In this section we will show some screen shots of our app .

12.1 Log in the app as user or admin:

This is the logging portion. Here have two categories
User & Admin

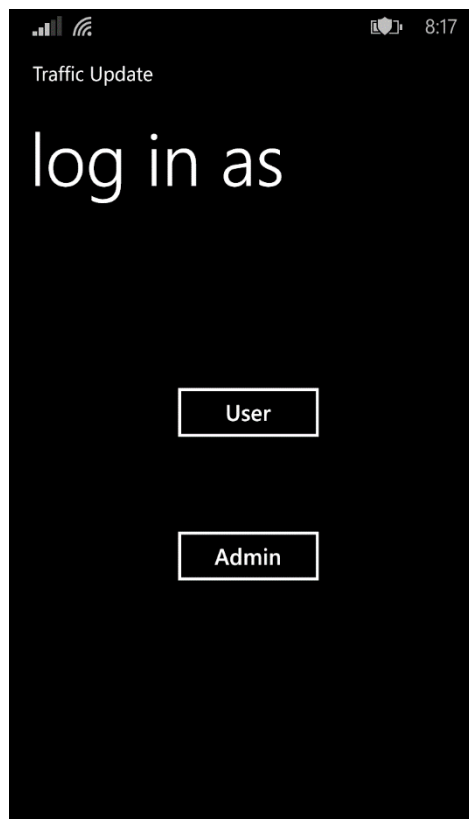
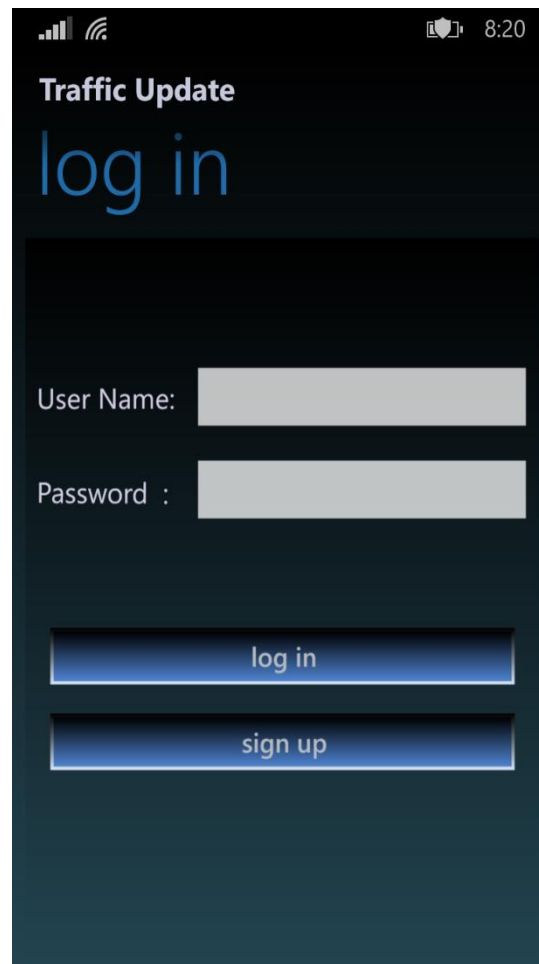


Figure: 4. Log in As

12.2 Log in:

Here has the final login. If user is not signup then he can sign up here.



The image shows a mobile application interface for logging in. At the top, the status bar displays signal strength, Wi-Fi, and the time 8:20. The app title 'Traffic Update' is in white, and 'log in' is in a large blue font. Below the title are two input fields: 'User Name:' and 'Password :', both with grey rectangular boxes. At the bottom, there are two blue buttons with white text: 'log in' and 'sign up'.

Figure: 5. Log in

12.3 Menu:

In the Menu portion user can choice different option.

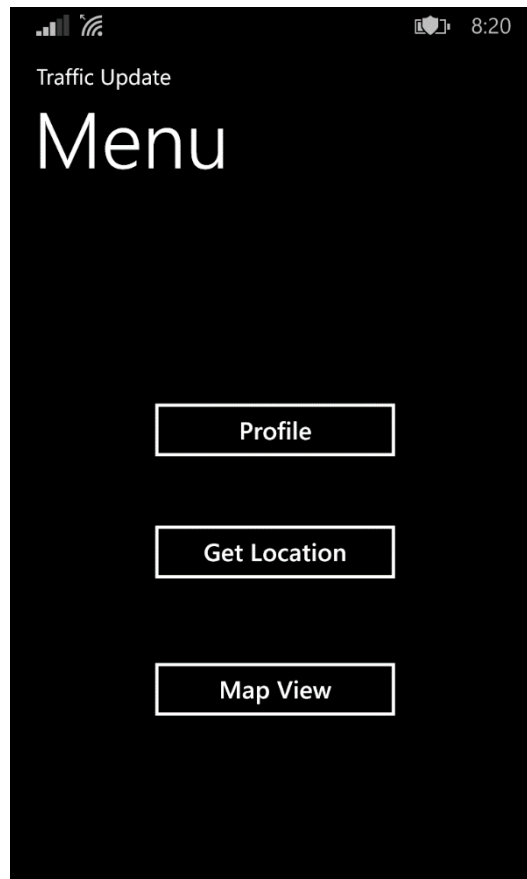


Figure: 6. Menu

12.4 Profile:

User can see his given information.

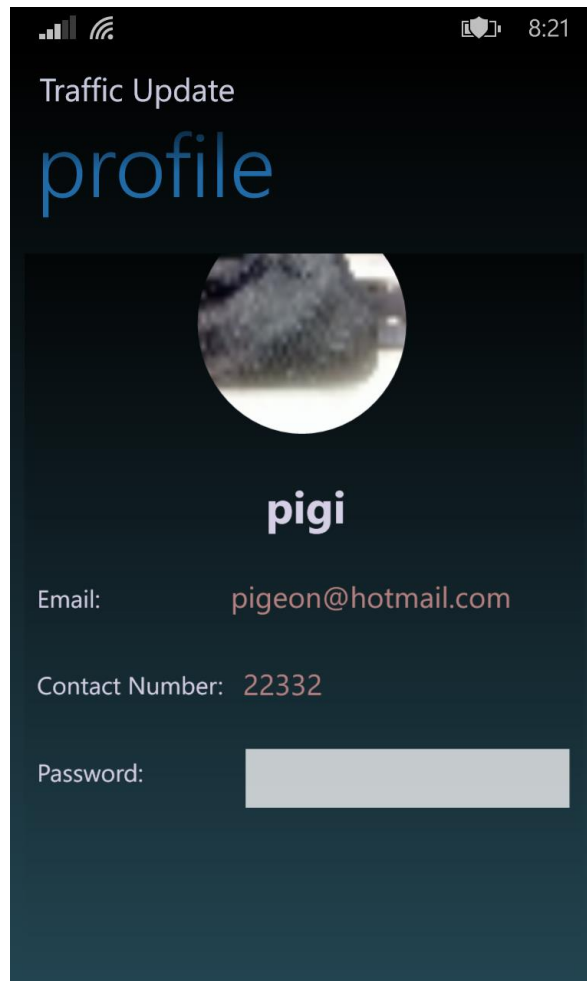


Figure: 7. Profile

12.5 Traffic Update:

Beginning to trace the location.

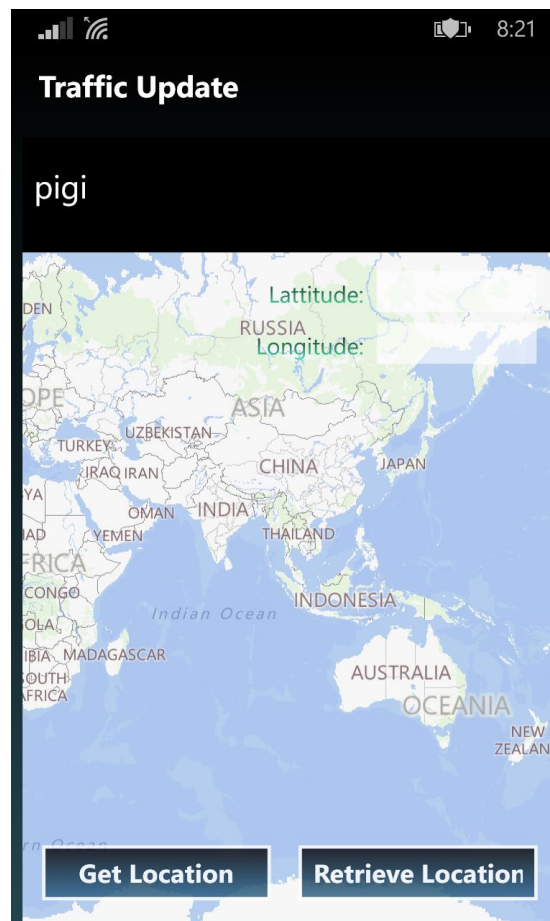


Figure: 8. Traffic Update

12.6 Traffic Update (cont.):

Here take the user's present location.

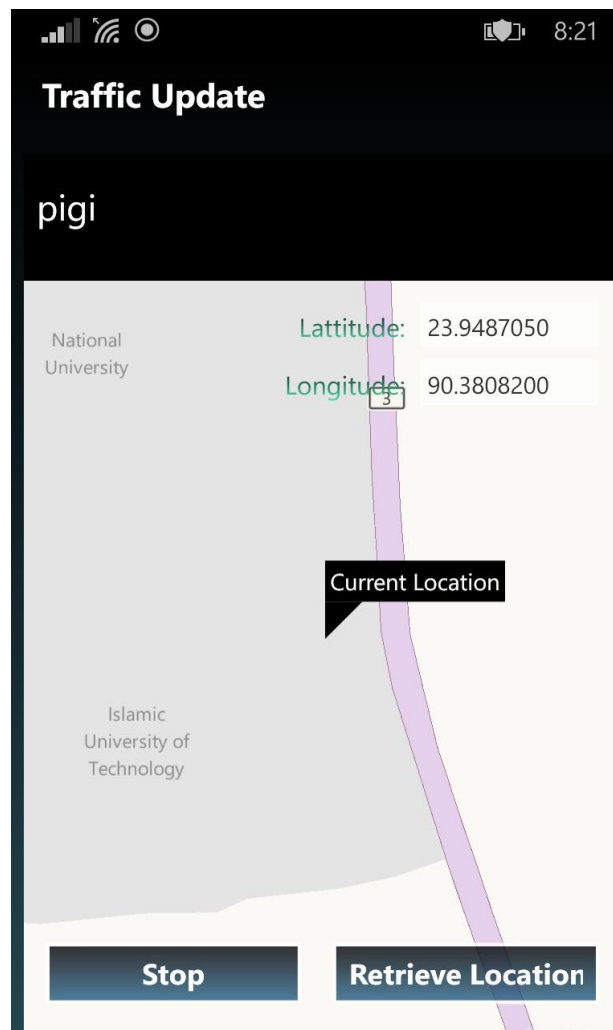


Figure: 9. Traffic Update (cont.)

12.7 Traffic Update (cont.):

Tracking vehicles current location.

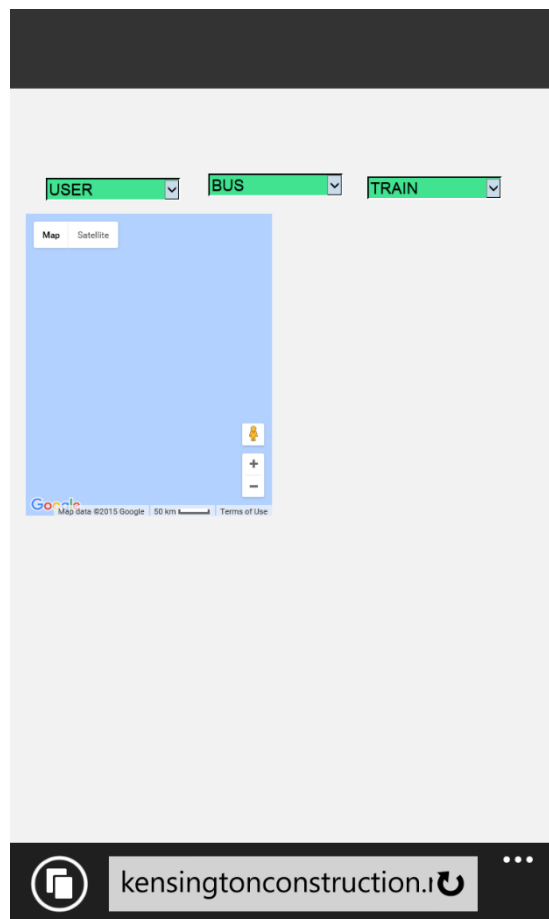


Figure: 10. Traffic Update (cont.)

12.8 Traffic Update (cont.):

User select his own define vehicle.

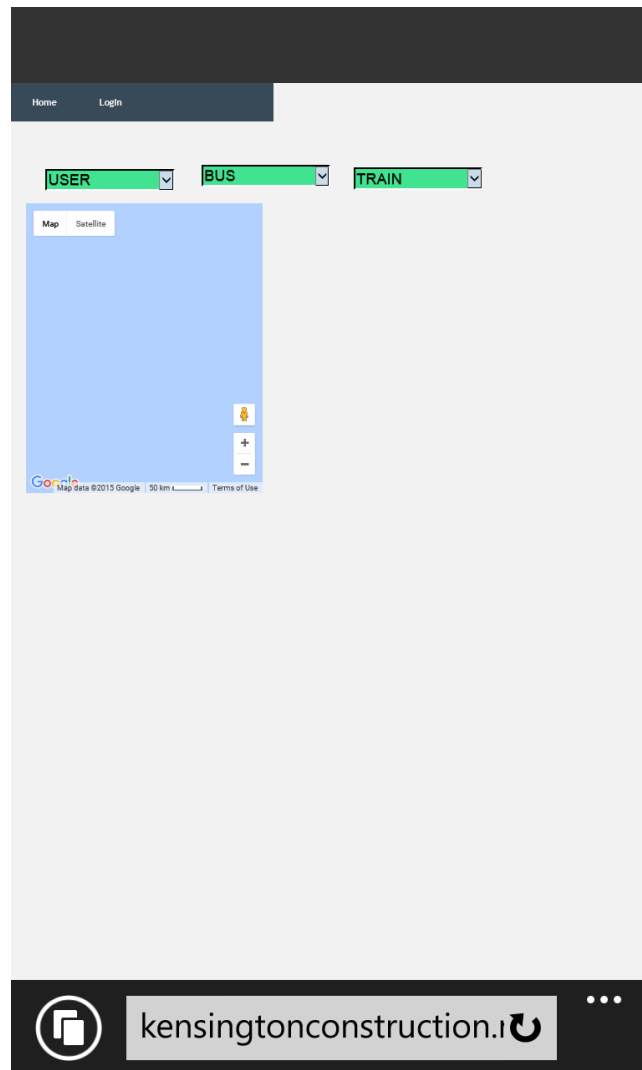


Figure: 11. Traffic Update (cont.)

12.9 Traffic Update (cont.):

Starting to show user's desired vehicles current location.

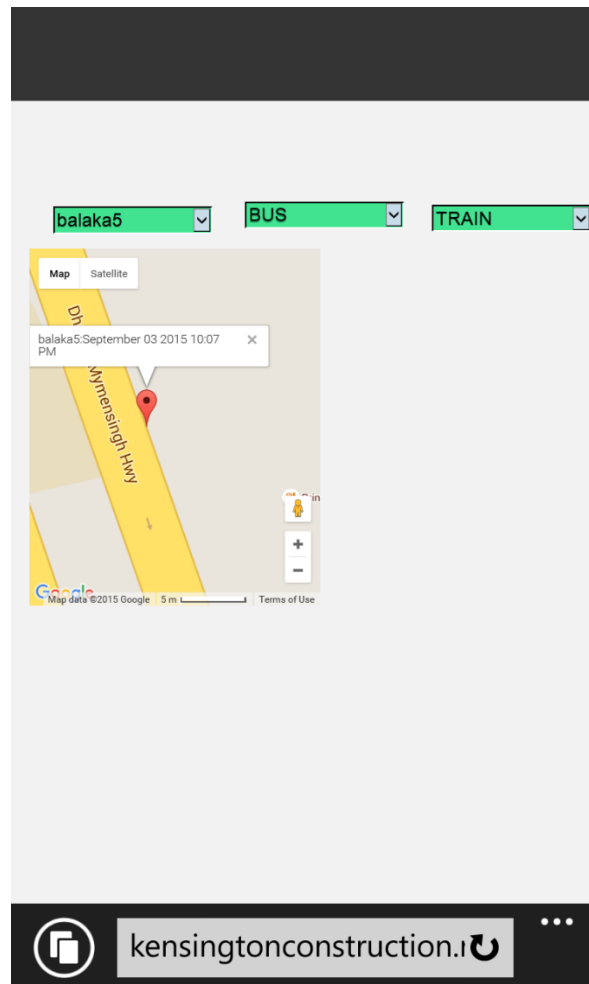


Figure: 12. Traffic Update (cont.)

12.10 Traffic Update (cont.):

Show the nearest vehicles location.

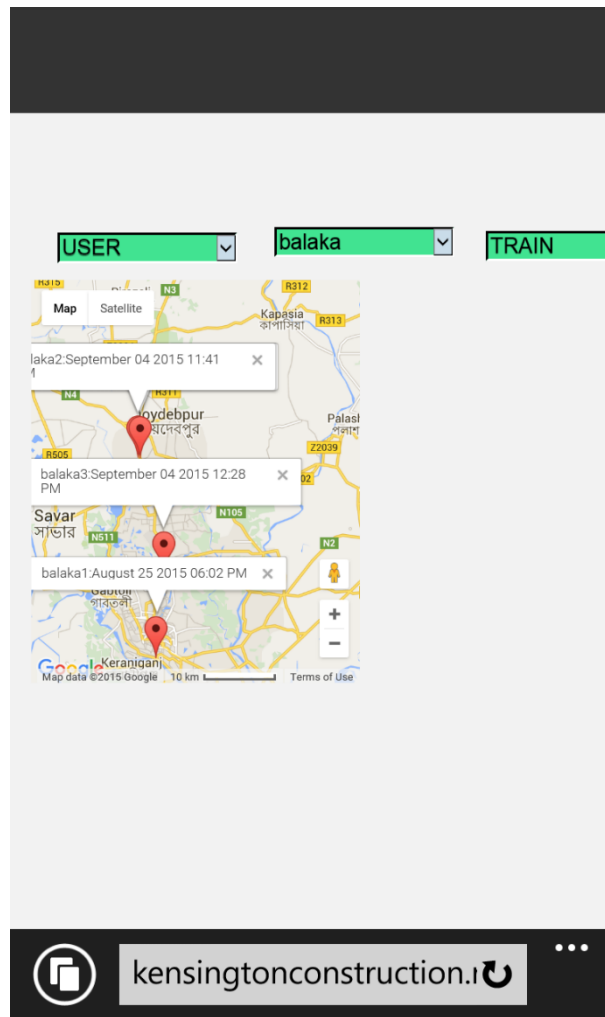


Figure: 13. Traffic Update (cont.)

12.11 Traffic Update (cont.)

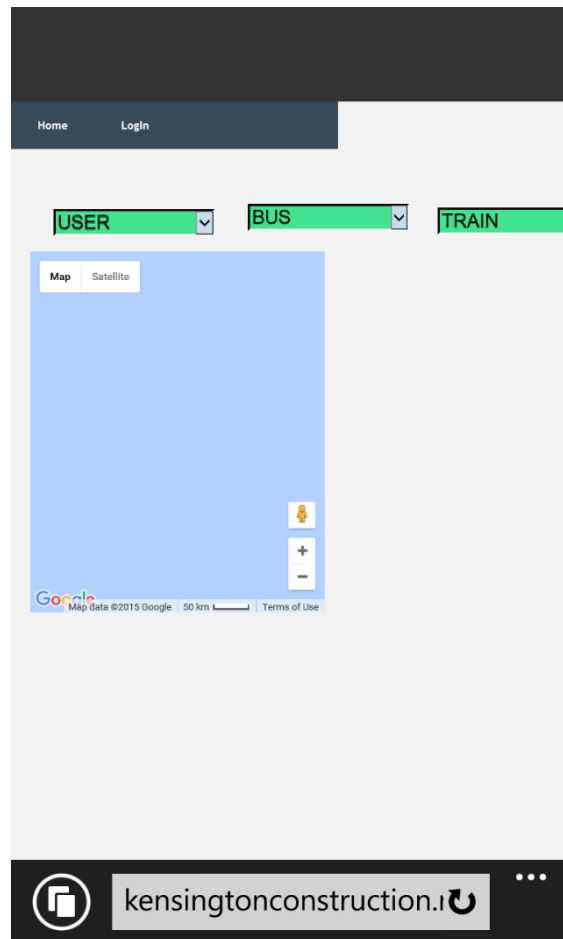
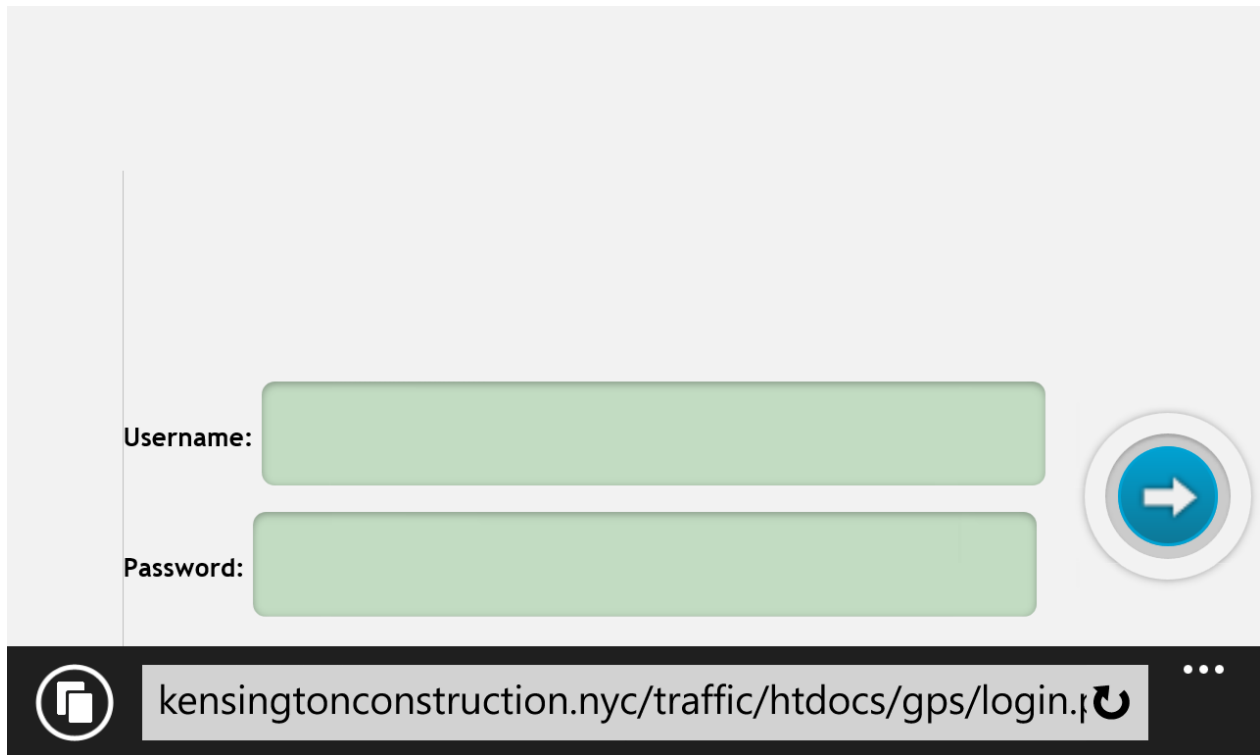


Figure: 14. Traffic Update (cont.)

12.12 Traffic Update (cont.) :

Registration of the vehicles.



The image shows a web browser window with a login form. The form has two input fields: "Username:" and "Password:". Both fields are currently empty and have a light green background. To the right of the password field is a blue circular button with a white right-pointing arrow. Below the form is a dark browser address bar containing the URL "kensingtonconstruction.nyc/traffic/htdocs/gps/login.php" and a refresh icon. On the left side of the address bar is a square icon, and on the right side are three dots.

Figure: 15. Traffic Update (cont.)

Chapter 13

Future Scope & Enhancement

Due to time constraints, we are planning at a later to enhance this app. The following points would be given emphasis on:

- Develop a full and integrated online based traffic update management system.
- Change the database from phpMyAdmin to Oracle.
- Providing e-payments facilities.
- Developing a multilingual system.
- Improve its user friendliness as well as security.
- Use GPS tracker on vehicle to track the exact location of a vehicle.

Chapter 14

Conclusion

The aim of this project is to build an app for people which will allow anyone to get vehicle update at any time. Moreover we tried to save the precious time of people.

Giving that no software project is never exhaustive and has always been subjected to continuous changes and improvements over time, we have settled future scopes and enhancement while hoping to give as much as possible our best knowhow to it.

Traffic Update vehicle tracking devices will combine both active and passive tracking abilities: when a cellular network is available and a tracking device is connected it transmits data to a server; when a network is not available the device stores data in internal memory and will transmit stored data to the server later when the network becomes available again.

Vehicle tracking has been accomplished by installing a box into the vehicle, either self-powered with a battery or wired into the vehicle's power system. For detailed vehicle locating and tracking this is still the predominant method.

