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GPS Assisted Traffic Alerting and Road Congestion Reduction Mechanism

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ABSTRACT

Traffic congestion is one of the major problems which almost all people face in their day-to-day life. Resources such as time, fuel and money are wasted because of this problem. Both government and non-government parties have taken many actions to reduce this problem but it remains as it was. There are some solutions which provide non-live traffic alerts through mobile phones such as Dialog SatNav, Mobitel T-Navi. Alternative Traffic Alert (ANT) system provides real time traffic alerts to road travellers, giving them the best condition, cost beneficial and optimal alternative route to use at a time of a traffic jam. ANT Solution is implemented with the use of Global Positioning System (GPS) based vehicle tracking, vehicle motion based traffic condition evaluation, mobile and web technologies. This ANT approach supports any mobile phone while other available systems only limited to SMART phones. In addition ANT also performs cost, distance and velocity calculations before determining the best and optimal alternative route.

1. INTRODUCTION

Traffic congestion is a critical problem in urban areas lasting mostly in peak hours. This problem gravely affects day-to-day life styles and movements of people.

There are several reasons that stimulate traffic congestion. One of the main reasons is the number of vehicles in a city. Other than that the shortage of parking facilities, inadequate facilities for pedestrians are also reasons behind this [1]. Poor public transport system of Sri Lanka also increases traffic congestion in urban areas.

According to the facts revealed by researches [2], even Sri Lankan economy has also got affected by traffic jam problems because of fuel wastage and loss of man hours. In the view of the general public it wastes not only fuel but also money and time, because it causes higher running cost to the owner of a vehicle. In addition, air pollution is increased due to traffic congestion, resulting decrease in quality of air. In that case human health would be in danger in the future as scientists predict [3].

Although the government has taken actions to reduce this critical problem, traffic congestions remain same as before. In such a situation ANT system can be used to reduce traffic jams.

Any mobile phone user (both SMART and non-SMART phone users) can use the proposed system. The traffic condition evaluation is conducted through the GPS data gathered from GPS devices fixed in cabs during a specific time period. The output of the system is to send a message to the user's mobile phone to make aware of the traffic situations, alternative routes, cost, time and distance to avoid traffic.

2. EXISTING SYSTEMS

Currently, there are some traffic alert systems in Sri Lanka to aid road users by providing real time traffic alerts. Dialog Plc provides real time traffic alerts through SATNAV system (http://www.dialog.lk/personal/mobile/features-and- vas/miscellaneous/satnav/). This system provides automated and voice supported navigation with the use of GPS data. It is implemented with a detailed map of Sri Lanka, which enables to assist navigating to and from any destination in Sri Lanka. More than 200,000 places of interest around the country and routes across 9 provinces are included in the map. 3D building views are displayed in this map. Voice support is available in user preferred English, Sinhala or Tamil language. In addition, SATNAV provides live traffic alerts, breakdown or road construction alert and special alerts by Sri Lanka police such as road closure, detours etc. Their system supports only a range of mobile devices due to its sophisticated technology.

Another GPS system called T-Navi partners with Mobitel to provide live updates on traffic jams or road congestion (http://www.mobitel.lk/tnavi). T-Navi solution is available in three formats. Mobile application for SMART phones, PND (Portable Navigation Device) to be fitted in vehicles and software SD card for 2DIN devices. This system consists of 3D moving map and voice guidance components. Map displays static as well as dynamic places of interest. Voice guidance is available in English as well as in Sinhala. The map automatically gets updated when new roads come up. T-Navi offers turn-by-turn direction to users and also direct users to destination through routes based on traffic condition. T-Navi system only works in SMART phones on IOS (APPLE OS), WM (Windows Mobile), Android and Symbian operating systems.

Sirasa FM reports from a helicopter on the traffic situation on the entry roads to the city during the rush hours in the morning. In addition to reporting they make the users aware about alternative routes to be used. They also reports about road constructions and accidents. There are more examples from foreign countries to reduce this problem. In Switzerland, they have developed a system which is very much similar to T-navi solutions in Sri Lanka [4]. The target audience is only SMART mobile phone users.

3. DESIGN OF ANT SYSTEM

The architecture contains six main components, main application, databases, motor traffic police mobile interface and Road Development Authority (RDA) web interface, Android application, Unstructured Supplementary Services Data (USSD) application and Apache Tomcat webserver.

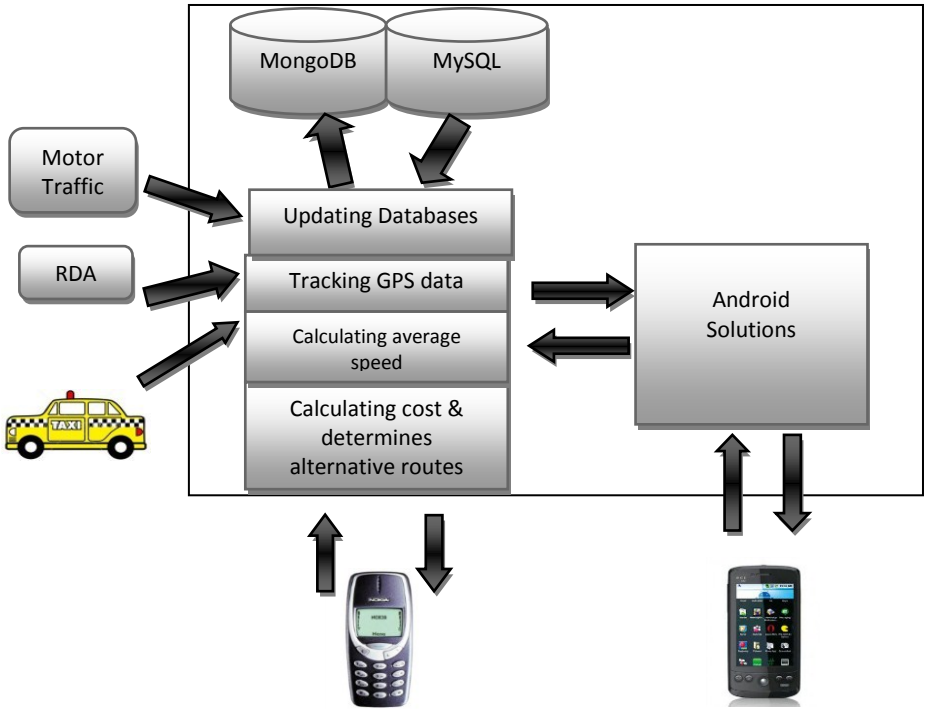

Figure 1: High Level Architecture of the ANT system.

3.1 Main Application

When Administrator logs into the system, the main application is switched on. Main application consists of panels such as alerts from RDA and motor traffic police, speed calculation of cabs, cost calculation for each route and retrieving all routes in maps.

3.2 Databases

ANT System uses two databases, MySQL and MongoDB to store data, the former to handle GPS data and latter to handle static data. Here, the GPS "data" are longitude & latitudes of cabs. Every ten seconds the main application connects with all the cabs and gets there location details and inputs those details into MongoDB. Cab details which travel in each route and condition & cost effectiveness of each route are stored in MySQL database. In addition data gathered from motor traffic police and RDA also stored in MySQL database.

3.3 Motor Traffic Police & Road Development Authority Web Interface

RDA can upload information into ANT system about road constructions before 24 hours of execution, about road constructions which are going to happen in a particular day through the web interface which is provided by ANT. As a result of it, road users can avoid that route to travel.

3.4 Android Application

ANT system provides an android application to android phone users. It consists of interface which user can send a message to main application in order to know the traffic condition. It also provides a user friendly map highlighting the route which user wants to travel, the place where the traffic jam is available and also the alternative routes to be used.

3.5 USSD Application

USSD application facilitates the user to send the route he/she wants to travel. For that, user can just send necessary data about the place he wants to travel through USSD. Through the mobile interface provided by ANT, motor traffic police can inform the ANT system about accidents happened at the moment via USSD technology. Not only that they can include the nature of the accident and the place where it happened in USSD.

3.6 Tomcat Web Server

As the main application and the Android application are two separate components in ANT system, Apache Tomcat web server is used in order to connect them. As a result of this combination, main application can develop the message and send it to the Android smart phone without any difficulty.

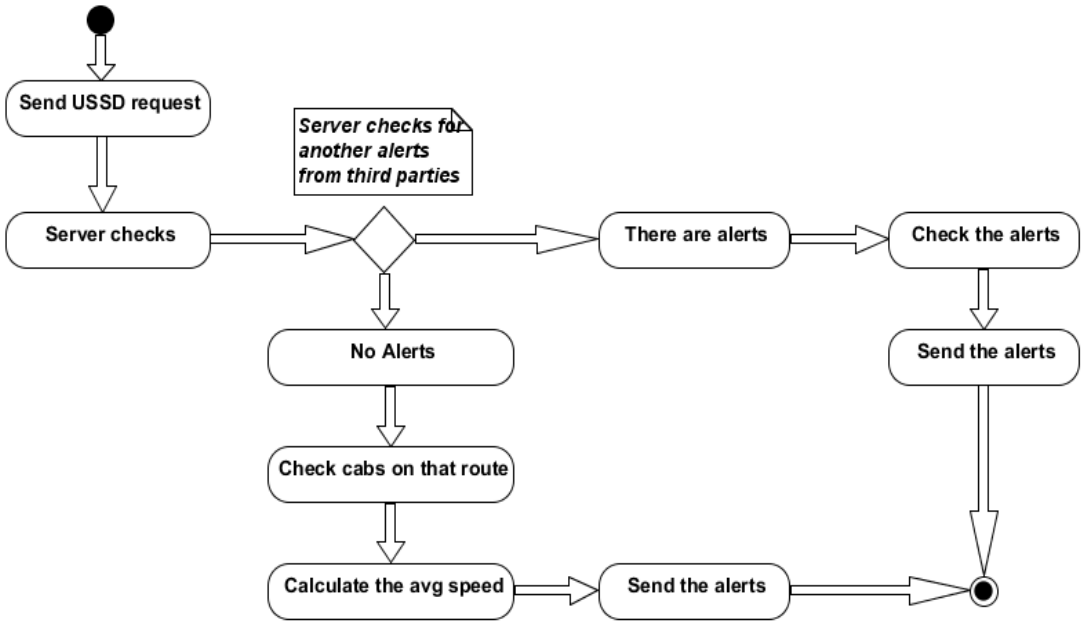

Figure 2: Activity Diagram of ANT system

4. IMPLEMENTATION

The project implementation is categorized into few sections such as implementation of the USSD application, implementation of the main application, implementation of the android mobile application and the implementation of the web application.

4.1 Implementation of USSD Application

This was developed for the use of normal mobile phone users and traffic policemen. Normal mobile phone users can invoke the application by sending a USSD request to #123#. Then the user has to choose the starting location and the end location by selecting a specific number which can be seen on the mobile interface. Only main towns are numbered there as for making the user friendliness since only ten inputs can be displayed vertically on a USSD request per once. Traffic policemen can invoke the application for feeding data by sending #119#. Then the route segment where the accident occurred and the type of the accident have to be chosen using the given digits displayed on the mobile interface.

4.2 Implementation of ANT Main Application

To implement the main application of the ANT system, Java Enterprise Edition (J2EE) platform is used. First the application checks the latest requests done by the users. Then it checks the availability of the stated route segment by searching the motor traffic police and RDA updates. If there are alerts found, then send the alert to user. This alert contains the traffic information and the best alternative route that can be used instead of the main route. If there are no such alerts then the system checks the cabs which are on the particular route segment. Then the GPS data of the cabs are taken into account, putting them into Mongo database and calculate the speed of each cab [5]. Finally system will calculate the average speed of the cabs and send the alert to the user. If the average speed is greater than 40km/h [6], alert stating that "The route can be used" will be sent to the user. If the average speed is less than 40km/h, alert stating that "Traffic exists!" will be sent to the user. This alert will also consist of the best alternative route that can be used instead of the main route. To obtain the best alternative route, Dijkstra algorithm is used [4]. Dijkstra shortest path algorithm efficiently finds shortest paths in a graph. It is applied to automatically find directions between physical locations, such as driving directions on websites like Google Maps.

4.3 Implementation of Android Mobile Application

This is developed using Android SDK technologies especially for the Android mobile phone users. Android 2.2 – "Froyo" version is used as the version of the system and Google API level 8 is used as the Google API level. First the user has to enter the two entries as before. Then the user inputs will be transferred to the main ANT system. As shown in Figure 3, a map will be loaded and main route will be highlighted. If there is a traffic jam on the particular highlighted route, a flag will be appeared on the route where the traffic jam occurred. All these information are exchanged through the main server where the main two databases are located. Using Simple Object Access Protocol (SOAP), the data will be loaded to android application from the main ANT application.

From the parameter class it generates the Web Services Description Language (WSDL) file since from the WSDL file client can send and expect to receive the message. If there is a traffic jam on the particular main route the best optimal alternative route will be shown as in Figure 4. On both occasions the cost of each route will be calculated and send to user along with the alert.

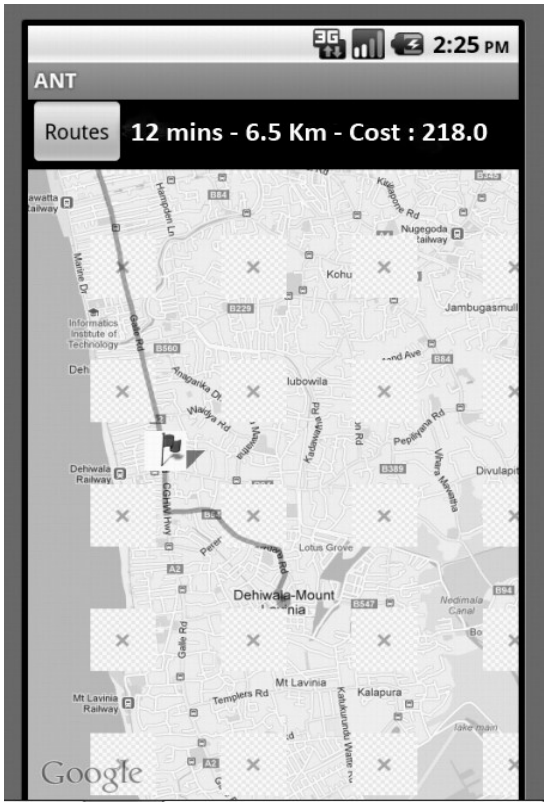

Figure 3: Highlighted main route

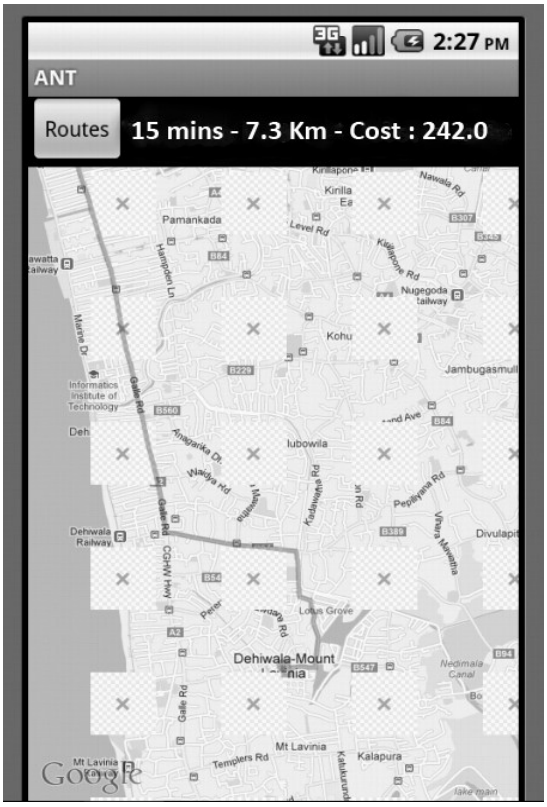

Figure 4: Highlighted alternative route

4.4 Implementation of Web Application

As per the pre-determined requirements, a web application interface was developed for RDA and motor traffic department for updating their news which were synchronized to the main databases in ANT system. Motor traffic police can update the web site when a road accident occurred. RDA section of the web interface would be updated when a RDA construction on the route is in progress. Users have the privilege of getting those alerts by surfing the web site.

4.5 Speed Calculation and Cost Calculation

Speed calculation of each cabs and retrieving the average speed of them play a major role in ANT solution. For achieving this purpose it is necessary to get the distance between two places on a particular cab's route and divide it from the corresponding time interval. The main input of the proposed system is GPS data. Those data include longitude, latitude and designated number of each cab. Here it is using a cab service

(such as Nanocabs) to get those data. Getting GPS data will be done using digital receiver electronic techniques [7].
System receives those GPS data in every ten seconds and stores them in a table called "traffic" in mongo database. After that system converts the longitudes and latitudes into kilometers since speed calculation cannot be done using longitudes and latitudes. "Haversine algorithm[1]" is used to convert those GPS values (longitudes and latitudes) into kilometers [8]. Then for a specific time period those distances will be calculated, get the difference between the distances and calculate speed per each cab. Then average speed of all cabs will be determined and based on the results necessary actions will be taken.

In cost calculation first the distances between the destinations will be determined. For this purpose also "Haversine algorithm[1]" will be used. Then if the distance is greater than 1 kilometer, for the 1st kilometer the cost will be Rs. 50 (call up charge). Then for every additional kilometer charge will be Rs. 30. Waiting (in traffic or parked) charge will be Rs. 1.50 per minute. These are the steps of calculating the cost and this is calculated for each route including the main route and alternative routes.

4.6 Determining the shortest path

Shortest path determination is one of the main functions in the ANT system. Obtaining the traffic alerts of the place where the traffic jam has occurred is not sufficient to the travellers. ANT system provides not only the live traffic alerts but also the alternative shortest routes, which can be used instead of the main routes. This is one of the key aspects where the ANT system differs from the existing traffic alerting systems which were mentioned earlier in section 2. "Dijkstra algorithm[2]" is used to determine the shortest path from a given set of routes network [4].

One of the central procedures of getting the shortest path is the Dijkstra labeling mechanism. This Dijkstra algorithm solves single source shortest path problem on a directed and weighted graph but only when all of the edge-weights are non-negative [4]. Here, it maintains a number of vertices. In Google Application Programming Interface (API), the vertices attached to any path in between starting point and the destination will be automatically determined. It repeatedly searches the different combinations of edges and vertices attached to the path of given starting point and the destination. It maintains a priority-Queue based on edge length, which determines via heap along the period. As a result of these steps, we can retrieve the shortest path of a route network [4].

5. CONCLUSION & FURTHER WORK

ANT system has been successfully implemented up to the expected level and the goal has been achieved for a set of selected routes. This system is implemented to help all road users to save their valuable time, money and fuel. The system has been tested with simulated GPS data and it will guarantee for the actual GPS data. Main features such as calculating the speed of each cab, retrieving the average speed, cost calculation for each route and identifying the best optimal alternative route are perfectly functioned.

There are several future enhancements that can be performed to improve the usability and other functional and nonfunctional performance of the ANT system. As per now only motor traffic police and RDA act as the external data providers for the system. In future it is planned to get more data using crowd sourcing methods. Here, the system will be providing premium accounts for the customers who use the system frequently. For this moment only one person can invoke the system at a given specific time. It is planned to enhance the system, which can be invoked by multiple users at a given time by integrating parallel processing technologies. Finally it is planned to build up a data repository for storing data related to the system and use it for the data mining technologies and pattern recognition in future.

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