Remote Vehicle Tracking System using GSM Modem and Google Map

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***Abstract*- Around the world and in Malaysia, the number of vehicles theft cases has been increasing at an alarming rate whereas the rate of recovery of the stolen vehicles is still minimal. Furthermore, many service provider companies lack proper fleet management system which causes low efficiency of services and reduced profit as the company could not monitor transportation operations. A real-time remote vehicle tracking system is one of the possible solutions to overcome these issues.**

This paper presents the development of the remote vehicle tracking system which integrates the Global System for Mobile Communications (GSM) Modem and Google Map. The GSM modem at the control center will receive the coordinates through Short Message Service (SMS) and updates the main database. The information then will be accessed by the website and the position of the vehicle will be displayed through the Google Maps application. A website has been developed to aid the user to track and view the vehicles' location and can be access anytime and anywhere as long as Internet connection is available. The three working functions are the latest tracked vehicle location, route history and route planner. The developed remote vehicle tracking system demonstrates the feasibility of real-time tracking of vehicles, which can be used for many applications including vehicle security and fleet management.

I. INTRODUCTION

The adoption of remote vehicle tracking system for fleet management and vehicle safety is still relatively small. Nevertheless, it is expected to grow significantly in the near future. According to independent analyst firm Berg Insight, the number of fleet management units deployed in commercial fleets in Europe is projected to grow from 1.5 million units in 2009 to 4 million in 2014 [1]. This shows the rapidly expanding market of the remote vehicle tracking system.

Remote vehicle tracking systems have been available in the market for some time. Their performance is commendable and they can track the vehicle's locations in real time [2]. However, there are still some shortcomings that can be addressed to improve the current systems. Firstly, the users often face difficulties in accessing and viewing their vehicles' location in a user friendly graphical interface. Secondly, the subscription cost to maintain their active operation can be prohibitive. Thirdly, these systems are not easily customizable.

In this paper, we propose and build a working prototype of a remote vehicle tracking system that can overcome all the issues highlighted above. The proposed system will be integrated with Google Map to ease users in viewing and locating their vehicle whenever and wherever as long as there is an internet connection (remotely accessible). Furthermore, the system will use the inexpensive Short Message Service (SMS) to transmit the location information. The SMS cost can be as cheap as 1 cent per SMS, depending on usage and service provider. Last but not least, the system is simple and can be easily customized for a variety of applications since it uses the popular Google Map Application Programming Interface (API) and common website programming languages.

Google Map was successfully introduced by Google to the communities several years ago and is now one of their most popular applications. Google Map is now the de-facto web mapping service application. By introducing Google Map API, endless possibilities have now opened for users to create their own Google Map applications. Google Maps has a wide array of APIs that allows users to embed the robust functionality and everyday usefulness of Google Maps into their own website and applications, and overlay their own data on top of them. It is for these reasons that Google Maps has been chosen in this work.

The simple and popular SMS service allows users to send up to 160 characters through the Global System for Mobile Communications (GSM) network. It has become of the most widely used data application in the world. Furthermore, most operators charge a minimal cost for their usage. For this work, the SMS is sufficient for sending the location information. Coupled with the wide area coverage of GSM Cellular Network around the world and in Malaysia [3], the remote vehicle tracking system will be able to operate in most parts of the world.

The proposed remote vehicle tracking system can be modeled using communication system architecture. It consists of a transmitter to send information, a medium for the information to be transferred and a receiver to receive the information. In the context of this paper, the transmitter will be simulated by a mobile phone, which is used to send the location information through Short Message Service (SMS). The GSM Cellular Network will be the medium for the information to be transferred. Finally, the GSM Modem which is installed and attached at the Control Center (personal computer) will act as the receiver to receive the SMS.

The rest of this paper is organized as follows. In Section II, the proposed remote vehicle tracking system will be described. The results of the prototype and discussions are given in Section III. Finally, Section IV concludes the paper and provides suggestions for future work.

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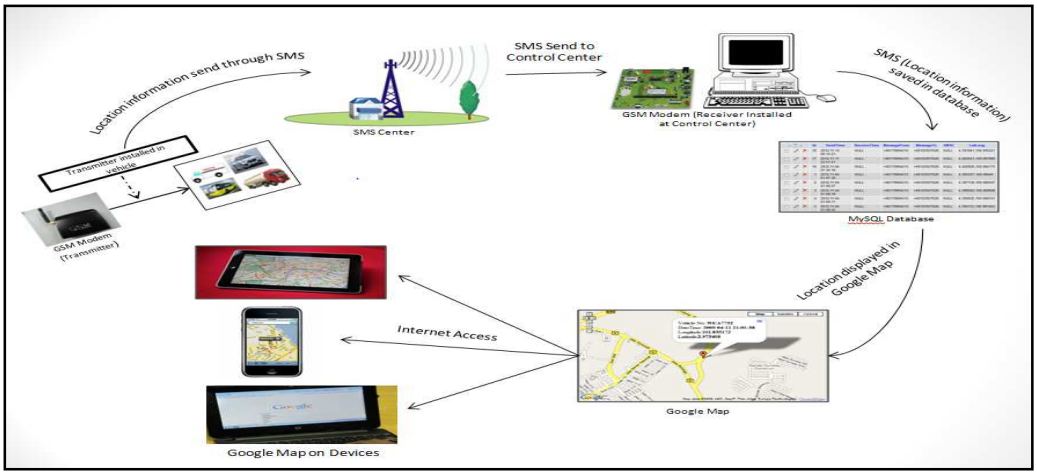


Figure 1: Remote Vehicle Tracking System Block Diagram

II. Remote Vehicle Tracking System

The proposed remote vehicle tracking system's block diagram is shown in Fig. 1. Firstly, the transmitter will be installed in the vehicles. The transmitter's function is to send the location information of the vehicle. These transmitters will be powered by the vehicle's battery system. Figure 2 shows an example of the transmitter, the Intellitrac's X1 [4]. Next, the location information will be send using SMS through the GSM service provider's SMS center. The GSM Modem installed at the control center will receive the SMS and update the location information in the MySQL Database. The location information then will be displayed on the Google Map embedded on a website and can be access remotely whenever and wherever through an internet connection.

The transmitter (client) side can be implemented using a GPS receiver to obtain the location and a GSM modem to send the location to the control center (server). The frequency the location data is sent can also be preset, on-demand or even dynamically assigned by user depending on the complexity of the system. However, in this project, the transmitter will be simulated by a mobile phone as it is out of the scope and is not the focus of this work. For the GSM Modem at the control center, the U-Blox EVK-G26H evaluation kit as shown in Fig. 3 is used as it provides better support for developmental purposes [5]. A simpler GSM Modem can also be used to replace above model once the prototype works according to the requirements. The GSM modem will pass on any received SMS to the SMS server system installed at the control center. For this project, the Diafaan SMS software [6] is used as it offers good connectivity with MySQL database. Finally, the location information from the database will be displayed on the Google Map display on a website.

The system can be setup using the following procedures:

- Install the transmitter in vehicle by connecting to the vehicle's battery system. Ensure that the transmitter is able to send location information through SMS (simulated by a mobile phone).
- Install the GSM Modem at control centre (user's personal computer).

Figure 2: X1 Transmitter [4]

Figure 3: EVK-G26H [5]

- Setup the SMS server system. Test the system by receiving SMS from the GSM Modem.
- Prepare the Google Map API code and script. Compile all the code and script in a website template to ease the user to use it.
- Test the integrated system by using the transmitter to send location information to GSM Modem and check the displayed location in Google Map API.

The integration between the GSM Modem and Google Map is the core and the most important part of the system. It can be divided into several components. The first component is the SMS Server which will serve as a platform to enable the GSM Modem at the control center to receive the location information from the transmitter through a SMS. The second component is the MySQL database which will store all the received SMS. The third component is the Google Map API which will display the location information through a Google Map. All the system functions, which consist of codes from JavaScrip, PHP, and HTML languages, are compiled in a website template to ease the users to access and use it.

The project starts with the installation and configuration of the GSM Modem at the control center (personal computer). The GSM Modem can be easily set up by connecting the modem's and computer's USB ports. The user can choose any available COM port to connect the GSM Modem device to the computer. Figure 4 shows the gateway properties of the GSM Modem.

A. SMS system

After setting up the GSM Modem, the next step is to setup the SMS aystem. Diafaan SMS Software was chosen as the SMS system [6]. Diafaan SMS Software offers a good connectivity with database such as Microsoft Access and MySQL. The detailed procedures and method to setup the SMS software can be found online [6]. After verifying that the SMS system is able to successfully receive SMS from transmitter, the next step is to integrate the SMS System to a MySQL database. This can be accomplished by editing the connector string properties in the SMS Software using the syntax as shown below:

Driver= {MySQL ODBC 5.1 Driver}; Server=localhost;
charset=UTF8;Database=smsdatabase;User=root;
Password=;Option=3;

It is important to note that the command will only work if a MySQL database is already setup. The connector string properties such as Username, Password, MySQL version, and MySQL database name can be edited according to the user's requirement and preferences.

After all the previous procedures have been completed, it is advisable to test the connection between the GSM Modem and SMS System by sending a SMS to the GSM Modem at the control center (the number depends on the SIM card inserted to the modem). Figure 5 shows the received SMS from the transmitter at the SMS server system and Figure 6 shows the MySQL database that has recorded the SMS received from the SMS server system. The reason to link the SMS server with MySQL database is because it will be easier for the Google Map API script and code to fetch the required information such as latitude and longitude (LatLong) and date and time (in order to identify the chronology order of the location) as the codes and scripts are written in PHP and HTML format.

B. Google Map

To display the tracked vehicle location information in a user friendly graphical interface, Google Map was chosen among other Web Mapping Service Application. Google had provided a Google Map Application Programming Interface (API) under Google Developer site for users who are interested to develop their own Google Map Application [7]. Google also provides good support to the developers by documenting all the JavaScript functions and syntax under the Google Developer's website. Google Map API v3 is the latest version and has additonal functions. However, in this paper, Google Map API v2 was used instead due to its better technical support from an established group of developers.

The next step is to develop the Google Map API codes and scripts which serve the function to display and present the received coordinate into a graphical method which is in Google Map. The first part is to connect the PHP code to the MySQL database. The required parameters that need to be declared in PHP before being passed to the HTML and JavaScript side are as follows:

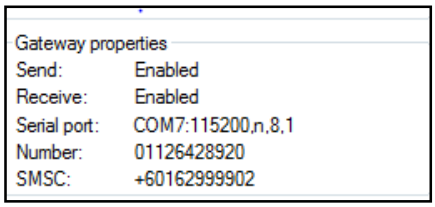


Figure 4: GSM Modem Gateway Properties

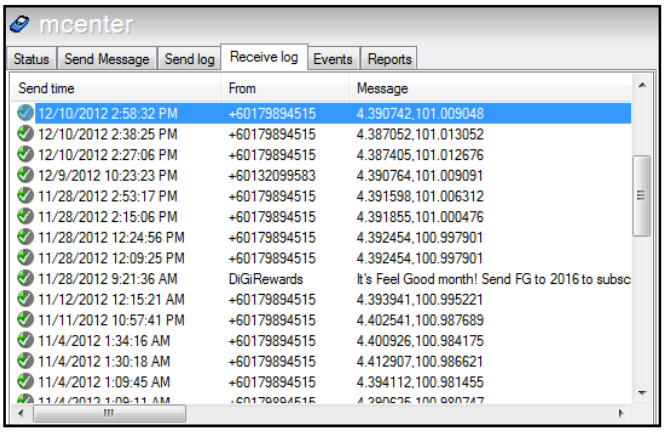
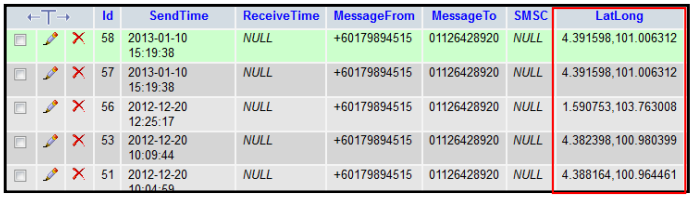


Figure 5: SMS Server System Receive Log



Id	SendTime	ReceiveTime	MessageFrom	MessageTo	SMSC	LatLong
58	2013-01-10 15:19:38	NULL	+60179894515	01126428920	NULL	4.391598,101.006312
57	2013-01-10 15:19:38	NULL	+60179894515	01126428920	NULL	4.391598,101.006312
56	2012-12-20 12:25:17	NULL	+60179894515	01126428920	NULL	1.590753,103.763008
53	2012-12-20 10:09:44	NULL	+60179894515	01126428920	NULL	4.382398,100.980399
51	2012-12-20	NULL	+60179894515	01126428920	NULL	4.388164,100.964461

Figure 6: MySQL Database

list($latitude, $longitude) = explode(",", "$latlong", 2);

It should be noted that above statement is very important as the function is used to split the information from the LatLong column (as shown in Fig. 6) into 2 different strings which is Latitude and Longitude. The second part is the JavaScript which will basically generate the Google Map and displays the location on the web browser. This part consists of two important components which is the variable declaration and the Google Map function.

For the variable declaration, the Google Map API Key needs to be included (note that Google Map API v3 does not require a key). The variable declaration function need to be included again in HTML as it is needed to fetch the information from the PHP side. All the information will be stored in arrays in order to ease the Google Map API to fetch the required information. Next, the Google Map function is used to generate the required Google Map. The inputs of this function include variables such as latitude, longitude and time that have been fetched from the MySQL database. The latest position of the tracked vehicle will be shown in the Google Map after the program code has been executed. Following are

parts of the statement and syntax of the Google Map function.

```
var map = new GMap2(document.getElementById("map"));
map.setCenter(new GLatLng(lat[0], long[0]), 30);
```

The above statement is used to declare the map as variable in order to display the map in the website. And the statement below is used to print out and display the Google Map on browser with predefined width and height (size) of the map.

```
</head>
<body onload="setupMap()" onunload="GUnload()">
  <div id="map" style="width: 750px; height: 350px"></div>
```

More details of the Google Map API syntax and function can be obtained from Google Map Developer Site [7].

Finally, other necessary software that are required to setup a website such as Wampserver which is use to host the PHP and HTML webpage via local-host and good for experimental webpage before hosting it online, and Macromedia Dreamweaver for PHP and JavaScript scripting can be used. Features such as design view in this software is essential to design and check the layout of the website before executing and hosting online.

III. Results (Prototype) and Discussion

In the remote vehicle tracking system prototype, there are three working functions:

- Track Latest Vehicle Position
- Track Latest Vehicle Route
- Destination and Route Planner

Website - Main Page

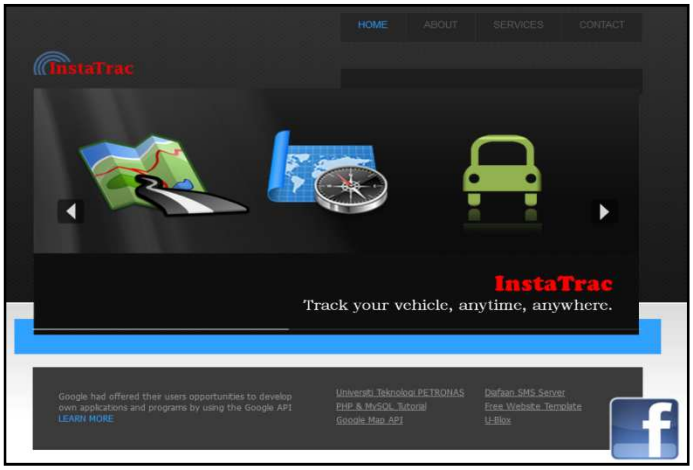


Figure 7: Main Page of Website

Figure 7 shows the main page of the website. It contains links to other pages such as ABOUT, SERVICES, and CONTACT and can also be linked to other website pages that can be used as sources of references.

Track Latest Vehicle Position

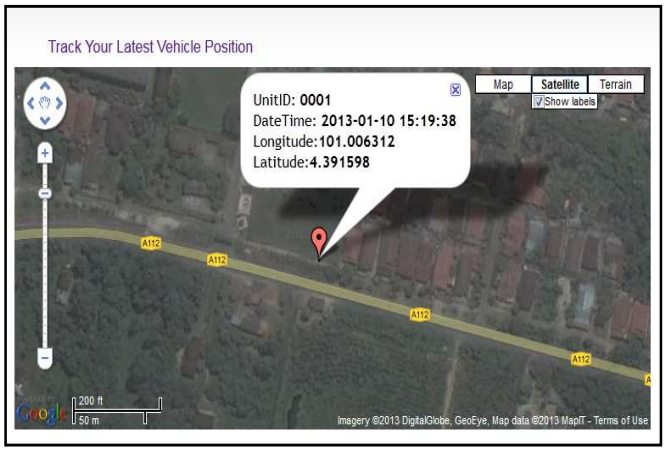


Figure 8: Track Latest Vehicle Position Function

This is the most basic function which shows the latest position of tracked vehicle. Upon execution, the latest coordinate will be selected from the database and will be displayed on the Google Map as shown in Fig. 8. The information window is also included which shows the latitude, longitude, date and time of the location.

Track Latest Vehicle Route

The function as shown in Fig. 9 which shows Latest Vehicle Route based on the user's input is the expansion of the first function. For example, the user can use this function to preview the last 5 locations of the vehicle. Note that Fig. 9 is the result after the user has keyed-in the required number of locations.

Figure 9: Track Latest Vehicle Route Function

Destination and Route Planner

The user can use this function as a route planner. The user has to just key in the preferred location (in the red highlighted box) as shown in Fig. 10. The function will then generate the suggested route to the user. In Fig. 10, the location of the route starts from the latest location or the location selected from the database.

The route planner function can also simulate the route selected. Fig. 11 shows the vehicle moving in animation mode

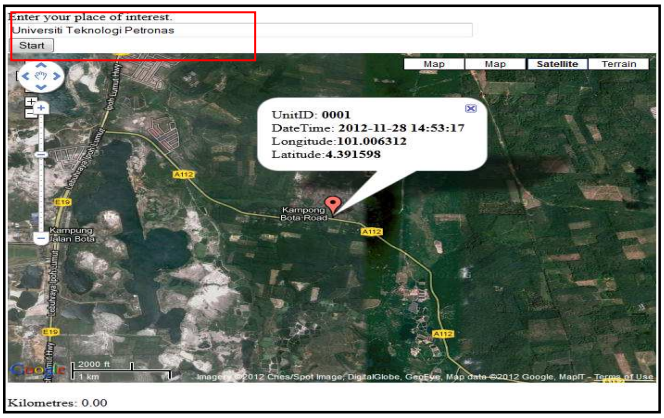


Figure 10: Destination and Route Planner (Current Location)

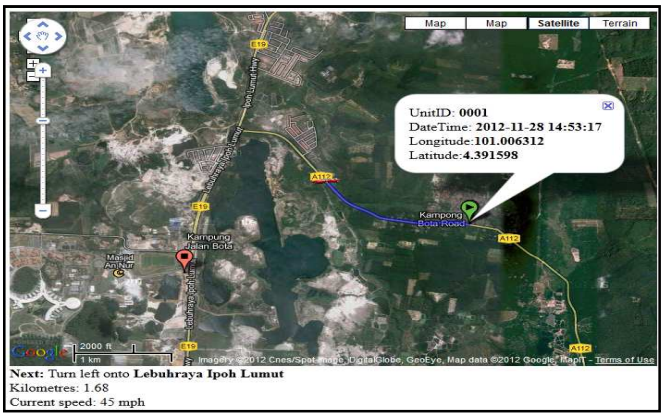


Figure 11: Destination and Route Planner (Vehicle Moving)

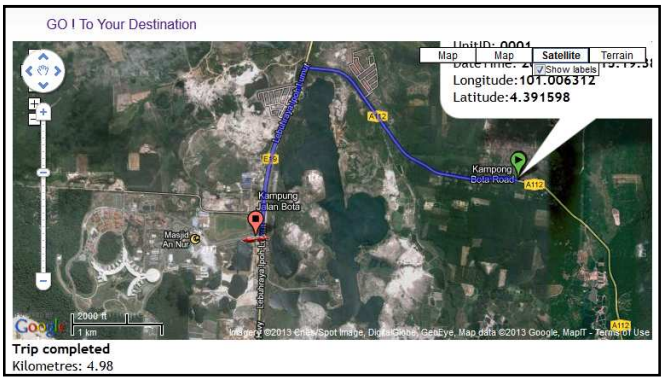


Figure 12: Destination and Route Planner (Vehicle Reached Destination)

towards the destination. The speed of the vehicle in the animation can be changed and for more functionality, the pause button can also be added to pause the animation. Figure 12 shows that the vehicle animation has stopped and the trip had been completed. The total travelled distance is also displayed.

All the listed functions have been tested and are working as per the requirements. Other useful functions and features can also be added to enhance the current system. For example, an application to track the up-to-the-minute graphical location information of each customer's parcel for a courier company can be realized with such a system. The potential applications that can be provided by the remote vehicle tracking system are enormous.

IV. Conclusion and Future Work

In this paper, a remote vehicle tracking system with its prototype have been developed and demonstrated. The system integrates a GSM Modem which will receive SMS containing the location information and displays it on the Google Map application. The graphical location information is hosted on a website so that it can be accessed remotely through the internet. The capability of such a system is shown through three working functions that can display the latest vehicle location, route history and route planner. The remote vehicle tracking system demonstrates the feasibility of real-time tracking of vehicles, which can be used for many applications including vehicle security and fleet management.

There are still several improvements that can be carried out in the future. For example, the system can be tested with a transmitter that is able to send the locations in real-time. Furthermore, several field tests can also be carried out in collaboration with the transportation companies. Finally, a fully integrated system in a box can be developed for commercial purposes.

Acknowledgment

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