Real-Time Tracking Management System
Using GPS, GPRS and Google Earth

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Abstract—Due to the high cost of fossil-based energy, several methods are proposed to reduce the usage of the energy in logistics and fleet management to be even more. GPS tracking system is a common approach to get vehicle location information in real-time for fleet planning. We proposed a GPS tracking system called Goo-Tracking that is composed of commodity hardware, open source software and an easy-to-manage user interface via a web server with Google Map or via Google Earth software. The system includes a GPS/GPRS module to location acquisition and message transmission, MMC to temporary store location information, and an 8-bit AVR microcontroller. Our system prototype is shown and tested on a trip from Bangkok to Chonburi. It has shown great stability and also robust message transfer protocol that most of locations are accurately acquired and transmitted to the server in real-time.

I. INTRODUCTION

Effective transportation and logistics has become a very important part of business due to the continuously increasing oil price. Several efforts have tried to deploy methods of making transportation even more efficient to reduce cost due to the increasing oil price. Vehicle tracking is one of the methods to reduce the cost by knowing in real-time the current location of a vehicle such as a truck or a bus. The location of a vehicle is used by a fleet operator to efficiently plan a schedule in order to reduce the transportation time and distance. This research introduces a vehicle tracking system using Global Positioning System (GPS) [1] for positioning, General Packet Radio System (GPRS) [2] for data transmission, and Google Earth software for location displaying.

The tracking system can also be very useful for Intelligent Transportation System (ITS) [3]. For example, it can be used in probe cars to measure real-time traffic data to identify the congesting area. It can also be a life saver in an emergency case to quickly and automatically report a vehicle position to a rescue agent when an accident happens to the vehicle. In addition, it can be attached to a vehicle with an anti-theft system to identify its location when it is stolen.

Our proposed system offers a real-time tracking system using a client-server model. Our client is an embedded device with a GPS/GPRS module to identify device location information that is periodically transmitted to a server. Our server is a personal computer with a web server program to receive the location information that is then converted into the format that can be displayed by using Google Earth software or Google Map technology. Therefore, our proposed system for real-time tracking management system is called Goo-Tracking.

The rest of the paper are as follow. We review related technology in Section II. In Section III, we propose the system architecture and implementation of the GPS tracking system. Section IV, shows the system prototype and some screenshots of our proposed work. We conclude our work and our future work in Section V.

II. BACKGROUND

A. GPS Technology

Global Positioning System (GPS) is a system composed of a network of 24 satellites of the United States, which are originally used in military services, and later allowed for commercial use. The satellites periodically emit radio signal of short pulses to GPS receivers. A GPS receiver receives the signal from at least three satellites to calculate distance and uses a triangulation technique to compute its two-dimension (latitude and longitude) position or at least four satellites to compute its three-dimension (latitude, longitude, and altitude) position. Once a location is computed, it can calculate an average speed and direction of traveling. Therefore, GPS is a key technology for giving device its position.

B. GPRS Technology

General Packet Radio Service (GPRS) is an enhancement of GSM networks to support packet switched data services such as email and web browser in addition to existing GSM data services such as Short Message Service (SMS) and Circuit Switched Data (CSD) for fax transmission. GPRS operates on the existing GSM network infrastructure that it utilizes available time slots during each frame transmission. Thus, it does not overload the existing GSM network traffic and can efficiently provide data services. The GPRS can transfer data at the maximum rate of 115.2 kbps (with the eight available slots of each frame). Due to a very large coverage area of GSM networks around the world, GPRS becomes the largest data service network available and always-on; thus, it is most suitable for a real-time tracking management system.
Google Earth and Google Map

Google Earth is a very popular free software that provides maps by satellite images around the world [4]. Google Map is a version of Google Earth that shows the maps on-line using a web server and a web browser. The program provides plug-ins for community to show objects in the program. Such objects are, for example, 3D objects of skyscrapers using Sketch Up software, pin objects to indicate a point of interest (POI), and line objects to show a track. To show such objects, Google Earth utilizes its own programming language called KML (Keyhole Markup Language) [5] which is an extensible markup language (XML) that is written to describe how the objects are rendered. The KML-based objects can also be used with Google Map to show line and pin objects. In our proposed system, we employ Google Earth software and Google Map as our choices of track displays to show locations of vehicles.

III. PROPOSED SYSTEM AND IMPLEMENTATION

Our real-time tracking management system is an open system that uses a free and open source software and is composed of commodity hardware that is easy-to-find. Our system is composed of three components, a GPS Tracking Device, a server and a database as shown in Figure 1. The GPS tracking device is an embedded system that transmits location information to the server through GPRS networks. The server is a personal computer that receives the information and puts it in the database. The database formats the information in a special form that can search and display using Google Earth software or Google Map.

A. GPS Tracking Module

The GPS Tracking Module is based on the 8-bit AVR RISC microcontroller which is a low power MCU with 32k ROM and 2k RAM and has several peripherals such as UART, SPI and I2C to connect to GPRS/GPS module, MMC module and GPIO Control module respectively as shown in Figure 2. The UART interface is connected to all-in-one GPRS and GPS module. The module has two functions, the GPS function locates device’s position and the GPRS function transmits the device’s location to the server. The SPI interface is connected to MMC module that stores position information when the communication is not available or for backup. The information is stored in FAT file system format for easy transfer to a personal computer. The I2C interface is connected to GPIO Control module which an I/O interface to control external devices such as a car alarm system or a Electronic Control Unit (ECU) of a vehicle for immobilization.

B. Goo-Tracking Firmware

The firmware of the GPS Tracking module is written and compiled using an open source AVR compiler [??]. The firmware performs three phases, the initialization, the GPS position reading, and the GPS data formatted and transmitted to Goo-Tracking server via GPRS networks.

The initialization phase prepares the module for reading and transmitting location information. It is composed of three functions. The first function is to initialize parameters on AVR microprocessor for UART, SPI, GPIO and timer for GPS reading. The second function is to initialize GPRS/GPS module to set up parameters to warm up GPS engine, to make a connection to a GPRS network and to connect to the server via TCP/IP socket. The third function is to initialize MMC module into SPI mode for data read/write.

In the GPS position reading phase, the MCU sends a series of AT commands to GPRS/GPS module via the UART port. To acquire the current location of the device, we issue the AT+WGPSPOS command to get the data in NMEA standard format.

In the GPS data formatted and transmitted phase, the NMEA-formatted data is then parsed and convert to our own format as shown in Figure 3. The format includes the device ID, session ID, time in UTC format, flags, latitude, longitude, speed, date, and reserved (Rsv) fields. Each line ended with the symbol (^) represents one sample of data from a GPS Tracking module in one session or fleet. Samples are bundled together, ended with the character \n, and transmitted to the Goo-server.

C. Goo-Tracking Server

Once the GPS Tracking Module is connected to GPRS networks, it transmits position information to Goo-Tracking Server which is a commodity personal computer running a Linux operating system with an open source software such as Apache web server, PHP, and MySQL program. The server
has three functions to receive the information, to store information in a database, and to display the information. The receiving function opens a non-blocking socket to receive data from multiple GPS Tracking Modules simultaneously. The storing function formats the receiving data into our database that is designed to provide real-time query response for real-time tracks and to provide search query response for the post-analysis of vehicle tracks.

| DeviceID, SessionID, UTC_Time, Flag, 1311.7836, N, 10056.2358, E, Speed, DDMYY, Rsv1, Rsv2, Rsv3, Rsv4, Rsv5, Rsv6^ |
| xxxxxx, yyyy, 225506, A, 1311.7836, N, 10056.23 58, E, 000.5, 191194, aaa, bbb, ccc, ddd, e, f^ |
| xxxxxx, yyyy, 225526, A, 1311.7836, N, 10056.23 58, E, 000.5, 191194, aaa, bbb, ccc, ddd, e, f^ |

Figure 3 The format of location data for transmission

IV. SYSTEM PROTOTYPE

We have implemented a prototype based on the designed in Section III. Figure 4 shows the prototype of our GPS Tracking Module. The size of the prototype is about 2.5” wide by 4.5” long and by 2” thick. Figure 5 shows the screenshot of our web page of the Goo-Tracking server. The figure shows the list of GPS Tracking modules that has tracking history. It shows the device ID, the device name and the operator’s or driver’s name.

Figure 6 shows a track of one GPS Tracking modules in one session shown using Google Map. The same track can be exported in KML format and viewed by using Google Earth as shown in Figure 7. The track can also be shown in real time which can be shown on both Google Map and Google Earth software as shown in Figure 8.

Figure 4 Our own prototype GPS tracking device

Figure 5 The web interface of the server to show information about GPS Tracking Module

Figure 6 The tracking trail of Google Map Server

Figure 7 The same tracking trail on Google Earth software
V. CONCLUSION AND FUTURE WORK

In this paper, we have proposed an open source GPS tracking system, Goo-Tracking system, using commodity hardware and open source software. The Goo-tracking system has shown the feasibility of using it for fleet management. It can also be used for lost vehicle tracking when working with a car alarm system. In the future, we will plan to integrate other related devices in a vehicle such as sensors. The sensors report vehicle status information to our server, which can be useful for information processing and for intelligent tracking management.

REFERENCES