A Refrigerated Cargo Tracking System Using GPS, Google Map API and PHP Web Service

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***Abstract*— Environment sensing systems and positioning systems such as GPS (Global Positioning System) are requirements for logistics supply chains, especially refrigerated cargo systems that require environment sensing data. In this paper, we state our system requirements and compare our proposed solution with other existing solutions. Our proposed system focuses on the cold chain tracking system to provide locations of vehicles and monitor the temperature of refrigerated cargo carried by the vehicles. The system includes Android phones with GPS module on the vehicles, a website for the visual control by using Google Map API, and a web service acts as a bridge between Android phones and database.**

***Keywords*— Cargo tracking system, food cold chain tracking system, refrigerated cargo, Google Map API, PHP Web Service, GPS.**

1. INTRODUCTION

Nowadays, it is essential for many firms to supervise their food delivery B2C (Business to Customer). To keep the food in an optimal temperature range and deliver goods to clients' addresses correctly are the most priority. Therefore, firms need comprehensive solutions to track their vehicles' geographical positions and collect environmental data, including the temperature.

For tracking of vehicles, cargos on the ways, GPS technology is widespread used by many applications. GPS is a space-based satellite navigation system that provides position information by using four or more satellites. For sending GPS information (Longitudes, Latitudes), a GPS receiver is a must. In order to track the location of cargo vehicles, modules with the GPS receiver need to be placed on cars and send data to the centre database periodically. However, GPS receivers cannot communicate well with satellites in indoor environments, so they are primarily used to track the vehicles' geographical positions on the ways of delivery.

For collecting environmental data such as temperature, sensors need to be deployed on the vehicles. TI MSP430F4152 MCU with internal temperature sensor is a wise option because of its efficiency, data rate, cost, low power consumption and ease of use.

For sending data (temperature and geographical position), we need a smartphone application to collect data and send to the database by using GPRS/3G.

Our proposed solution aims at the implementation of a refrigerated cargoes tracking system. This solution involves four different parts. First, it is a website using Google API to display vehicles' positions. This website is written in PHP language (Hypertext Preprocessor) and connected to MySQL database management system. Second, an Android application is used to send data to the database. Third, a PHP web service acts as a connection between Android application and database. The last part is the deployment MSP430 F4152 MCU with temperature sensors connected to Android application via Bluetooth connection.

However, in this paper we only focus on the first, third part to show what kinds of services we can provide for the firms.

The rest of this paper is organized as follows. In Section 2, we introduce other existing cargo tracking systems. In Section 3, we present the special requirements of refrigerated cargo tracking system and propose our system design. In Section 4, we show our real implementation. Finally, we conclude in Section 5.

2. LITERATURE REVIEW

There are many papers concern about the cargo tracking system but in different manners. He *et al*. proposed a system with RFID and GPS to send geographical position, business information to the database [1]. RFID is used for inventory and material handling process in warehouses to control when goods leave the warehouses. GPS is used to track goods in level of pallets, cases, cartons. A hybrid cargo-level tracking system for logistics developed by Yang *et al.* [2] exploits both infrastructure-based (GPS) and infrastructure-less positioning schemes (ad-hoc sensor networks). It focuses on the coverage, scalability, cost, and power consumption of infrastructure-based, infrastructure-less and hybrid schemes. TMO Global Logistics by Heywood *et al*. [3] estimate time of arrivals (ETAs) and TMO employees calling shipping dispatchers to find current cargo locations and relaying experience-based ETAs to the clients. It anticipates ETA approach into TMO Global Logistics' cargo tracking system to manually adjust shipments if necessary. Li *et al*. with "Design and implementation of modern logistics vehicles and cargo tracking systems" [4] concern about a modern logistics vehicles and cargo tracking system designed in view of current demand. It was designed to monitor the situation of cargo and vehicles in real-time. Zhou *et al*. present an agent based intelligent cargo tracking system including agent structure and system architecture based on the Internet of Things [5]. Its approach is to show a prototype system to track information while staying in the central location. Rousseaux *et al*. propose a rapid software prototyping for military applications – CHEOPS [6]. They used Ajax and Google Maps API. Then they conclude about perspectives and limitations of this method. Lou *et al*. [7] show the public bicycle transportation system by using geography information system (GIS) and Google Map API to display the locations of bike rental sites, the availabilities of bikes and parking spots for bike renters and management staff of the program.

These aforementioned systems are great for references. However, none of them conducts such a system like refrigerated cargo tracking system to provide environmental data. Therefore, we will propose a flexible solution to address this issue.

3. SYSTEM REQUIREMENTS AND PROPOSED SYSTEM DESIGN

3.1. System requirements

Based on some other studies, there are some requirements for this kind of system.

Reference [1], [2], [3], [4] and [5] show there is a must for a geographical tracking system. While [1], [2] and [5] proposed the use of RFID for indoor and GPS for outdoor tracking system, [3] only mentions the use of GPS for outdoor tracking system. In our system, GPS is definitely a best solution to collect vehicles' positions.

Our system aims at conducting the function of collecting environmental data (temperature). So, we use sensors to collect temperature and send to phones attached on the vehicles. To our knowledge, using Bluetooth is an easy way to connect sensors to Android phones. After consideration, we decided to use MSP430F4152 MCU to implement this function. MSP430F4152 has an internal temperature sensor, and ADC (Analogue to digital converter) to convert the temperature to digital data. These digital data can be sent to the smartphone by using Bluetooth.

All of these works need to be done by web based solutions for ease of access and maintenance [1]. The system also needs to be flexible and upgradable.

Beside the aforementioned, cost is always a big concern of all companies, especially for small and medium companies. Therefore which technologies (software, hardware) used in this system is a big concern. Open Source Software would be a good solution. We prefer PHP, MySQL [6] to JAVA and Microsoft SQL Server 2008 Express [1] or ASP.NET as in [4] due to its efficiency and cost. Moreover, the cost of MSP430F4152 MCU is quite cheap and easy to implement.

3.2. Proposed system design

To address the current drawbacks of other papers mentioned in the literature review, we propose solutions using hardware – MSP430 F4152 MCU (with embedded temperature sensor), Android phones and software solutions (Web services, website, and Android application).

In this system, we design a Website to show routes of vehicles in real time. It is necessary for companies to track their vehicles' routes due to several reasons. The first reason is that companies need to know when cars leave the warehouse and

arrive at customers' stores. The second reason is the manager can control their products in best conditions or forecast when cars arrive at customers' stores.

We chose PHP language to implement our website and web service because it is totally free and flexible. PHP is easy to integrate with other technologies and languages like Google Map API, JavaScript, JQuery, AJAX (Asynchronous JavaScript and XML). The solution architecture is shown in the Fig. 1 and it consists of the following parts.

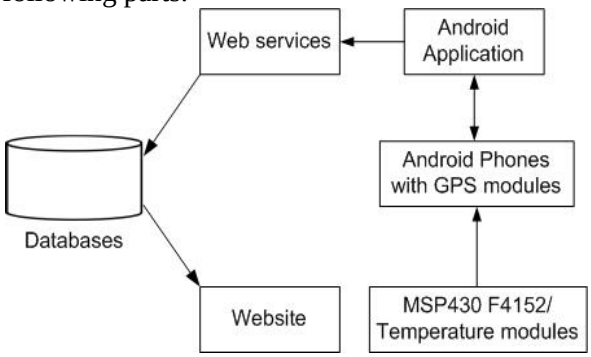

Fig. 1 Abstract View of Solution Architecture

We implement Web services and Web application by PHP language to provide a connection between database and Android applications. Android application used JSON format (JavaScript Object Notation) to send data from the phone to the Web services. JSON is a lightweight data-interchange format. It is easy for machines to parse and generate. JSON is syntax for storing and exchanging text information, similar to XML (Extensible Markup Language). However JSON is smaller than XML, faster and easier to parse. JSON is fully supported by Android OS and PHP. Currently, we only concern about GPS information and Temperature. But in the future, if firms need to upgrade the system to provide more information, JSON can handle it well because it is very flexible and easy to be modified. Therefore, JSON format is superior to XML in this case.

In addition, in our website, we use Google Map JavaScript API v3 to embed Google Map in our own web pages. According to Google, version 3 of this API is designed to be faster and more applicable to mobile devices, as well as traditional desktop browser. The JavaScript Maps API v3 is a free service, available for any website. We use Google Map to display the route of specific vehicle and its temperature from MySQL database. The web pages are reloaded periodically to update new routes and information from database.

This proposed solution surely meets the need of some companies with refrigerated cargoes delivery system. Our Website can be a good tool for manager control their vehicles and goods' quality in the way of deliver or track the route and predict when cars arrive at customers' stores.

4. IMPLEMENTATION

Considering all the system's requirements and other systems, we implemented our system based on Fig. 1.

In term of database design, we use two tables to store the information needed in this system as shown in Fig. 2 below.

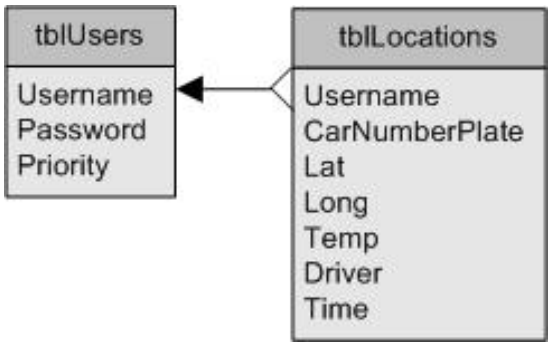

Fig. 2 Design of database

We chose to use MySQL as our database. MySQL is the most used open source relational database management system (RMDBMS) that runs as a server providing multi-user access to a number of databases. MySQL is a popular choice of database for use in web applications, and it is a central component to use with Linux, Apache and PHP. That is the reason why we choose MySQL as our database.

In order to connect Android devices to MySQL database, we implemented PHP web service to retrieve data from smartphone and put them to database. Both Android application and PHP web service use JSON format for data transfer. Because of the flexible in changing its format, JSON is a best solution for exchange data between Android and database system. In the future, if we need to expand our system such as provide more information (speed, business orders, etc.); it is easy by changing JSON format. After collecting GPS information and temperature from sensors, Android application will pack these data into a JSON package and send to PHP web service. PHP web service listens to data through POST method and inserts them to MySQL database.

Firms' manager can track vehicles' positions and temperature by using other website as shown in Fig. 3.

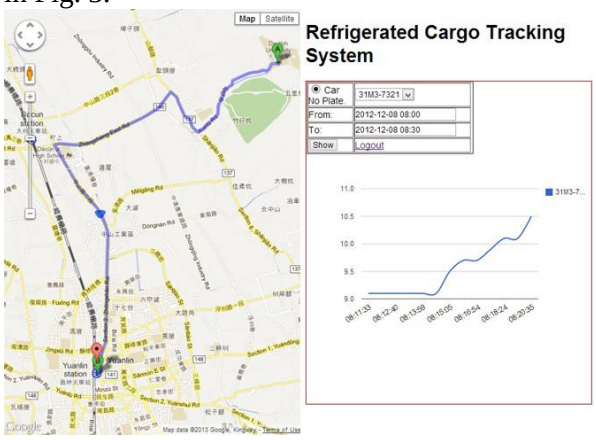

Fig. 3 Refrigerated Cargo tracking system's website

This website was written by PHP language and embedded JavaScript Google Map API v3 to display the route on Google Map. To display the route of a vehicle, just select it from a dropdown list and then select time as shown in Fig. 4.

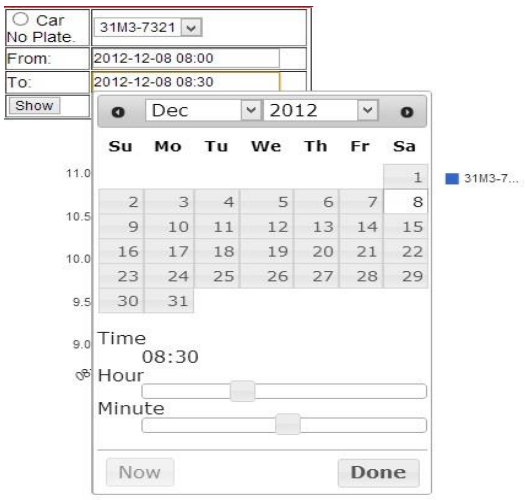

Fig. 4 Vehicle and time selection

After selecting car number plate and time, we can display the route of vehicle on Google map and this route is refreshed and updated every 30 seconds. Other information is display when clicking on the map's marker as shown in Fig. 5. This information includes current temperature, driver's name, and time.

Due to the specific requirements of this system, temperature should be kept in an optimal range. Therefore, we design a function that displays the temperature's graph for managers to monitor temperature range as shown in Fig. 6. We can select detail information by hover mouse into the line. This function is important to monitor temperature; it lets users know when temperature is above a threshold. It was based on Google Chart Tools

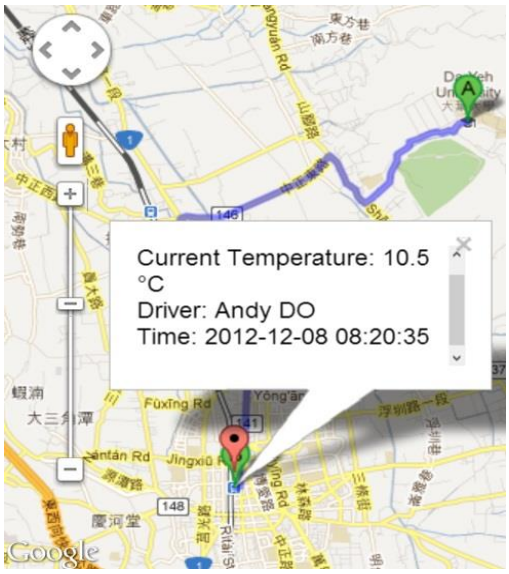

Fig. 5 Information display

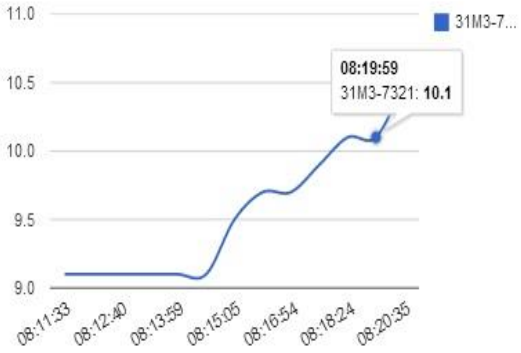

Fig. 6 Temperature's graph

As designed in Fig. 2, this website can be used by many people with different priorities and responsibilities. Thus, logout function was designed in Fig.3 to delete all information stored in cookies. In addition, login function was implemented for different managers can controls different car teams directly under their management as shown in Fig. 7.

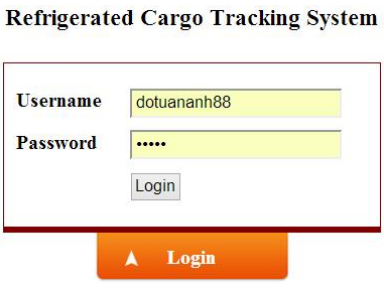

Fig. 7 Login function

Last but not least, we implemented the temperature embedded in MSP430F4152 MCU as prototype. As mentioned in the introduction, currently, we do not concentrate on the hardware design. However, we have succeeded in connecting MSP430F4152 to Android devices by using Bluetooth to transfer temperature as shown in Fig. 8.

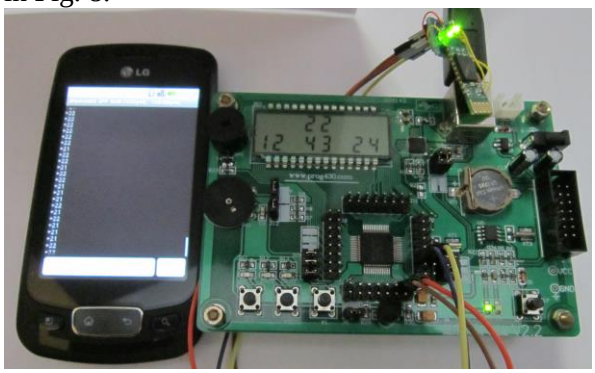

Fig. 8 Temperature sensing module

To summarize, we compare our solution with other solutions in Table 1. Our system was implemented with free and flexible technologies for ease of use, maintenance and upgradable. Since we only focus on refrigerated cargo on the way of delivery, so our system does not include the usage of RFID for storing process and indoor tracking. However none of [1], [2], and [4] possessed the function of environmental sensing as we did (MSP430F4152 temperature sensor). Indeed, many existing solutions and our solution are deal with tracking and tracing system for logistic. Although our system still has some limitation compared with other systems such as indoor tracking, we have succeeded in implement environmental sensing function, flexible and upgradable.

TABLE 1: COMPARISON TABLE

Criteria	Reference number			
	He 's solution [1]	**Yang 's solution [2]**	**Li 's Solution [4]**	**Our Solution**
Indoor Tracking	No	Yes	No	No
Outdoor Tracking	Yes (GPS)	Yes (GPS)	Yes (GPS)	Yes (GPS)
Sending Other Information except positions	Yes	No	No	Yes
RFID usage for storing process	Yes	No	No	No
Environmental sensing	No	No	No	Yes
DBMS usage	Yes	No	Yes	Yes
Management Application	Yes	Yes	Yes	Yes
Mobile app/ mobile sender	Yes	No	Yes	Yes
Data transmission	GPRS	GPRS	GPRS	3G
Flexibility/ Upgradeable	Yes	---	Hard to upgrade	Yes
Easy to implement	Yes	---	No	Yes
Real implementation	Yes	No	Yes	Yes

5. CONCLUSION

Our system features the process of outdoor positioning of refrigerated cargo delivering system. It provides a continuously tracking system based on Android devices, web service, database and website for users. Moreover, our system can connect Android devices to temperature sensors embedded in MSP430F4152 via Bluetooth connection to provide temperature information. Especially, the graph function shows the log of temperature in a graphical ways and easy to understand. It results in the precise tracking system and temperature monitor.

To our knowledge, our system is new technology and would be trend in logistics industries, especially cold delivery system. Our system aims at the flexibilities, upgradable and cost. These above advantages increase work efficiency and satisfaction.

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