大　葉　大　學

資訊工程學系碩士班

碩士論文

A Refrigerated Cargo Tracking System Using GPS, Google Map API and PHP Web Service
結合 GPS、Google 地圖及 PHP 網頁服務實作的冷藏貨物追蹤系統

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中　華　民　國　１　０　２　年　６　月

DAYEH UNIVERSITY

Department of Computer Science and
Information Engineering

Master Thesis

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

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Taiwan, June 2013

中文摘要

貨物追蹤系統是現在物流業中重要的一環，現有系統大多著重在對貨物或運送車輛進行追蹤。然而在如今世界村概念下的食物供應鏈中，許多企業提供了許多來自不同地點的食物，對這些企業來說如何追蹤食物是否在最佳溫度範圍內，並將貨物正確送到客戶的地址，變成是企業物流最優先考慮的方向。因此，我們提出一個冷藏貨物追踪系統，對於冷藏或冷凍物品的運送，除了提供貨物或運送車輛的位置資訊外，系統也提供更詳細的運送過程溫度的變化情況以協助企業監督並確保貨物的運送品質。

在本論文中，我們探討冷藏追蹤系統的系統規格、提出的我們的解決方案，並比較與其他現有解決方案的優缺點。我們提出的冷藏追踪系統能提供車輛的位置和監控車輛上冷藏貨物的溫度。此系統包括放置於車輛上具有 GPS 模組及傳送資料 APP 的 Android 手機、一個使用谷歌地圖 API 的網站以顯示追蹤車輛軌跡及物品溫度、一個 Web 服務用於將 Android 手機上的 APP 傳送的資料存入資料庫中、以及一個具有嵌入式溫度感測器的 MSP430F4152 微處理器以偵測冷藏物品的溫度。

我們所提出的系統可以即時的將車輛的位置顯示在谷歌地圖上。此外，它也可以在地圖軌跡上的每個位置顯示溫度及其他相關訊息，每當溫度大於一個預定義的門檻值時，系統會利用顏色提醒用戶作進一步的處理。本論文提出的系統架構也可以適用於其他需要監測系統環境資料的應用。

關鍵詞：貨物追踪系統，冷藏貨物追踪系統，谷歌地圖 API，PHP Web 服務， GPS。

ABSTRACT

With the expectation to implement the cargo tracking system and after surveying many existing systems; we found that there are not many systems focusing on refrigerated cargo tracking systems. Therefore, we would like to propose a refrigerated cargo tracking system and to show what functions we can provide for companies.

Nowadays, it is essential for many firms to supervise their food delivery. To keep the food in an optimal temperature range and deliver goods to clients' addresses correctly are the most priorities. Environment sensing systems and positioning systems such as GPS (Global Positioning System) are requirements for this kind of systems that require environment sensing data.

In this thesis, 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 proposed system includes Android phones with GPS module on the vehicles, a website for the visual control by using Google Map API, a web service acts as a bridge between Android phones and database, and an MSP430 F4152 MCU with embedded temperature sensor.

Our proposed system can provide the vehicles' positions on Google Map with live data. Also, it can show the temperature and other information of each position on the map. Whenever temperature is greater than a predefined threshold, the system will let the user know for further control.

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

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Chapter I. INTRODUCTION

1.1. Background Knowledge

1.1.1 Cargo system

Cargoes or containers are designed for the handling, storage, and possibly loading or unloading, picked up, dropped off, and maintained, stored, or loaded or unloaded from one mode of transport to another. Cargo can be transported by cars, trains, ships, or airplanes.

To load and unload cargo, we need container terminals to handle it. World container terminals are classified into five categories by their ownerships: public terminals, carrier-leased dedicated terminals, terminal-operator built and operation terminals, carrier built and operation terminals, and joint venture of carriers and terminal operators. The operation characteristics of the five patterns are specified as bellow.

Public terminals

All the shipping lines share with each other the facilities of public terminals in loading and discharging, and are changed at tariff rates, generally with a ‘first come, first serve’ principle and without any priority in berth usage except paying priority tolls. Container handling and other charges are calculated at common tariff rates, or paid at quantity discount rates in case container volume is over the fixed quantity agreed upon in contracts. Singapore (PSA before 1997), Busan, and Keelung are categorized into this operation pattern.

Carrier-leased dedicated terminals

Carriers sign long-term lease contracts with the port authorities for their own exclusive use. Carriers pay rents and facility charges and the port authorities entitle contract carriers to right and priority in berth usage. Carrier could be entitled to purchase or install container handling facilities at his own account to compensate for rents and facility charges. Owing to the joint services among shipping lines, single user long-term contracts are transferred to multi-user contracts so that several shipping lines share terminal usage, Kaohsiung, Keelung (some parts of the port), Kobe, Yokohama, and Tokyo are categorized into this operation pattern.

Terminal-operator built and operation terminals

By making a deposit and allocating to the port authorities in proportion to the total handling charges as agreed in the contract, a terminal operator leases container terminals or invests directly in the construction, operation of container terminals and handling facilities. Hong King (HIT, MTL, CHL), Shanghai (SCT), Tianjin (CSXOT), Singapore (PSA after 1997) are categorized into this operation pattern.

Carrier built and operation terminals

By making a deposit and allocating to the port authorities in proportion to the total handling charges as agreed in the contract, a carrier or several carriers lease container terminals or invest directly in the construction, operation of container terminals and handling facilities, Except the usage of their fleet, the carriers are entitled to provide other shipping lines with berthing and container handling services.

Malaysia (PTP), Taipei Port (invested by Yang Ming Line, Evergreen, Wan-Hai), and Qingdao (Zhungguang, Kuaikuei, Tiasing) are categorized into this operation pattern.

Joint venture of carriers and terminal operators

By making a deposit and allocating to the port authorities in proportion to the total handling charges as agreed in the contract, a joint venture of shipping lines and terminals or invest directly in the construction, operation of container terminals and handling facilities. Shanghai (Yangshan terminals, Zhunghai terminals), Shenzhen, Shekou are categorized into this kind.

1.1.2 Refrigerated Cargo

However, to carry food or goods needed low temperature, we should use refrigerated container. A refrigerated container or reefer is an intermodal container (shipping container) used in intermodal freight transport that is refrigerated for the transportation or temperature sensitive cargoes. While reefers have an integral refrigeration unit, they rely on external power, from electrical power points at a land based site or a container ship. When being transported over the road on a trailer they can be powered from diesel powered generators which attach to the container. Some reefers are equipped with a water cooler system, which can be used if the reefer is stored below deck on a vessel without adequate ventilation to remove the heat generated. Water cooling systems are expensive, so modern vessels rely more on ventilation to remove heat from cargo holds, and the use of water cooling systems is declining. The impact on society of reefer containers is vast, allowing consumers all over the world to enjoy fresh products at any time of year and experience previously unavailable fresh products from any other part of the world.

Currently, redundant refrigeration is often required the utmost in system reliability. This type of reliability can only be achieved through the installation of a redundant refrigeration system. A redundant refrigeration system consists of integrated primary and back-up refrigeration units. If the primary unit malfunctions, the secondary unit automatically starts. To provide reliable power to the refrigeration units, these containers are often fitted with one or more diesel generator sets. Containers fitted with these systems may be required for transporting certain Dangerous Goods in order to comply with the International Maritime Organization's regulations. Fig.1.1 shows a container that is fitted with two refrigeration units and a single diesel generator.

Fig.1.1 A container fitted with two refrigeration units and a single diesel generator

1.1.3 Specific need

Nowadays, it is essential for many firms to supervise their B2C (Business to Customer) food delivery. To keep the food in an optimal temperature range and deliver goods to clients’ addresses correctly are the most priority in the delivery process. Therefore, firms need comprehensive solutions to track their vehicles’ geographical positions and collect environmental data, including the temperature, humidity and other parameters. For the aforementioned reasons, to track vehicles’ positions and send environmental sensing data to a control center become vital functions for refrigerated cargoes on the way of delivery (by ships, trains or container vehicles).

1.1.3.1 GPS (The Global Positioning System)

For tracking of vehicles, cargos on the ways, GPS (Global Positioning System technology) is widespread used by many applications. GPS is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The system provides critical capabilities to military, civil and commercial users around the world. It is maintained by the United States government and is freely accessible to anyone with a GPS receiver. The GPS project was developed in 1973 to overcome the limitations of previous navigation systems; it integrates ideas from several predecessors, including a number of classified engineering design studies from the 1960s. GPS was created and realized by the U.S. Department of Defense (DoD) and was originally run with 24 satellites. It became fully operational in 1994. Roger L. Easton is generally credited as its inventor. Advances in technology and new demands on the existing system have now led to efforts to modernize the GPS system and implement the next generation of GPS III satellites and Next Generation Operational Control System (OCX). Announcements from the Vice President and the White House of U.S. in 1998 initiated these changes. In 2000, U.S. Congress authorized the modernization effort, GPS III. In addition to GPS, other systems are in use or under development. The Russian Global Navigation Satellite System (GLONASS) was developed contemporaneously with GPS, but suffered from incomplete coverage of the globe until the mid-2000s. The planned European Union Galileo positioning system, Chinese Compass navigation system, and Indian Regional Navigational Satellite System are also under developed.

For sending GPS information (Longitudes, Latitudes), a GPS navigation device (GPS receiver) is a must. A GPS navigation device is any device that receives Global Positioning System (GPS) signals to ascertain the device's location on Earth. GPS devices provide latitude and longitude information, and some may also calculate altitude, although this is not considered sufficiently accurate or continuously available enough (due to the possibility of signal blockage and other factors) to rely on exclusively to pilot aircraft. GPS devices are used in military, aviation, marine, and consumer-product applications. GPS devices may also have additional capabilities such as:

- Maps, including streets maps, displayed in human readable format via text or in a graphical format
- Turn-by-turn navigation directions to a human in charge of a vehicle or vessel via text or speech
- Directions fed directly to an autonomous vehicle such as a robotic probe
- Traffic congestion maps (depicting either historical or real time data) and suggesting alternative directions
- Information on nearby amenities such as restaurants, fuelling stations, tourist attractions, etc.

In other words, all GPS devices can answer the question "Where am I?", and may also be able to answer:

- Which roads or paths are available to me now?
- Which roads or paths should I take in order to get to my desired destination?
- If some roads are usually busy at this time or are busy right now, what would be a better route to take?
- Where can I find food, fuel or other needs nearby?
- The shortest route between two locations

There are several kinds of GPS navigation devices. One of them is the dedicated navigation device. Dedicated devices have various degrees of mobility. *Hand-held*, *outdoor*, or *sport* receivers have replaceable batteries that can run them for several hours, making them suitable for hiking, bicycle touring and other activities far from an electric power source. Their screens are small, and some do not show color, in part to save power. Cases are rugged and some are water resistant. Other receivers, often called *mobile* are intended primarily for use in a car, but have a small rechargeable internal battery that can power them for an hour or two away from the car. Special purpose devices for use in a car may be permanently installed and depend entirely on the automotive electrical system.

Due in part to regulations encouraging mobile phone tracking, the majority of GPS receivers are built into mobile telephones, with varying degrees of coverage and user accessibility. Commercial navigation software is available for most 21st-century smartphones as well as some Java-enabled phones that allow them to use an internal or external GPS receiver (in the latter case, connecting via serial or Bluetooth connection). Some phones using assisted GPS (A-GPS) function poorly when out of range of their carrier's cell towers. Others can navigate worldwide with satellite GPS signals as well as a dedicated portable GPS receiver does, upgrading their operation to

A-GPS mode when in range. Still others have a hybrid positioning system that can use other signals when GPS signals are inadequate.

More bespoke solutions also exist for smartphones with inbuilt GPS capabilities. Some such phones can use tethering to double as a wireless modem for a laptop, while allowing GPS-navigation/localization as well. One such example is marketed by Verizon Wireless in the United States, and is called VZ Navigator. . Other products including iPhone are used to provide similar services. Nokia gives Ovi Maps free on its smartphones and maps can be preloaded.

According to market research from the independent analyst firm Berg Insight, the sales of GPS-enabled GSM/WCDMA handsets was 150 million units in 2009, while only 40 million separate GPS receivers were sold (according to Wikipedia).

GPS navigation applications for mobile phones include on-line (e.g. Waze, Google Maps Navigation) and off-line (e.g. iGo for Android, Maverick) navigation applications. Google Maps Navigation, which is included with Android, means most smartphone users only need their phone to have a personal navigation assistant.

Many Android smartphones have an additional GPS feature, called **EPO** (Extended Prediction Orbit). The phone downloads a file to help it locate GPS satellites more quickly and reduce the Time to First Fix.

1.1.3.2 Temperature sensor

Temperature sensors are vital to a variety of everyday products. For example, household ovens, refrigerators, and thermostats all rely on temperature maintenance and control in order to function properly. Temperature control also has applications in chemical engineering. Examples of this include maintaining the temperature of a chemical reactor at the ideal set-point, monitoring the temperature of a possible runaway reaction to ensure the safety of employees, and maintaining the temperature of streams released to the environment to minimize harmful environmental impact. While temperature is generally sensed by humans as “hot”, “neutral”, or “cold”, chemical engineering requires precise, quantitative measurements of temperature in order to accurately control a process. This is achieved through the use of temperature sensors, and temperature regulators which process the signals they receive from sensors.

From a thermodynamics perspective, temperature changes as a function of the average energy of molecular movement. As heat is added to a system, molecular motion increases and the system experiences an increase in temperature. It is difficult, however, to directly measure the energy of molecular movement, so temperature sensors are generally designed to measure a property which changes in response to temperature. The devices are then calibrated to traditional temperature scales using a standard (i.e. the boiling point of water at known pressure). The following sections discuss the various types of sensors and regulators.

Temperature sensors are devices used to measure the temperature of a medium. There are two kinds on temperature sensors: 1) contact sensors and 2) noncontact sensors. However, the three main types are thermometers, resistance temperature detectors, and thermocouples. All three of these sensors measure a physical property (i.e. volume of a liquid, current through a wire), which changes as a function of temperature. In addition to the 3 main types of temperature sensors, there are numerous other temperature sensors available for use.

Contact Sensors

Contact temperature sensors measure the temperature of the object to which the sensor is in contact by assuming or knowing that the two (sensor and the object) are in thermal equilibrium, in other words, there is no heat flow between them. Examples (further description of each example provide below)

- Thermocouples
- Resistance Temperature Detectors (RTDs)
- Full System Thermometers
- Bimetallic Thermometers

Noncontact Sensors

Most commercial and scientific noncontact temperature sensors measure the thermal radiant power of the Infrared or Optical radiation received from a known or calculated area on its surface or volume within it. An example of noncontact temperature sensors is a pyrometer, which is described into further detail at the bottom of this section.

Thermometers are the most common temperature sensors encountered in simple, everyday measurements of temperature. Two examples of thermometers are the Filled System and Bimetal thermometers.

The familiar liquid thermometer consists of a liquid enclosed in a tube. The volume of the fluid changes as a function of temperature. Increased molecular movement with increasing temperature causes the fluid to expand and move along calibrated markings on the side of the tube. The fluid should have a relatively large thermal expansion coefficient so that small changes in temperature will result in detectable changes in volume. A common tube material is glass and a common fluid is alcohol. Mercury used to be a more common fluid until its toxicity was realized. Although the filled-system thermometer is the simplest and cheapest way to measure temperature, its accuracy is limited by the calibration marks along the tube length. Because filled system thermometers are read visually and don't produce electrical signals, it is difficult to implement them in process controls that rely heavily on electrical and computerized control.

In the bimetal thermometer, two metals (commonly steel and copper) with different thermal expansion coefficients are fixed to one another with rivets or by welding. As the temperature of the strip increases, the metal with the higher thermal expansion coefficients expands to a greater degree, causing stress in the materials and a deflection in the strip. The amount of this deflection is a function of temperature. The temperature ranges for which these thermometers can be used is limited by the range over which the metals have significantly different thermal expansion coefficients. Bimetallic strips are often wound into coils and placed in thermostats. The moving end of the strip is an electrical contact, which transmits the temperature thermostat.

Resistance Temperature Detectors

A second commonly used temperature sensor is the resistance temperature detector (RTD, also known as resistance thermometer). Unlike filled system thermometers, the RTD provides an electrical means of temperature measurement, thus making it more convenient for use with a computerized system. An RTD utilizes the relationship between electrical resistance and temperature, which may either be linear or nonlinear. RTDs are traditionally used for their high accuracy and precision. However, at high temperatures (above 700°C) they become very inaccurate due to degradation of the outer sheath, which contains the thermometer. Therefore, RTD usage is preferred at lower temperature ranges, where they are the most accurate.

There are two main types of RTDs, the traditional RTD and the thermistor. Traditional RTDs use metallic sensing elements that result in a linear relationship between temperature and resistance. As the temperature of the metal increases, increased random molecular movement impedes the flow of electrons. The increased resistance is measured as a reduced current through the metal for a fixed voltage applied. The thermistor uses a semiconductor sensor, which gives a power function relationship between temperature and resistance.

1.2. Motivation and Contribution

Recently, Refrigerated Cargo Tracking System has drawn much of companies' concerns. It is because of the reality needs in food supply chain systems (meat, fish, dairy, and frozen foods delivery). However, how to track vehicles' routes and monitor environment sensing data (temperature…) are problems need to be solved to improve the quality of goods and the efficiency of entire system. Currently, to my knowledge, there are not many comprehensive applications for refrigerated cargo tracking system. Therefore, I would like to conduct this system and apply it in real life. Because most of Cargo tracking systems focused on traditional cargoes or containers, we would like to survey on this topic and classify the specific requirements of refrigerated cargo tracking system. That is the motivation makes me conduct this thesis.

Our proposed solution aims at the implementation of a refrigerated cargoes tracking system. First, it is a website using Google API to display route of vehicles in real time or in a specified period of time. Also, it can display other business information and environmental sensing data (temperature…). Moreover, this website can display the duration of stays and notify users when the temperature exceed a threshold. This website is written in ASP.NET and connected to MySQL database management system. Second, an Android application is used to collect latitude, longitude, environmental sensing data and other business information, and then send them to the database center. Third, a PHP web service acts as a connection between Android application and database. The PHP web service receives data in JSON format from phones and inserts it to MySQL database. The last part is the deployment MSP430 F4152 MCU with temperature sensors connected to Android application via Bluetooth connection. These temperature sensors collect temperatures' data and send them to the phone.

We hope that, our proposed solution can meet the real requirement and needs in logistic field, especially the refrigerated cargo tracking system.

1.3. Organization of thesis

The rest of this thesis is organized as follows. The second chapter is literature review, it concerns about several existing solutions in cargo tracking system. We propose system requirement and our system design in chapter three. The main chapter describing our implementation of refrigerated cargo tracking system will be on chapter four. The last chapter is conclusions and future works.

Chapter II. LITERATURE REVIEW

There are many papers concerning about the cargo tracking system 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 with EPCglobal standard. They propose a total solution architecture using integrated RFID and positioning system technologies for seamless, global wide, track and trace system for logistics supply chain. EPCglobal standard is employed in RFID tracking. He’s architecture is shown in Fig.2.1.

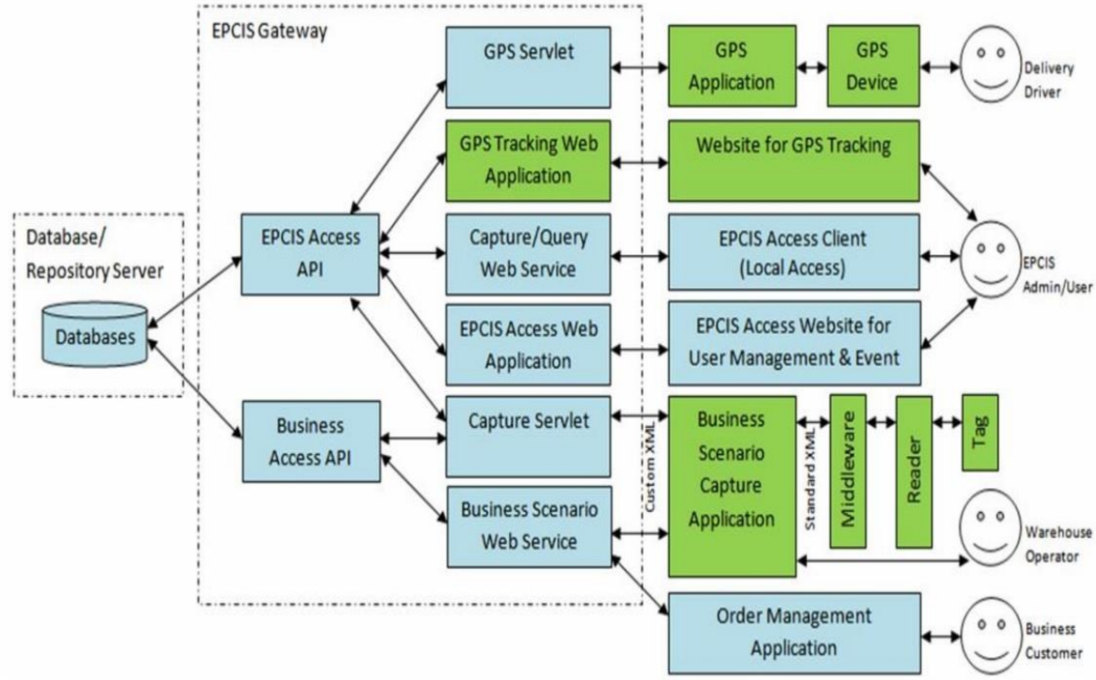

Fig.2.1 System architecture of [1]

In Fig.2.1, the GPS is used to track goods in level of pallets, cases, cartons. GPS capture client running in mobile device can communicate with GPS module to get the data on the geographical position. The GPS capture client will interface with GPS and transmit data together business context information to a central server through GPRS. An application used to control suppliers' order picking and palletizing, uploading to container and shipping out till manufacture's receiving, unloading and storing. During the process in the supply chain, the real-time information about the product can be captured through the proposed solution of integrated RFID and GPS; so that users can use a website to track and trace. Data will be stored in database through EPICIS gateway so that other applications can access and use them for various purposes such as business information presentation for vehicle tracking.

In Fig.2.2, 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. Each cargo is attached with a tiny battery-powered tracking device, which senses the environment and collects data. Through the communication network, the collected data is transmitted to a central server for monitoring, positioning, and tracking. The detailed requirements are Coverage (Global, indoors, outdoors), Accuracy (GPS-level accuracy, capable of supporting higher accuracy for areas of special interests), Sensing (system is expected to be capable of environment sensing as in cool chain), Duty cycle (On considering the costs and battery life, the location update rate is generally in the order of ten seconds when cargos are in motion) and Cost effectiveness (Low deployment cost, low operation and maintenance cost)

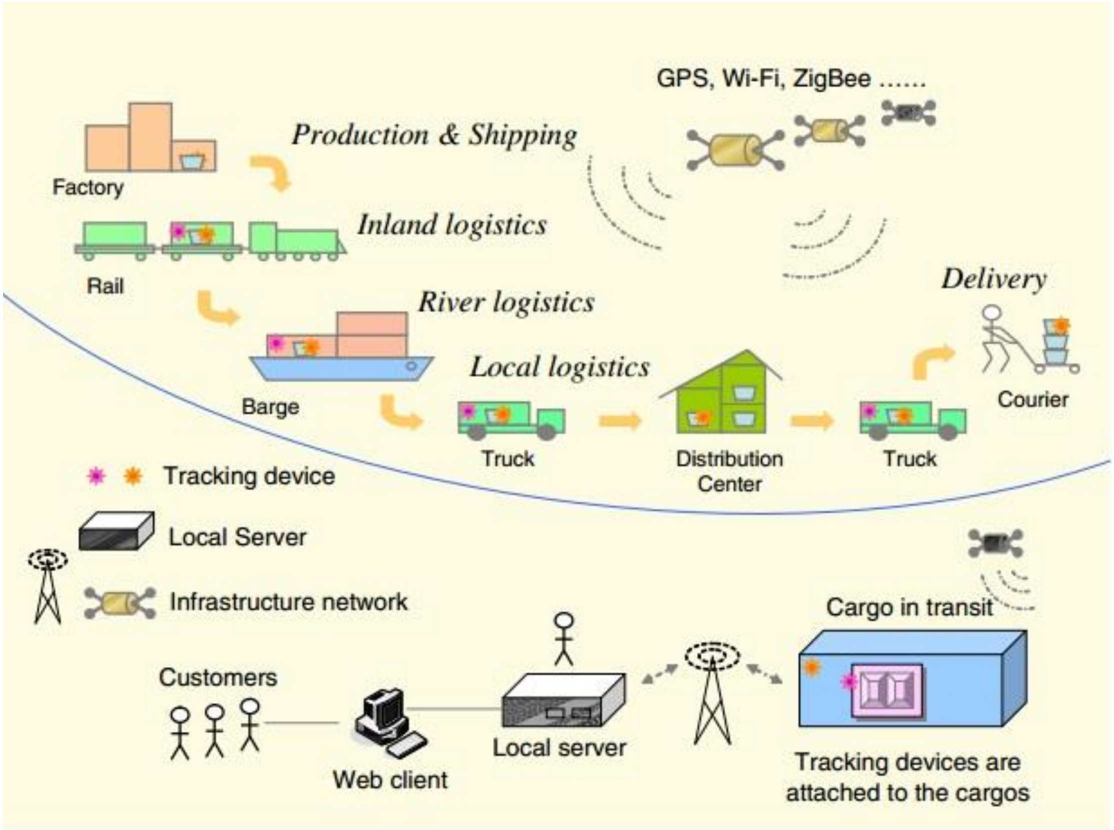

Fig.2.2 System architecture of [2]

The hybrid system proposed in this work involves two kinds of hybrids:

- Hybrid wireless positioning and communication system: Diverse wireless systems are exploited in a seamless and autonomous way. Specifically, GPS, WiFi, ZigBee, and RFID are exploited for positioning, while GSM/3G, WiFi, and ZigBee are utilized for communications.
- Hybrid infrastructure-based and infrastructure-less positioning technology: Two kinds of positioning technologies are exploited in a hybrid and complementary mode to optimize the total deployment costs and operation costs.

TMO Global Logistics proposed 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. An improved ETA calculation would increase the resolution of the prediction and would increase the accuracy of the prediction. The ETA calculation should be automated and require very little input or time commitment from a TMO employee.

Li *et al*. with "Design and implementation of modern logistics vehicles and cargo tracking systems" [4] concerned 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 as shown in Fig.2.3. The system is mainly composed of mobile terminal and monitoring center. The monitoring center is the core module of the system. Mobile terminal includes gathering barcode information of cargo and GPS, associating them with vehicles information and sending all the messages to the center via GPRS. Monitor center uses C/S (Client/Server) structure. The server deploys and releases Web Service which receives the information from mobile terminals and returns the processing result requested by the terminals. The client operates the server database to extract information such as GPS information and then displays it on the E-map, in order to achieve functions, such as vehicle positioning, track display, and cargo inquires.

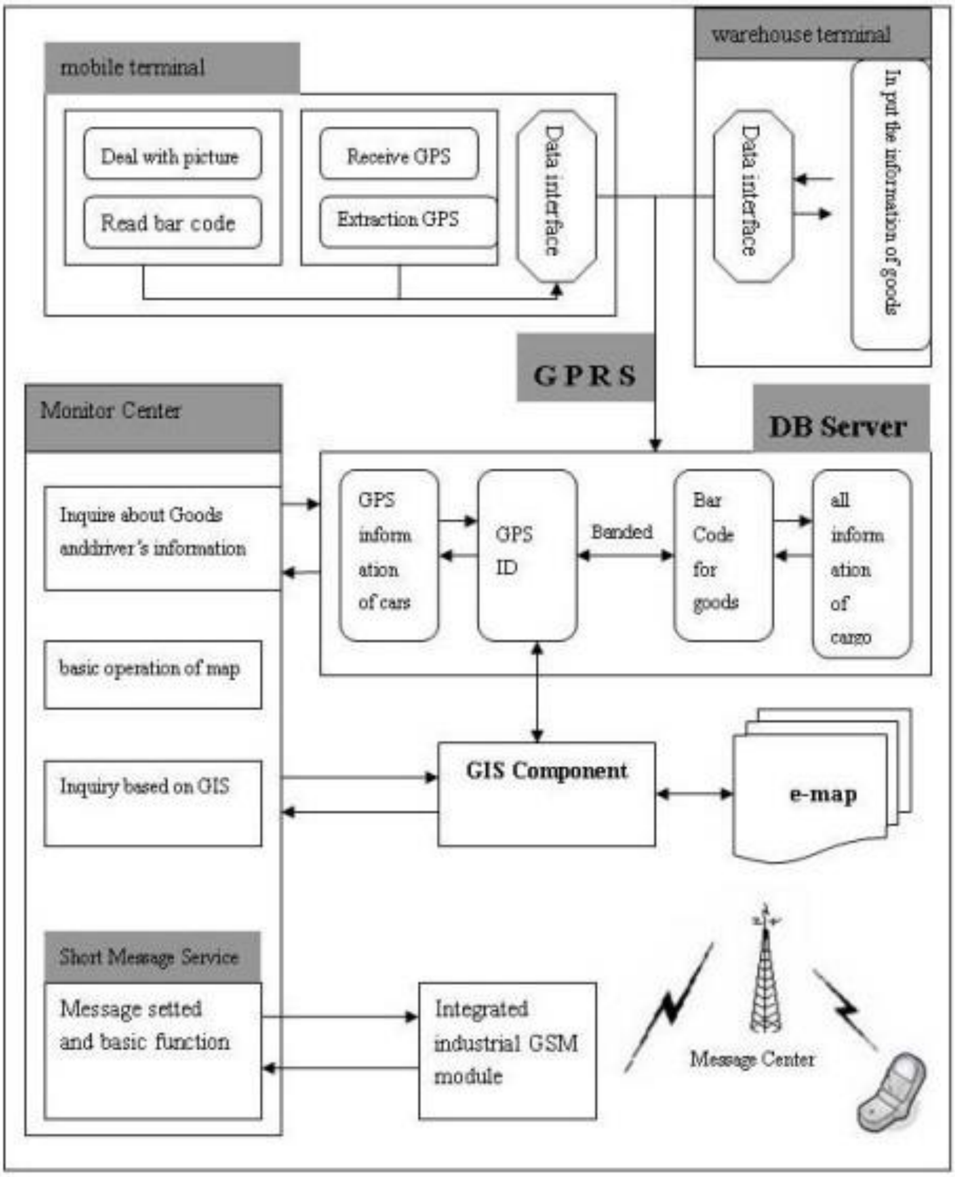

Fig.2.3 System architecture of [4]

As in Fig.2.3, mobile terminal connects with GPS module through Bluetooth or serial port and communicates with GPS module by the embedded software. Mobile terminal extracts GPS information according to the actual demands. The latitude, longitude and speed information would be displayed in the mobile terminal's interface when communications succeeds and would be transported to the monitor center. The mobile terminal transfers the GPS, barcode information and other messages through GPRS network to database in the monitor center. The client operates the server database to extract information such as GPS information and then displays vehicle position, track display and cargo inquiries on the E-map.

Zhou *et al*. present an agent based intelligent cargo tracking system, as shown in Fig.2.4, 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 by developing Cargo Information Modelling (CIM) and Intelligent Cargo Tracking. CIM is a process including the generation and management of a digital representation for the physical and functional characteristics of a cargo. CIM can build a foundation for cargo tracking. Cargo information can be stored in a cargo database or RFIDs, intelligent tags and RFID are necessary for the data storage on cargo level, the sensing, tracking and tracing and processing of these data plus the transfer and communication of cargo related data. Intelligent cargo tracking system contains sensors and RFID tags. An Intelligent Cargo Tracking System includes three parts: Fixed site on ground (warehouse or super market), Mobile site (vehicles), and Cargo Information Management Center. Cargo information management center includes three parts: Communication part (router, antenna, communication software), middleware (cargo information management, user information management, transportation information management, GIS, reasoning engine and cargo/transportation knowledge base), and UI (User interface and web service packaging and providing).

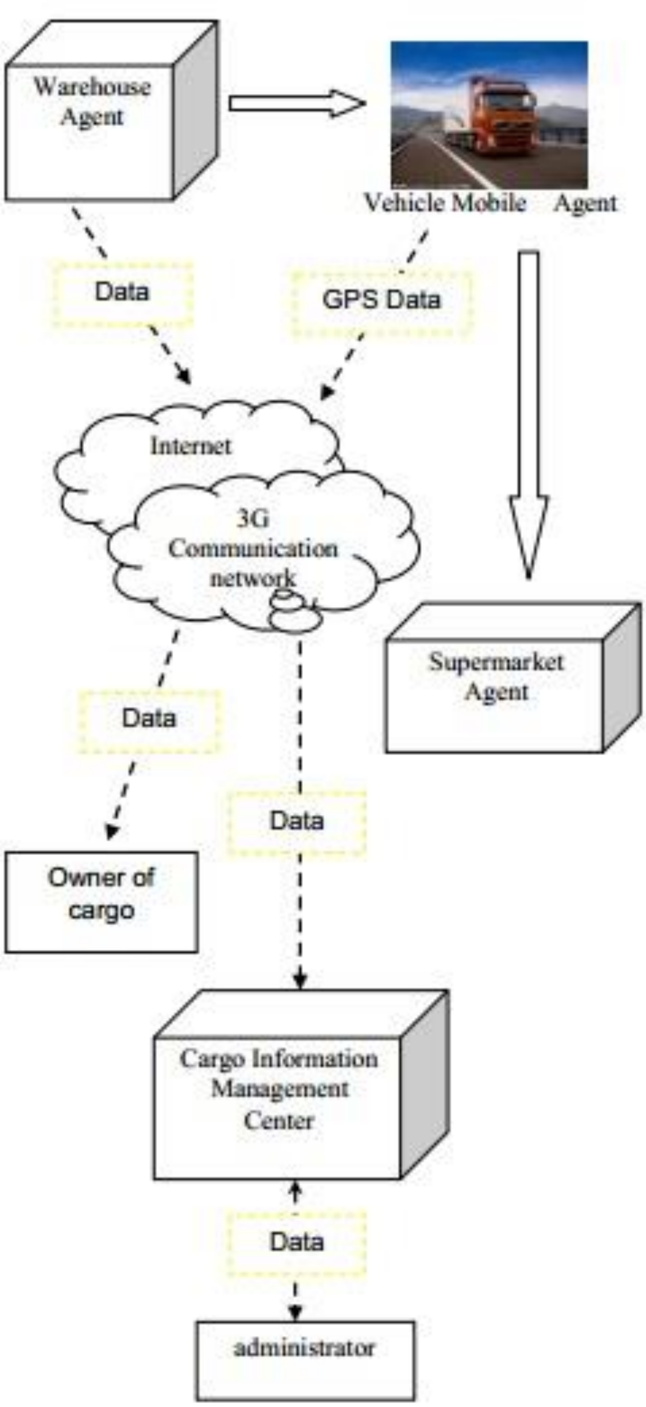

Fig.2.4 Deployment diagram of [5]

In Fig. 2.4, the intelligent agents include warehouse agent, vehicle mobile agent, super market agent, owner agent, vehicle mobile agent. The tracking system and technology presented in this paper is the standard in every freight management system. They proposed the internet and mobile communication based tracking system which provides the access of any information regarding your ship, cargo, business vehicle, contents, goods, at any time. The cargo tracking systems are designed to give the user real time information about the vehicles and cargo. There are different types of freights including airfreight, sea freight, road freight, rail freight. The cargo tracking system can trace the exact location of the flight, ship or cargo from which the direction and the distance are calculated.

Lou *et al*. [6] 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. Bike renters often encounter problems such as unable to locate the bicycle rental sites. Apparently, GIS is needed to cope with the situation. GIS can perform information query, dynamic monitoring, system analysis, management, and decision making, and provide constant, displayable image of the dynamic distribution of rental bikes for both and renters and managers. The main modules of this system are as follows:

- Geographic location display module: a display of public distribution of the entire public bicycle network.
- Network status display module: a display of the currently available number of bicycles and parking spots in a specific rental site.
- Spatial Query module: showing a specific area of service site distribution map.
- Coordinate maintenance module: initializing and maintaining the coordination of rental sites.
- Statistical analysis module: analyzing rental trends, patterns of customer rental behaviors and activities
- Site-recommending module: recommending to the renters a list of rental sites where they can rent or return bikes based on instant information of the system.

- New display module: a display of public bicycle rental service-related news and announcements.
- System management module: managing the public bicycle transportation information system.

[6] adopted ASP.NET and Orabcle9i database to build Web applications. In this system, they used the Google Maps API to dynamically display the locations of the bike rental sites, which brings a drastic efficiency to the bicycle rental system.

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.

Chapter III. SYSTEM REQUIREMENTS AND PROPOSED SYSTEM DESIGN

3.1. System Requirements

Based on some other studies, there are some requirements for the refrigerated cargo tracking system. In term of users, they would need the following functions:

- Monitor the route of vehicles in real time.
- Monitor the route of vehicles in a specified period of time.
- Display the vehicles' information, such as car number plate, drivers' name.
- Display other business information if needed.
- Display the environment sensing data (temperature).
- Display the durations of stay
- Notification if environment sensing data above a threshold.

In term of system design, it should meet the following requirements:

- Position tracking system (GPS receiver, client application).
- Environmental sensing data collection (Collect temperature data).
- Data communication (Send longitude, latitude, and temperature via GPRS/3G/Wi-Fi).
- Control Center (Web service to collect data from GPS receiver client to central database).
- Website to display the routes of vehicles, environmental sensing data, and other functions.

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 MSP430 F4152 MCU to implement this function. MSP430 F4152 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.

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 MSP430 F4152 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 (PHP Web services, ASP.NET website, and Android application).

The solution architecture is shown in the Fig.3.1 and it consists of the following parts.

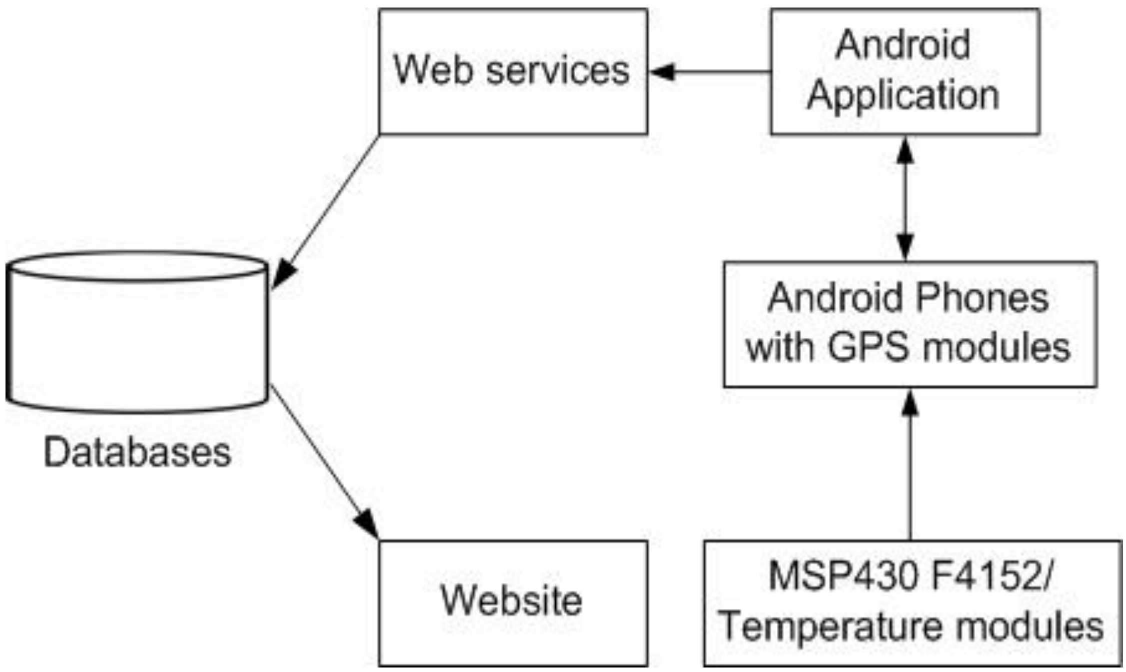

Fig.3.1 Abstract View of Solution Architecture

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 web service because it is totally free and more flexible. Using PHP language to code Web service is one of the simplest and effective ways. Also, PHP can connect with MySQL, MS SQL Server without any difficulties.

We implement Web services by PHP language to provide a connection between database and Android applications. Android applications 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.

ASP.NET was chosen to implement Web application due to its popular and ease of usage. It is also easy to integrate with other technologies and languages like Google Map API, JavaScript, JQuery, AJAX (Asynchronous JavaScript and XML). 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 vehicles and its temperature from MySQL database. The web pages are reloaded periodically to update new routes and information from database.

Fig.3.2 shows more detail about the solution architecture. MSP430 F4152 MCU Temperature sensor connected to Android phone via Bluetooth connection. The Android application will pack GPS and temperature in JSON format and send to PHP Web service. PHP Web service process these data sent from Android application via POST method and then insert them to MySQL database. Finally, the Website using Google Map API could display routes, temperature, and other information by query data from MySQL database.

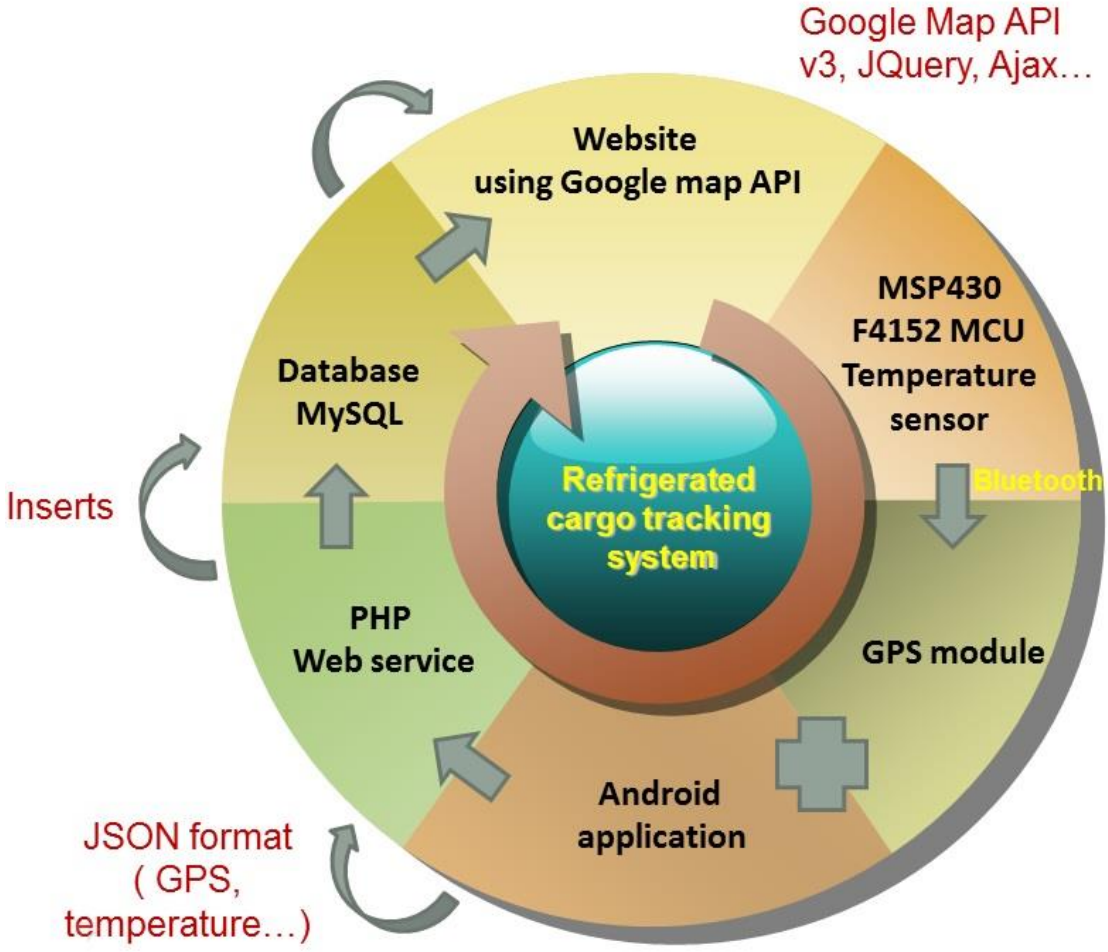

Fig.3.2 Solution Architecture

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.

Chapter IV. IMPLEMENTATION

After the literature review and proposed system design, we come to the implementation of this system. As mentioned in the three previous chapters, we will conduct the implementation with the following main parts:

- Database Design.
- PHP Web Service.
- ASP.NET Web Pages.
- Android Application.
- MSP430 MCU with Temperature Sensor implementation.

4.1 Database Design

In the proposed system, we chose MySQL as our database. The structure of database is shown in Fig.4.1.

As shown in Fig.4.1, ID field is used to index the records in databases for database processing later. Username and CarNumberPlate fields are used to store the username of each Android phone device and Car Number Plate of each vehicle respectively. Latitudes and Longitudes are stored in Lat and Lng fields. Temperature data come from MSP430 MCU will be kept in Temp field. Sample records are shown in Fig.4.2.

1	ID	int(11)	
2	Username	varchar(50)	utf8_unicode_ci
3	CarNumberPlate	varchar(20)	utf8_unicode_ci
4	Lat	double	
5	Lng	double	
6	Temp	float	
7	Driver	varchar(50)	latin1_swedish_ci
8	time	timestamp	
9	Lat2	double	
10	Lng2	double	

Fig.4.1 Database Structure

ID	Username	CarNumberPlate	Lat	Lng	Temp	Driver	time	Lat2	Lng2
1	dotuananh88	31M3-7321	24.128700256347656	120.66500091552734	24	Andy DO	2013-02-23 16:35:09	NULL	NULL
2	dotuananh88	31M3-7321	24.12929916381836	120.66699981689453	24	Andy DO	2013-02-23 16:35:20	NULL	NULL
3	dotuananh88	31M3-7321	24.129899978637695	120.66799926757812	23	Andy DO	2013-02-23 16:35:34	NULL	NULL
4	dotuananh88	31M3-7321	24.130199432373047	120.66899871826172	23	Andy DO	2013-02-23 16:35:46	NULL	NULL
5	dotuananh88	31M3-7321	24.13050079345703	120.66999816894531	22	Andy DO	2013-02-23 16:35:59	NULL	NULL
6	dotuananh88	31M3-7321	23.999967575073242	120.59940338134766	0	Andy DO	2013-02-25 19:48:59	NULL	NULL
7	dotuananh88	31M3-7321	23.999906539916992	120.59947967529297	24	Andy DO	2013-02-26 12:45:59	NULL	NULL
8	dotuananh88	31M3-7321	23.999792098999023	120.5993423461914	24	Andy DO	2013-02-26 12:46:18	NULL	NULL
9	dotuananh88	31M3-7321	23.999521255493164	120.59928894042969	25	Andy DO	2013-02-26 12:46:31	NULL	NULL
10	dotuananh88	31M3-7321	23.999353408813477	120.59947967529297	25	Andy DO	2013-02-26 12:46:56	NULL	NULL
11	dotuananh88	31M3-7321	23.99930191040039	120.59964752197266	25	Andy DO	2013-02-26 12:47:08	NULL	NULL
12	dotuananh88	31M3-7321	23.99921226501465	120.59979248046875	25	Andy DO	2013-02-26 12:47:20	NULL	NULL
13	dotuananh88	31M3-7321	23.999244689941406	120.59996795654297	25	Andy DO	2013-02-26 12:47:33	NULL	NULL
14	dotuananh88	31M3-7321	23.999343872070312	120.6001205444336	26	Andy DO	2013-02-26 12:47:45	NULL	NULL
15	dotuananh88	31M3-7321	23.99933624267578	120.60026550292969	26	Andy DO	2013-02-26 12:47:57	NULL	NULL

Fig.4.2 Sample records

4.2 PHP Web Service Implementation

The main part of PHP Web Service is shown in Fig.4.3.

```
1 <?php
2
3 // array for JSON response
4 $response = array();
5
6 if (isset($_POST['Username']) && isset($_POST['CarNumberPlate']) &&
7     isset($_POST['Lat']) && isset($_POST['Lng'])&& isset($_POST['Temp']) &&
8     isset($_POST['Driver']) && isset($_POST['time']))
9     {
10         $Username = $_POST['Username'];
11         $CarNumberPlate = $_POST['CarNumberPlate'];
12         $Lat = $_POST['Lat'];
13         $Lng = $_POST['Lng'];
14         $Temp = $_POST['Temp'];
15         $Driver = $_POST['Driver'];
16         $time = $_POST['time'];
17
18         // include db connect class
19         require_once __DIR__ . '/db_connect.php';
20
21         // connecting to db
22         $db = new DB_CONNECT();
23     |
24         // mysql inserting a new row
25         $result = mysql_query
26         ("INSERT INTO tbllocations2(Username, CarNumberPlate, Lat, Lng, Temp, Driver, time)
27          VALUES('$UserName','$CarNumberPlate','$Lat','$Lng','$Temp','$Driver','$time')");
28
29         // echoing JSON response
30         echo json_encode($response);
31     }
32 ?>
```

Fig.4.3 PHP Web Service

Web Service acts as a bridge between Android devices (GPS receiver) and the central database (MySQL). Whenever Android application requests this web service, this web service will take data via POST method and insert data to the database as shown from line 10 to 16 of Fig.4.3. Username, Car Number Plate, Latitudes, Longitudes, Temperature, Driver Name, and Time will be retrieved via POST method and will be sent to MySQL database via a SQL statement as shown in line 25 to 27 of

Fig.4.3. Android application uses JSON format for data transfer. Because of the flexibility in changing its format, JSON is a best solution for exchange data between Android application and the 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.

4.3 ASP.NET Website

The proposed Cargo Tracking System main page is shown in Fig.4.4. This is the main part of this system. We develop this Website to demo what we can provide for the companies. This website was written in ASP.NET and C# language. Moreover, to satisfy the firms' need as mentioned in chapter 3, we also use AJAX, JQuery, Google Map API v3 in this system.

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 browsers. The JavaScript Maps API v3 is a free service, available for any website. We use Google Map to display the route of specific vehicle or all vehicles and their temperatures from MySQL database. The web pages are reloaded periodically to update new routes and information from database every 10 seconds.

The upper part of this website contains several criteria to display the route and information of selected vehicle and all vehicles.

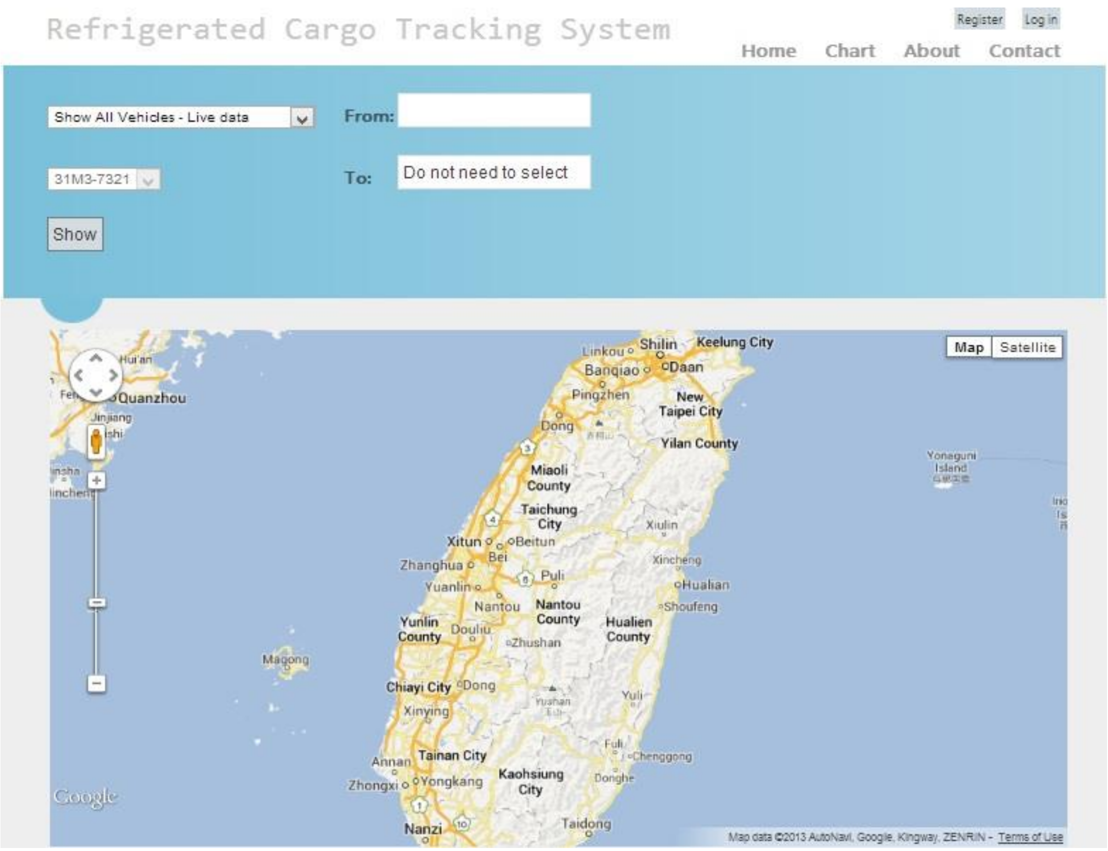

Fig.4.4 Cargo Tracking System main page

Fig.4.5 JQuery Calendar

In Fig.4.5, this calendar is created by using JQuery. We can select month, year, date, hour and minute with this popup window. Also, in some situations, we only need to provide start time; however in other situations, we need to provide starting time and end time. If users do not input starting time, a red label “Please Select Starting Time!” will be shown and mouse will be focus on that textbox as shown in Fig.4.6.

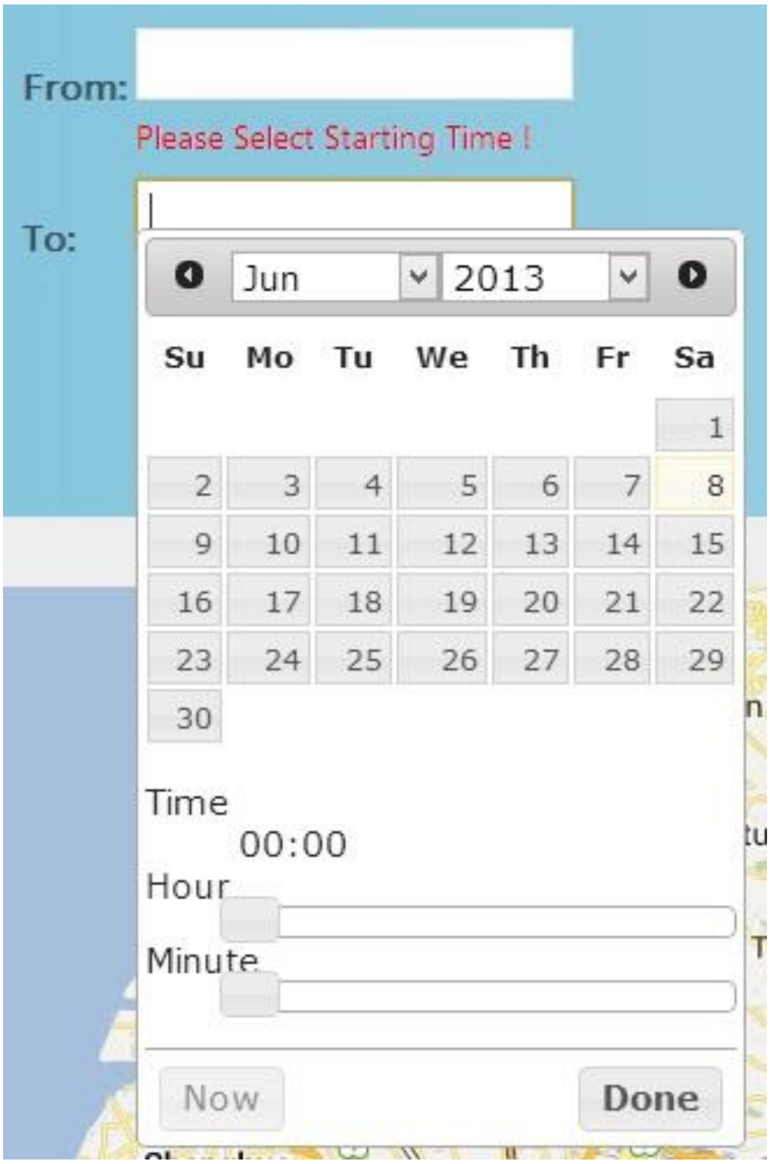

Fig.4.6 JQuery Calendar Error Notification

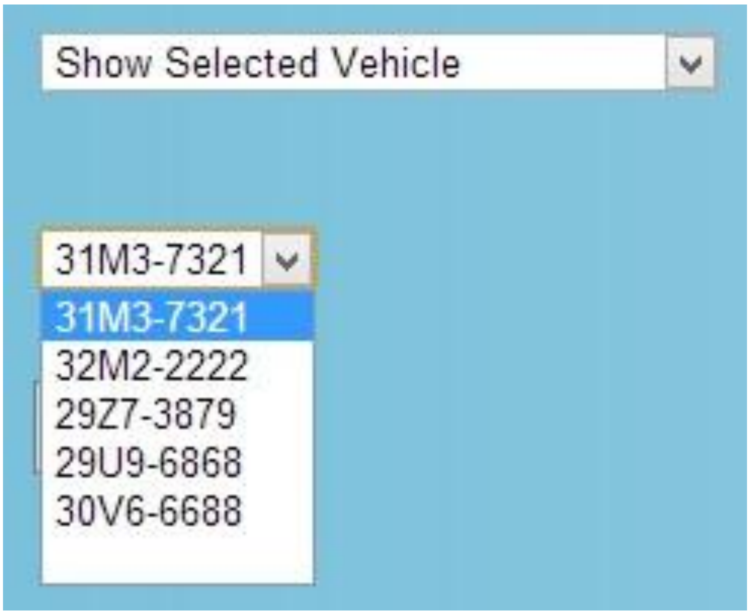

Fig.4.7 Dropdown List Car Number Plate

Car Number Plates are reloaded from database and being displayed in a dropdown list in two options: Show Selected Vehicle and Show Selected Vehicle – live data as shown in Fig.4.8.

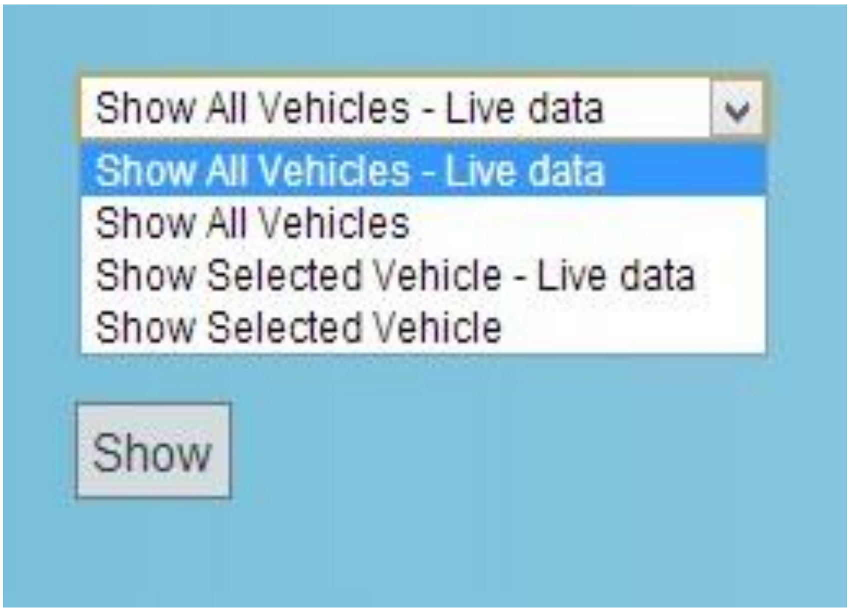

Fig.4.8 Vehicle display options

In Fig.4.8, we can choose one from 4 options:

- Show All Vehicles – Live data: This is a real time function to display all vehicles' information. We use different colour marks to represent different vehicles. All vehicles will be shown on Google Map from a specific start time as shown in Fig.4.9. In addition, the user can change the Google Map to Google Satellite for more image information as shown in Fig.4.10. In this webpage, data are reloaded every 10 seconds to update new route and information from vehicles. In this option, users do not need to select end time.

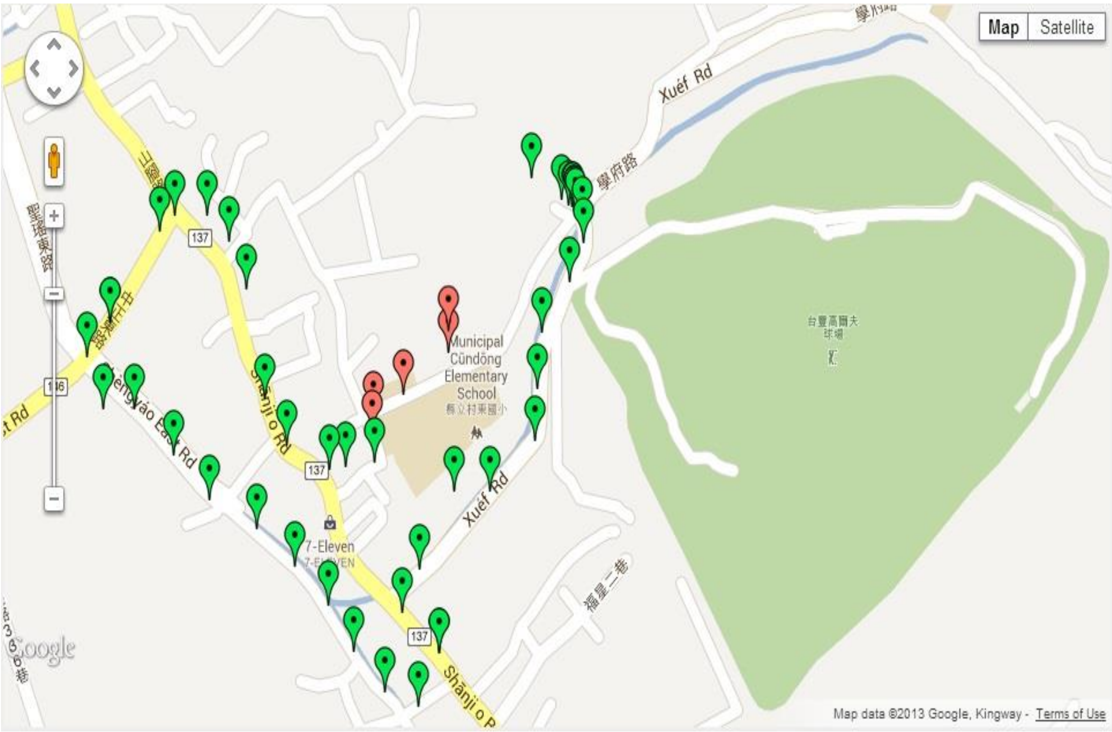

Fig.4.9 Show All Vehicles – Live data (Google Map version)

Fig.4.10 Show All Vehicles – Live data (Google Satellite version)

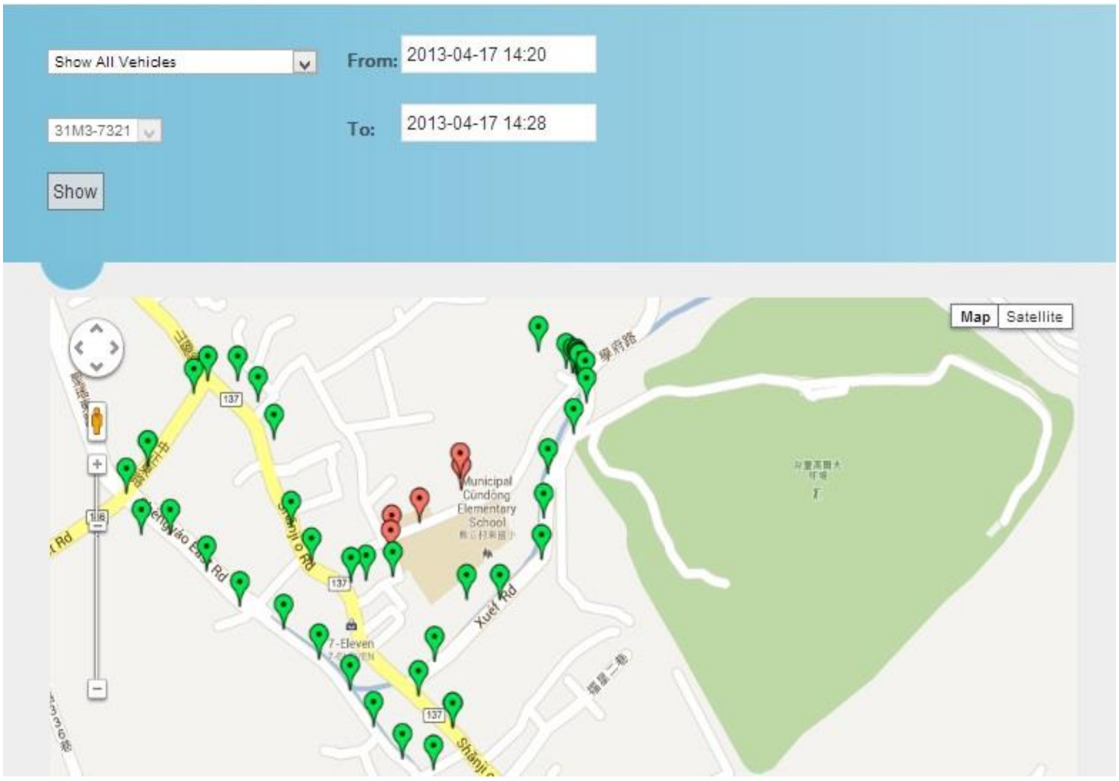

Fig.4.11 Show All Vehicles

- Show All Vehicles: All vehicles will be shown on Google Map from a specific start time to a specific end time. In this option, users need to select both of start time and end time as shown in Fig.4.11.
- Show Selected Vehicle – Live data: A selected vehicle will be shown on Google Map from a specific start time. In this option, users do not need to select end time. However, users do need to select car number plate from Dropdown List CarNumberPlate as shown in Fig.4.12.

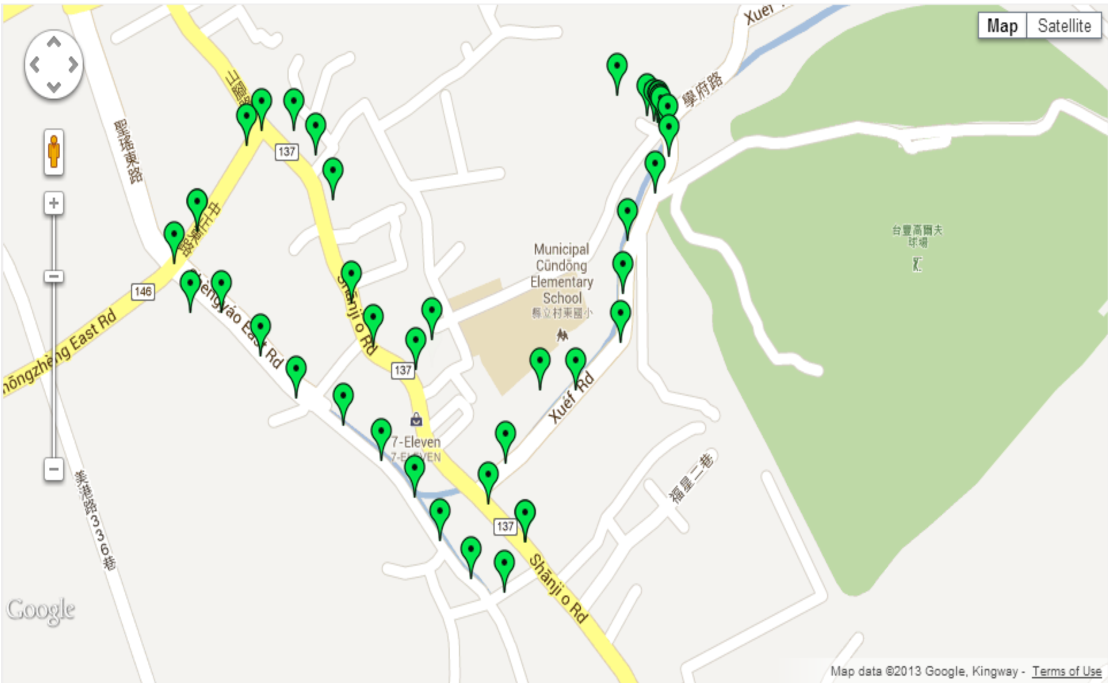

Fig.4.12 Show Selected Vehicles – live data

- Show Selected Vehicle: A selected vehicle will be shown on Google Map from a specific start time to a specific end time. In this option, users need to select both of start time and end time. Also, users do need to select car number plate from Dropdown List CarNumberPlate as shown in Fig.4.13.

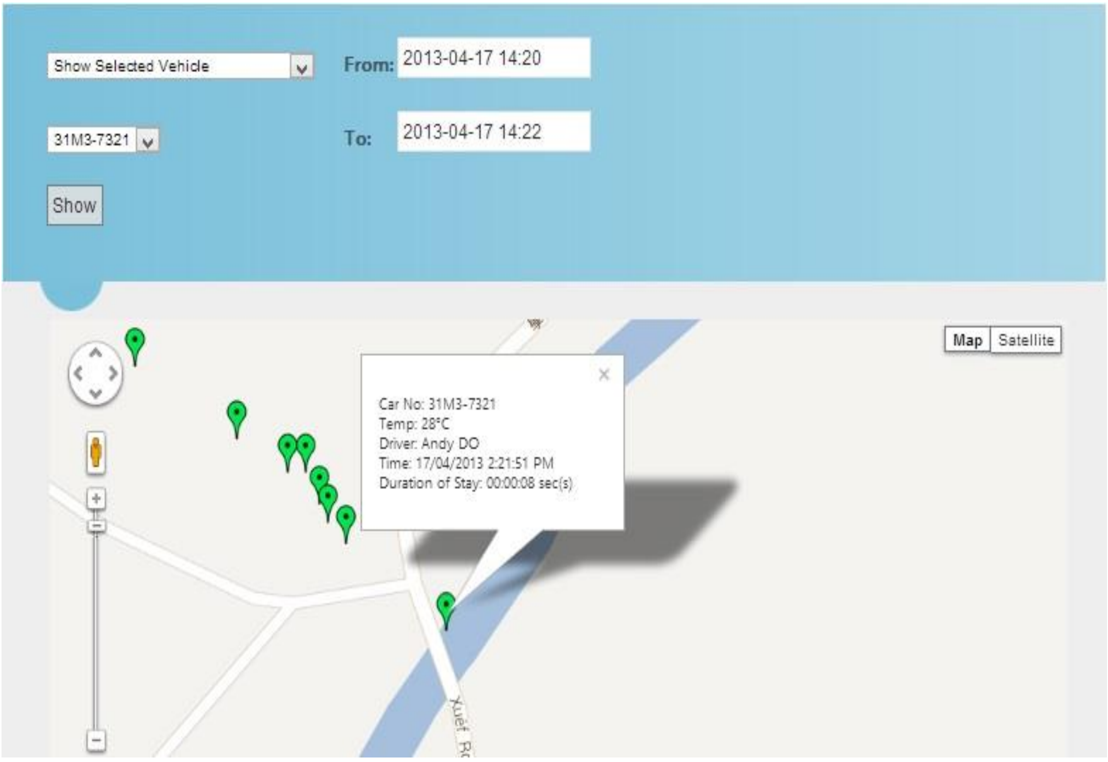

Fig.4.13 Show Selected Vehicles

In this proposed system, users can see more detail such as car number plate, temperature, time, and duration of stay by clicking on any marker you want as shown in Fig.4.14.

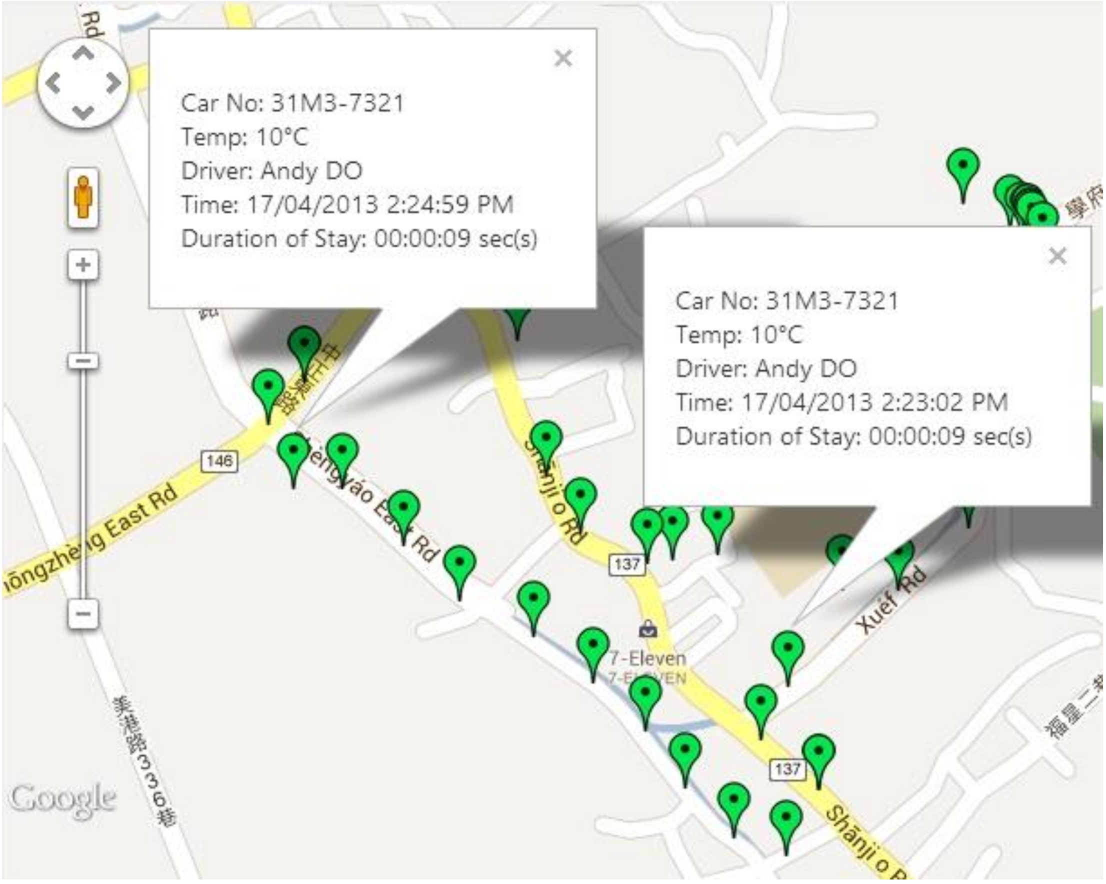

Fig.4.14 Information display

When temperature exceed a threshold, the marker at that position will be bounded to let the users know as shown in Fig.4.15.

Another function that our system can provide for firm is temperature monitor function. We choose Google Charts to implement this function. As shown in Fig.4.16, a line represents the temperature by time. Users can see more detail by hover the mouse at a desired point. This function is used to monitor the temperature to ensure that the temperature always in an optimal range, or in other words, food is well preserved on the way of delivery.

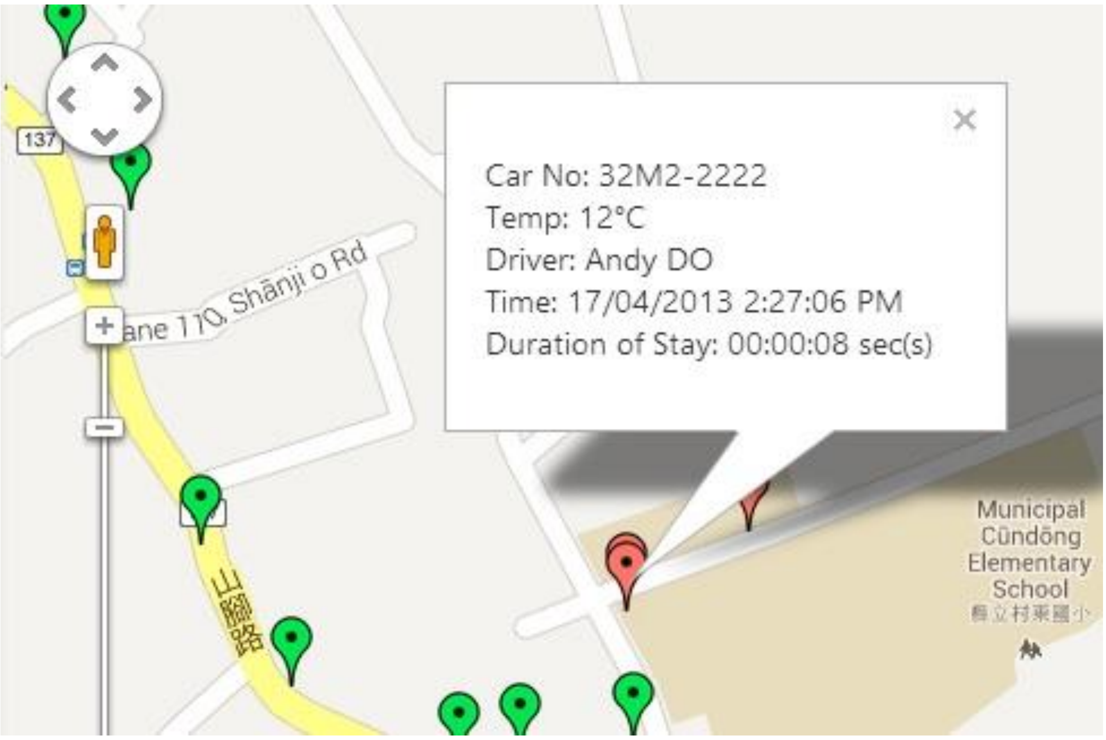

Fig.4.15 Temperature alert function

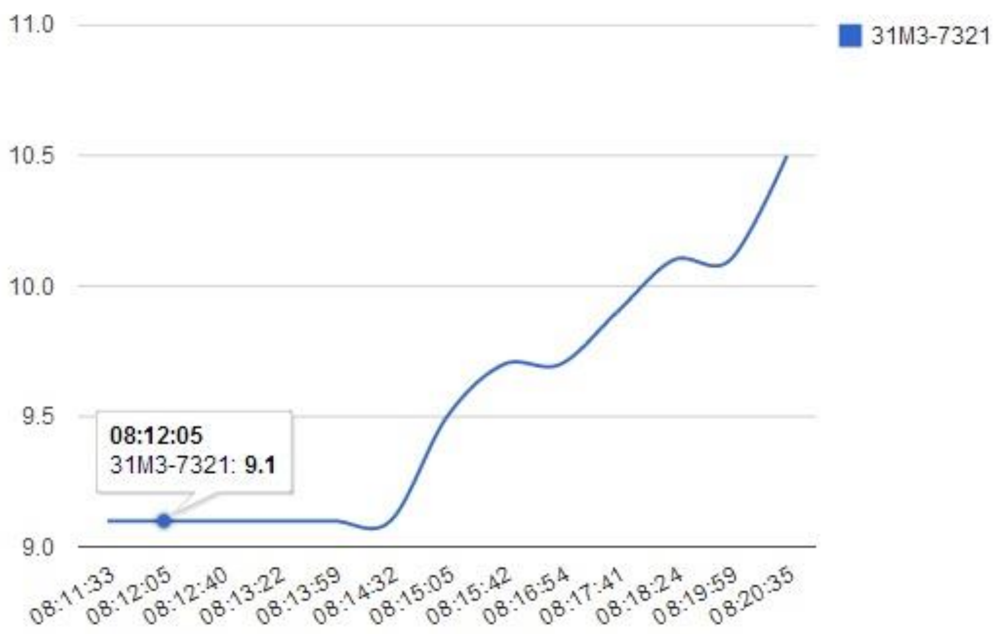

Fig 4.16 Temperature monitor

4.4 MSP430 F4152 MCU Implementation

The Texas Instruments MSP430 - family of ultralow-power microcontrollers consist of several devices featuring different sets of peripherals targeted for various applications. The architecture, combined with five low power modes, is optimized to achieve extended battery life in portable measurement applications. The device features a powerful 16-bit RISC CPU, 16-bit registers, and constant generator that contribute to maximum code efficiency. The digitally controlled oscillator (DCO) allows wake-up from low-power modes to active mode in less than 6 µs. The MSP430 F4152 is a microcontroller configuration with two 16-bit timers, a basic timer with a real-time clock, a 10-bit A/D converter, 16KB Flash, 512B RAM a versatile analog comparator, two universal serial communication interfaces, up to 48 I/O pins, and a liquid crystal display driver. Typical applications for this device include analog and digital sensor systems, remote controls, thermostats, digital timers, hand-held meters, etc.

In this proposed system, we have successfully implemented temperature sensor module with MSP430 F4152 as shown in Fig 4.17. Android phone connected with temperature sensor via Bluetooth connection. Temperature is displayed in Android phone and MSP430 LCD. However, I do not focus on this sensor implementation.

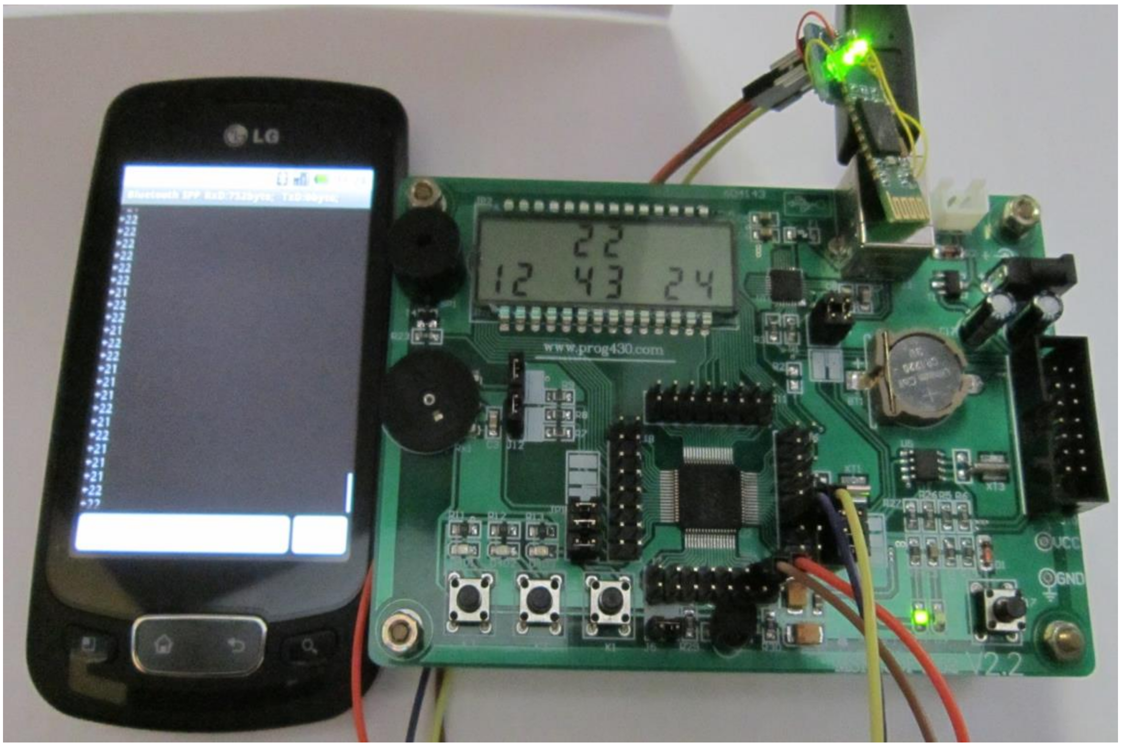

Fig.4.17 MSP430 F4152 implementation

4.5 Android Application Implementation

Android application is used to collect GPS information from the embedded GPS sensor and temperature from MSP430 F4152 with temperature sensor. After collecting latitudes, longtitudes, and temperature, they will be packed in JSON format and sent to PHP web service via POST method for further process. The running snapshot of Android application is shown in Fig.4.18.

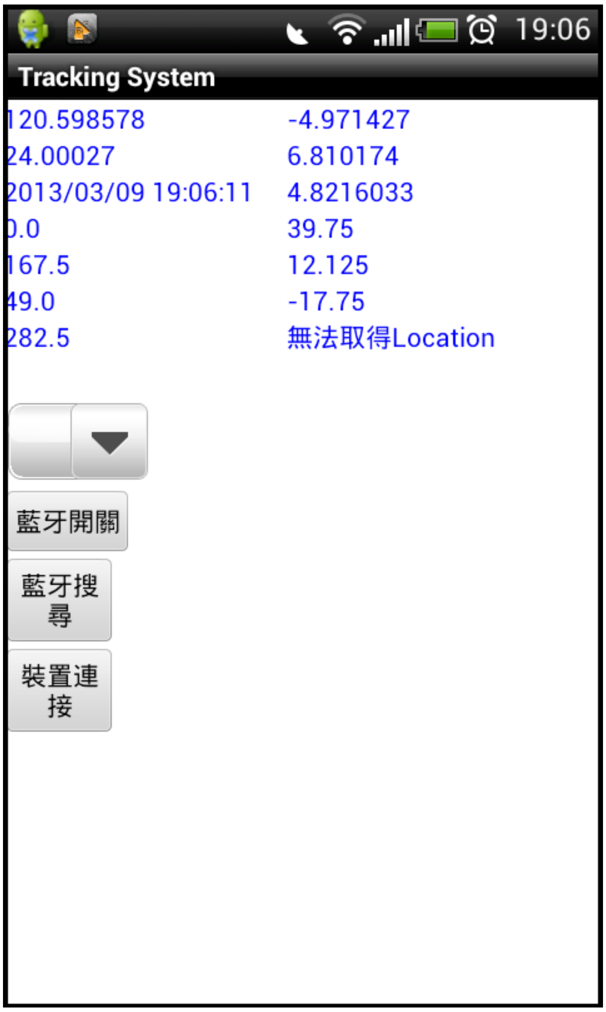

Fig.4.18 Android application

Chapter V. CONCLUSION AND FUTURE WORK

The major contributions of this thesis are listed as below:

- Outdoor Tracking by using smartphone embedded GPS sensor to send longitudes, latitudes to the database in every 10 seconds.
- Sending other information such as environmental sensing data (temperature…)
- Using MSP430 F4152 with temperature sensor connected with Android phone.
- Using MySQL database to store GPS and environmental sensing data.
- Website for management.
- This system is flexible and upgradable.

In comparison with other systems such as [1], [2], [3], [4], and [5] presented in chapter 2, our solution possess almost of their functions as shown in Fig.5.1. This system surely meets the demands in reality for refrigerated cargo tracking system.

However, our proposed system still has some drawbacks and need to be enhanced in the future implementation. In the future, we hope we could implement some other functions such as predict the ETA (Estimated Time Arrival) or implement other sensors (humidity sensor…) to meet the firm's requirements.

Table 1. Comparison table

Criteria	Reference number				
	He 's solution [1]	Yang 's solution [2]	Li 's solution [4]	Zhou 's solution [5]	*Our Solution*
Indoor Tracking	No	Yes	No	No	*No*
Outdoor Tracking	Yes (GPS)	Yes (GPS)	Yes (GPS)	Yes (GPS)	*Yes (GPS)*
Sending Other Information except positions	Yes	No	No	Yes	*Yes*
RFID usage for storing process	Yes	No	No	Yes	*No*
Environmental sensing	No	No	No	No	*Yes*
DBMS usage	Yes	No	Yes	Yes	*Yes*
Management Application	Yes	Yes	Yes	Yes	*Yes*
Mobile app/ mobile sender	Yes	No	Yes	No	*Yes*
Data transmission	GPRS	GPRS	GPRS	3G	HSDPA/*GPRS*
Flexibility/ Upgradeable	Yes	---	Hard to upgrade	Yes	*Yes*
Real implementation	Yes	No	Yes	Yes	*Yes*

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