GPS projectile vehicle tracking system

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GPS PROJECTILE VEHICLE TRACKING SYSTEM

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SCHOOL OF ELECTRICAL AND ELECTRONIC ENGINEERING

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Abstract

Vehicle tracking based on Global Positioning System (GPS) was first developed in 1960s, which has brought a certain stage of development in vehicle anti-theft evolution. However, the common vehicle tracking system is not able to meet the basic requirements of the Singapore Police Force (SPF) to track the suspected vehicles. The SPF has requested for a comprehensive, simple and yet low cost tracking system to track runaway vehicle.

In this dissertation, a GPS projectile vehicle tracking system to fulfill the function of tracking the target vehicle is specially developed for the SPF. The system can be divided into two parts: Tracking Device and Control Device. The development of the two devices is based on the Android Application (App) development, which offers a low cost and convenient method for the project. In this project, two Apps are successfully developed: the first App is to acquire the GPS information of the target vehicle and send SMS to the Control Device, while the second App is able to convert the GPS information into display on the Google Map. The connection between the two devices is simply through SMS. Furthermore, the specific SMS is able to activate the Apps in both devices, which allows the system to be a highly automated. The testing of the two devices is successful to fulfill the requirements of the SPF.

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Acronyms

- GPS.....Global Positioning System
- SMS.....Short Message Service
- API.....Application Programming Interface
- ES.....Embedded System
- CPU.....Central Processing Unit
- RAM.....Random-Access Memory
- ROM.....Read Only Memory
- ARM.....Advanced RISC Machine
- DSP.....Digital Signal Processor
- SDK.....Software Development Kit
- JDK.....Java Development Kit
- ADT.....Android Development Tools

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Chapter 1

Introduction

1.1 Motivation

The economy development and technology evolution over the last decades has stimulated the popularization of vehicles around the world. However, this transportation revolution brought much stress to the society, which led to an increased number of traffic accidents every year. This phenomenon attracts much attention from the public, especially the police who tend to figure out a solution for better control of the severe traffic condition.

Vehicle tracking system based on GPS technology has become a mature industry in recent years, which helps the users acquire the accurate location information of vehicle^[1]. This vehicle tracking property of the system draws the attention of the police. However, the vehicle tracking systems more focus on the anti-theft function, and they are the built-in devices in private vehicles. This makes it impossible for the police to install a tracking device in each and every vehicle in the country, which allows for an extremely high cost. It is obvious that this method not only brings much reluctant cost to the society, but also tends to be inefficiency.

However, in the contrast, the police only need to track the suspect vehicles to achieve the location information of them which will increase the efficiency of their work and help them have a better control of the suspect vehicles. With the continuous increase in the vehicle quantity, it becomes more and more necessary to have a convenient tracking device to help the police work efficiently, which will also definitely bring a more healthy traffic environment.

It can be seen from the discussion above, a high-tech vehicle tracking device with

small size and functional modules has a significant and good impact on the traffic. In this dissertation, a GPS projectile vehicle tracking system is provided for the practical application, which offers a convenient and high efficient system for the police to track the suspect vehicles.

1.2 Objectives and Specifications

In this dissertation, a GPS projectile vehicle tracking system has been developed to fulfill the functions of tracking the target vehicles. A simple, low cost and convenient method to track the suspect vehicles is proposed and developed for the SPF. The proposed tracking system also permits ease of expansion development in other various functions. This GPS projectile vehicle tracking system is based on Android App development, which will reduce the reluctant cost and bring convenience to the users.

1.3 Major Contributions

In this dissertation, a GPS projectile vehicle tracking system that consists a Tracking Device and a Control Device is successfully implemented. The Tracking Device acts as a “bullet” which will stick on the suspected vehicle and transmit the GPS information of the target to the police’s receiver. And the Control Device is the receiver which will display the information sent from the Tracking Device on the map. The two devices are Android mobile phones, and two different Apps have been built in each of them to fulfill the tracking requirements. And the connection between the two devices is just through SMS.

The merits of this vehicle tracking system are as followings:

- Low cost

The whole tracking system is just based on two simple mobile phones.

- Convenience

The connection between Tracking Device and Control Device is just through SMS.

- Automation

The activation of the App in Tracking Device (on moving vehicle) just use SMS.

- Multi-function

The vehicle tracking system is multi functional. The tracking device has the phone number setting and time interval setting.

1.4 Organization of Dissertation

This dissertation consists of six chapters. Chapter 1 has a basic introduction of the motivation, objectives and specification of the project. It also gives an overview of the paper content.

Chapter 2 introduces the background information of the technology applied in the project including GPS technology, Android operating system and the Google Maps Service. This background introduction provides the knowledge foundation of the dissertation.

Chapter 3 discusses the GPS projectile vehicle tracking system and proposes three plans to fulfill the project requirements. In addition, it also makes a comparison between the three proposed plans to make the final decision. At last, it gives an overview of the working principle of the final plan.

Chapter 4 presents the designing of the App in Tracking Device. It introduces the function modules and working flow of the Tracking Device system. And it also gives an introduction of the App development in Tracking Device. The visual machine testing and phone testing are also presented at the end of this chapter.

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Chapter 5 presents the designing of the App in the Control Device. It introduces the function modules and working flow of the Control Device system. In addition, it introduces the App development in Control Device and gives the phone testing.

Chapter 6 concludes the report and gives the suggestions for the further development.

Chapter 2

Technology Background

2.1 GPS

Global Positioning System (GPS) is a high-accuracy navigation system, which can provide the location and time information of the target under any weather condition. GPS is mainly based on the satellites network composed of 24 satellites which are about 20000 kilometers away from the earth and could emit a steady stream of the positioning signals to the earth^[2]. As long as a GPS receiver on the earth receives signals from any four of the satellites, it could obtain the GPS information of the receiver after calculation, such as position (longitude, latitude, altitude), time, motion status information and so on. Currently, GPS navigation and positioning technology is the only one which can achieve such a high precision, high speed, all-weather and global navigation and positioning performance.

2.1.1 The characteristics of the GPS

Compared with other navigation and positioning system, GPS system has the following advantages:

(1) High positioning accuracy

GPS system can provide users with three-dimensional navigation information, namely, three-dimensional position, three-dimensional velocity information and precise time information, which can ensure the positioning error is less than 15 m^[2].

(2) Short observation time

Nowadays, with the constant improvement of GPS system and the software, the time to achieve the relative static positioning within 20 km is only 15 to 20 minutes^[3].

Regarding the rapid static relative positioning measurement, when the rover and benchmark station is within 15 km apart, rover observation time is just around 1 to 2 minutes^[3]. After that, positioning is available at any time and the real-time positioning speed is relatively fast. Currently, GPS receiver can finish each the locating and speed measuring work in 1 second or even less time, which is especially important for the high dynamic user.

(3) Simple operation

With the continuous improvement in the GPS receiver, a higher degree of automation is achieved. The volume of the GPS receiver is getting smaller and smaller, and the weight is becoming lighter and lighter, which greatly reduce the labor intensity and work tension of the surveyors. This makes the measurement work become relaxed and happy.

(4) Global and all-weather operations

Due to the number of GPS satellites is bigger and the distribution is reasonable, so the GPS receiver at any place on the earth can synchronously observed at least four satellites continuously, thus ensure the global characteristics. Currently, GPS observations can be done at any time of a day, not influenced by cloudy night snow, fog, wind, rain, etc, which ensure the all-weather characteristics.

(5) Real-time positioning

The time required for the system to locate is very short, from cold start to capture the satellites and then to the accurate positioning, the longest time is just 30 seconds. And the refresh time of each positioning is only 0.5 second to 1 second^[3].

(6) Multi-functional and wide application

GPS system not only can be used for positioning and navigation, but also can be used in the speed and time measurement. Speed measuring precision can reach 0.1 m/s^[3], and time measuring accuracy can reach tens of nanoseconds. Its application field is

still expanding.

(7) Strong anti-interference ability, good secrecy.

GPS system uses the spread spectrum modulation technology and related technology, thus ensure the user receiver system strong anti-interference ability, good secrecy, etc.

2.1.2 The History of GPS Development

Compared with the traditional positioning technology, Global positioning system (GPS) is the revolutionary in navigation and positioning on the earth. Generally, the GPS technology was going through the following stages:

(1) Astronomy navigation

By taking advantage of the satellite radio emission signals for navigation and selecting the appropriate spectral band, radio navigation is available. Based on this principle, the United States in December 1965, established the first generation satellite navigation system, namely NNSS Marine navigation system.

(2) Transit satellite navigation system

Marine navigation satellite system was the plan for careful positioning established by the U.S. navy and applied physics laboratory in December 1958, which was also known as TRANSIT. In January 1963, the United States announced the TRANSIT officially put into use, and successively launched 10 man-made satellites from 1965 to 1973^[5]. In January 1967, the United States declared that the TRANSIT was open to private users. After that, several satellites will be launched every few years, which was to ensure five or six satellites work all the time for NNSS, in order to maintain normal operation of the system.

However, there are many drawbacks in Transit satellite navigation system:

- a. The system only has five or six satellites, so the time required to complete a positioning is about 16 minutes^[5]. The system has poor real-time performance, which is not fit for the navigation of high speed moving object.
- b. If unable to input accurate velocity data, when sailing in waves, the system can't get the accurate positioning parameters, which may make the error increase to 200-300 meters^[5].
- c. Anti-interference measures were not taken in the system. This makes the system vulnerable to weather condition, magnetism, radio waves and other compulsory interference of artificial factor, which will definitely affect the normal measurement execution.

(3) Global Positioning System

Aiming to correct the deviation of the transit system and to make better use of satellite navigation system, United States Department of Defense decided to develop the next generation global navigation system for its armed forces and also for civil use in December 1973, entitled "global positioning system (GPS) plan"^[6]. From June 1977 to April 1980, the United States had launched seven satellites for the first phase of work, and carried on the system test to tens of key projects. Finally, the number of satellites reached 24 in 1992 and 1993. Russia also announced that had completed global positioning system (GPS) GLONASS on December 14, 1995. From then on, it was the symbol that the era of mankind using GPS space resources and environment was beginning.

2.1.3 The composition of the GPS system

GPS global satellite positioning system mainly includes three major components: space segment, control segment and user segment^[7].

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Figure 2.1 GPS system of operation

(1) Space segment

Space segment is composed of 24 GPS satellites, at present, there are 21 working satellites and 3 spare satellites orbit the GPS satellite constellation. The 24 satellites are distributed evenly in six orbits (4 satellites in one orbit plane), which are 20000 kilometers away from the earth. The orbital tilt angle is 55° ^[7]. This satellites distribution makes the receiver at anywhere in the world can observe more than four satellites at any time. With the time passes by, the navigation accuracy will decrease gradually caused by the friction between the GPS satellites and the atmosphere.

Figure 2.2 GPS satellite constellation

(2) Control segment

For navigation and positioning, the first thing to know is the location of the satellite. The location of the satellite is based on satellite ephemeris which is the description of satellite motion and the orbit parameters after calculation. The ephemeris of each GPS satellite is provided by the measurement and calculation from the ground monitoring system. Whether all the equipments on the satellite are working normally and whether the satellites are running along the correct orbit, will be observed and controlled by the ground monitoring system. Another important role of the ground monitoring system is to keep the satellites at the same time standards - GPS time system. This would require the ground station monitoring the time of each satellite, and calculate the clock difference which is sent by the ground station to the satellites. After that, satellites will deliver the real-time navigation message to the user's equipment. This is the so-called ephemeris offered by satellites.

Control segment is composed of three parts: Master Monitor Station, Monitor Station, Ground Antenna.

Master Monitor Station: Its task is to collect all the tracking data from monitoring stations and calculate satellite orbit and clock difference parameters. After that, it will forward the data to the satellites. Master Monitor Station itself is also a monitor, which could diagnose, schedule and adjust the working status of the satellites.

Monitor Station: Monitoring stations are equipped with P code receiver and precision cesium clock, which conduct the tracking measurement of the satellites in pseudo P code. The observation results will be sent to the master monitor station every 15 minutes^[8] with the aid of the ionosphere and meteorological data.

Ground Antenna: Its main function is to send satellite ephemeris and clock difference information received from the master monitor station into memory on the satellites once a day.

(3) User segment

The user segment is also known as GPS signal receiver. Its main function is to capture the selected satellites in a certain angle and follow up the operation of the satellites^[8]. When the receiver capture the signal from the satellites, it can measure the pseudo distance from the satellites to the receiving antennas and the rate of change of distance, in order to decipher the navigation message sent from the GPS satellites. Based on these data, the microprocessor computer of the receiver can calculate the user's location information such as longitude and latitude, altitude, speed and time. A receiver's hardware and software as well as the GPS data post-processing software package in the machine will form the complete GPS user equipment. Generally, the GPS receiver generally includes an antenna, signal processor, a display device, recording device and a power supply (Figure 2.3).

Figure 2.3 GPS receiver basic structure

2.1.4 GPS Positioning Principle

The basic principle of GPS navigation system is to measure the distance between position of the known satellite and the position of the user's receiver, and then integrate satellite data to know the location of the receiver. Applying the data from three or more satellites from the known space can achieve the position of receiver on

the ground. However, in addition to the three-dimensional coordinates in the position, there exists a deviation between the receiver clock and the satellite clock. So if this deviation is seen as the unknown factor, there are total four unknown factors in the positioning and navigation. As a result, the receiver must receive signals from at least four satellites at the same time to calculate the three-dimensional coordinates of the receiver.

Figure 2.4 Receiver position coordinates solver

The real distance R between the satellite and the receiver is obtained by measuring the time Δt of the GPS signal received by the receiver, shown in the equation 2.1.

$$R = c\Delta t \tag{2.1}$$

c is the propagation speed of the GPS signal, i.e., the speed of light.

Due to the impact of clock difference, the clock of the receiver V_{t0} and the UTC time V_{ti} are not necessarily synchronous, ie $V_{ti} - V_{t0} \neq 0$. When the UTC time is earlier, then $V_{ti} - V_{t0}$ is positive, otherwise it is negative. Due to the presence of the clock difference between V_{t0} and V_{ti} , an error occurs in measuring the signal transmission distance. The distance measured from the satellite to the receiver is called pseudo

distance ρ , shown in the equation 2.2.

$$\rho = R + c(V_{ti} - V_{t0}) \quad (2.2)$$

The coordinates of the four satellites can be calculated according to the ephemeris file, let (x_i, y_i, z_i) ($i=1, 2, 3, 4$) be the coordinates of the four satellites in space at time t respectively;

Then according to product of the signal transmission time Δt and the speed of light c , the pseudo distance between the satellite and the receiver is able to be achieved.

Let ρ_i ($i=1, 2, 3, 4$) be the distance between the receiver and the four satellites respectively;

Δt_i ($i=1, 2, 3, 4$) be required time of the signal transmitting from the four satellites to the receiver respectively;

V_{ti} ($i=1, 2, 3, 4$) be the time clock of the four satellites obtained from the ephemeris of the satellites, V_{t0} be the time clock of the receiver. Equation system 2.3 can be obtained. The position of the receiver (x, y, z) can be achieved by solving the equations^[7].

$$\begin{aligned} [(x_1 - x)^2 + (y_1 - y)^2 + (z_1 - z)^2]^{1/2} + c(V_{t1} - V_{t0}) &= \rho_1 \\ [(x_2 - x)^2 + (y_2 - y)^2 + (z_2 - z)^2]^{1/2} + c(V_{t2} - V_{t0}) &= \rho_2 \\ [(x_3 - x)^2 + (y_3 - y)^2 + (z_3 - z)^2]^{1/2} + c(V_{t3} - V_{t0}) &= \rho_3 \\ [(x_4 - x)^2 + (y_4 - y)^2 + (z_4 - z)^2]^{1/2} + c(V_{t4} - V_{t0}) &= \rho_4 \end{aligned} \quad (2.3)$$

2.2 Android Operating System

Android is an operating system based on the Linux kernel which is first designed for the portable devices^[9]. Android is initiated by Andy Rubin, and only suitable for the smartphone at first. In 2005, Google backed financially and set up the Open Handset Alliance for further development, gradually extended to the tablet computer and

other areas. The main competitors of Android are the Apple's IOS and RIM's Blackberry OS. In the first quarter of 2011, The share of Android in the global market exceeded that of the Symbian system for the first time, becomes the world's first system. In February 2012, the data showed that the Android operating system occupies 52.5% of the global smartphone operating system market^[10].

2.2.1 Merits of Android Operating System

(1) Openness

When it comes to Android's advantages, the first thing must be the Android's real openness, which includes the underlying operating system and also the upper Applications. The cooperation between Google and the Open Handset Alliance aimed to establish a standardized and open mobile software platform, forming an open ecosystem in the mobile industry.

The openness of the Android also motivates many application developers into the development of the Android application, which will bring a lot of new applications for the Android platform.

(2) Equality

All applications in the Android system have full equality. There is no differences between the system default built-in applications and the applications from developers. Application developers can develop personal favorite applications to replace the system program, building personalized Android mobile phone system, which is not possible in other mobile platforms. At the beginning of the development, the Android platform is designed to be composed of a series of application platform, where all the applications are running on a virtual machine. The virtual machine provides a series of API communication between the applications and hardware resources. And in addition to the virtual machine, all the other applications are all equal.

(3) Unboundedness

The unboundedness of the Android platform performance means that the communication between applications is without constraint. Developers can develop applications easily to interact with other applications. For example, an application needs to play sound modules, and just your phone already has a mature music player, at this point you do not have to repeat the development of the music playback function, instead you only need to simply add a few lines of code, which will add the mature music playback function to your program.

(4) Convenience

Development and application in the Android platform is very convenient. If familiar with the Android platform, it is very easy to develop a fully functional application. Android platform provides an easy access to library for developers to and a large number of tools, as well as Google maps and other strong functions, which simply needs a few lines of code to add powerful map to the application.

(5) Multi-functional

Due to the open platform, many hardware manufacturers launched a variety of strange products, but these differences do not affect data synchronization and software compatibility. For example, the original application on nokia phones can be ported to MOTOROLA's mobile phone use easily, as well as the contacts, short message data.

2.2.2 Android System's Architecture

Android system architecture is same as other operating system. A layered architecture is adopted. Android is divided into four layers, from senior to junior, which is the application layer, application framework runtime layer, system layer and the kernel respectively^[11].

Android mobile operating platform is based on Linux as the core, which is also an open operating system. With the rapid development of Android, it allows the developers to use a variety of programming languages to develop Android applications. Java is no longer the only language for the Android applications development, which was highly recommended by most the developers. This development makes the Android become a real sense of the open operating system. After all the Android operating system is very complex, the system architecture is shown in Figure 2.5.

Figure 2.5 Android system architecture

(1) Application layer

All applications of this layer are written in Java. In general, many applications are published together based on the same series of core application package, which mainly includes dial-up, browser, music players, contacts and so on. Applications in this layer program are completely equal. Developers can arbitrarily to replace built-in

applications with their own applications.

(2) Application framework layer

Application framework layer is the most familiar to the developers. The design of application framework simplifies the reuse of components, which allows any application can call for the functions of other applications. This also makes user to easily replace the components without affecting the use of other modules. However, this replace function needs to follow the framework security restrictions.

There are 9 segments in this layer^[11]:

- a. Activity Manager: Used to manage the life cycle of applications, and provide the most commonly used back function of navigation.
- b. Window Manager: Used to manage all the application windows.
- c. Content Providers: Able to make an application to access data from another application or share data through the content management.
- d. View System: Used to build the basic components of the application, including a list, grid, buttons, text boxes, and even an embedded Web browser.
- e. Package Manager: Used to manage the program in the Android system.
- f. Telephony Manager: Manage all the mobile phone functions.
- g. Resource Manager: Able to provide needed resources for the application, including images, text, sound, string, or even local layout file.
- h. Location Manager: Used to provide location services, for example GPRS positioning.
- i. Notification Manager: Main management of status bar of the mobile phone, which developers in the development of the Android application will often use, such as text messages to prompt, low electricity prompt and the background light.

(3) Android Runtime Library

There are two parts in this layer, the library and the Android runtime library.

Library is mainly C/C++ library, which can be called by different applications in the Android system and provide services for the developers through the application framework. However, Android runtime library contains most of the Java programming language core library function, providing the functions for running the applications

(4) The Linux kernel

Android operating system is Linux 2.6 kernel. Its function mainly relies on Linux, such as security, memory management, process management, network protocol stack, and driver model. For developers, there is an abstraction layer added between the hardware and software, which makes it not necessary to consider the details of the underlying hardware in the development. However, for the mobile phone developers, they just need to make some corresponding changes of this layer, which will let the Android platform run on their own hardware platforms.

2.2.3 The Android System Components

There are four components for Android development: Activity, Service, Broadcast Receiver, Content Provider^[11].

(1) Activity

In Android system, Activity is the foundation of all the applications. In other words, all the program process is running in Activity. Therefore, Activity is the most basic module in Android operating system.

Generally, an Android application is composed of more than one Activity. There can be mutually jump between multiple Activity. For example, after pressing a button, it may jump to other Activity. Before opening a new screen, the former screen will be

set for the suspended state and pressed into the history stack. Users can fallback return to the screen opened before through the fallback function. We can selectively remove some screens which are not necessary to keep, because Android system will save the current screen in the stack.

(2) Service

Service is one of the Android system components, which is the same level as the Activity. However, it can't run independently, just run in the background. It can interact with other components. The Service is long life-cycle code without the interface. The Service is also a program that can run for a long time, but it has no user interface. The Service can be used in the application in many occasions. For example, when the system is playing multimedia, the user starts another Activity at this moment, the program has to continue to play in the background. In short Service is always hidden in the background.

(3) Broadcast Receiver

In Android system, broadcast is a widely used mechanism of the transfer of information between applications. However, the Broadcast Receiver is a component which is able to fulfill the function of filtering, accepting then responding to a broadcast, which is able to let an application to make response to the external event. For example, when download a program successfully, Broadcast Receiver can be used to deal with this. Broadcast Receiver cannot generate UI, which is not transparent for the user. Broadcast Receiver informs the user what happened through the Notification Manager. Broadcast Receiver can be either registered in the Android Manifest. xml, or registered in the runtime code using Context. the register receiver ().As long as it is registered, even if the application is not started, the system will initiate it when it is in need. Applications can also their own intent radio broadcasts to other applications using Context .send Broadcast ().

(4) Content Provider

Content Provider is the third-party application data access solution provided by Android.

In Android, the protection of data is very tight. In addition to the data in the SD card, database, file and so on of an application are not allowed to be directly accessed by other applications. Certainly, Android won't really make each application a single island, however it provides a window for all applications, which is the Content Provider. When an application wants to provide data to outside, the data can be derived from Content Provider classes, which are encapsulated into a Content Provider. Each Content Provider has a uri as a separate identity. Everything looks like a REST, but in fact, it is more flexible than the REST. Similar to the REST, uri also can have two types, one is with the id, the other is a list. However, developers don't need to do according to this model, instead the uri in the form of id can return data in the form of list. As long as it is known by the caller, it is without demanding the so-called REST.

In addition, unlike REST, uri is not the only available in the Content Provider doesn't REST. Content Provider can also accept the Projection, Selection, OrderBy parameters, which make it able to behave like a database for Projection, Selection and Sorting. The results after query will return in the form of Cursor, the caller access the columns of data by moving the Cursor.

Content Provider blocked storage details of the internal data, which provides the unified interface model. This abstraction greatly simplifies the writing of upper application which also provides a more convenient way for data integration. Database is commonly used for fulfilling the internal Content Provider. Android provides a powerful SQLite support. But most of the time, it also can be the package of files or other mixed data.

In Android system, the Content Resolver is used to initiate the positioning of the

Content Provider and the access to Content Provider. But it only provides the synchronize access to Content Provider interface. Usually Content Provider needs to access the large data source. The low efficiency can lead to congestion of the calling thread. So Android provides a AsyncQueryHandler which helps access to the Content Provider.

In the major components, Service and Content Provider is in need of continued access. If Service is time consuming, the asynchronous interface is commonly provided. In contrast, Content Provider, regardless of efficiency, will provided the synchronous access to the interface.

2.3 Google Map Service

This chapter mainly analyzes the mobile Map service and illustrates the Google Map. In addition, it also gives the information of the Android platform location service class and Map class.

2.3.1 Mobile Map Service

Mobile map service refers to the accurate positioning using GPS or network. And use WAP or client to locate the user's position through the communication between mobile network and mobile map application server. This will provide the service related to geographic information including the location of the user, the route query and so on.

Users not only can get related information, but also can achieve the intuitive map information through man-machine interface in the process of query^[12].

The client in mobile phone map query provides users with the query input interface and also the interface used for connecting to the server. In addition, it will show maps searched on your phone. Server-side accepts the client's request in the way of HTTP, and return the map data to the client in the form of raster as requested. The basic

structure of the mobile map query system is shown in the Figure 2.6.

Figure 2.6 Mobile query system

Mobile map is simple mobile file installed on a mobile phone. The detailed map information must be downloaded from the asynchronously terminal after it is parsed in the application network terminal. Currently, the mobile phone provides users with map download, view and a collection of various operations (zoom in, zoom out, search), in the form of graphics, text, to the users. This map service satisfies the basic requirement of the users. In mobile map service, the most important thing is positioning technology.

2.3.2 Future of the Mobile Map

(1) Popularization

With the development of the society, people have more and more demand for geographic information. There is not only the convenience, but also the efficiency and benefit that people can get from map service. Because people can't get through the map service through the personal computer at anytime and anywhere in their daily life, mobile phone for map service is very good solution to this problem. The popularization of the mobile map service will definitely benefit the life of people greatly.

(2) Commercialization

Mobile map service serves as a new and high technology industry, which has a positive impact on the high-tech industry. On one hand, the combination of location service and map service can improve the efficiency of some related industry service, on the other hand, it will modify some traditional industries which will lead a big improvement in the new environment.

(3) Electronic

With the continuous development of technology, mobile map service will permeate more industries, but with some restrictions. Take the mobile network coverage in China as an example, although mobile communication network coverage is very wide in China, but there are blind spots in some remote areas.

2.3.3 Google Maps

In October 2004, Google acquired the company Keyhole headquartered in California, which focused its main business on the vector map. In April 2005, Google launched Google Maps which is a kind of free map service and includes three modes: the traditional map, satellite map and hybrid map.

Traditional map is able to provide user route planning, guidance and also help the user to determine the direction directly:

Satellite map enables users to get the aerial view of the current location;

Mixed map allows users to gain a sense of direction more accurately.

Google Maps has the following characteristics:

(1) Map Preview Generation

Map is not dynamically generated depending on the user's request, but processed to the image in advance, and transferred into code stored in the server. When the user

wants to move or scale map operation, the system only needs to download a new image to fill the new area.

(2) Low Development Cost

The API provided by Google Maps is free for the developers. The only thing need to do is to apply for an API key before use Google Maps, which reduce the requirement for the application developers in terms of two aspects: map service and development. It is very important to improve the map service level, which has significant influence for developing map applications.

(3) High Frequency of Data Updating

Google Maps provide the map service using two different data sources: the vector map and high-resolution satellite image, which is updated irregularly by Google map. Users can enjoy the latest map information service synchronously.

Currently, people show great interest on the map service offered by the Google Maps, which benefit people's daily life a lot and fulfill their basic requirement. In addition, there are more and more applications based on the Google Maps emerging to rich the people's life. Google Maps application highlights its strong usability and interesting, which has become an indispensable part of our daily life.

2.3.4 Google Maps API

Google Maps API^[13] is first published in 2005, which is divided into four versions: Google Maps JavaScript API, Google Maps API for Flash, Google Static Maps API and Google Maps Data API.

(1) Google Maps JavaScript API: Able to allow users to write JavaScript code to embed the Google Map in their own web page or application, and implement the operation of the map service.

(2) Google Maps API for Flash: Able to embed the Google Maps into the web page

or application based on flash. In addition, it can make related operations to the content of map in 3D mode through many different services.

(3) Google Static Maps API: The main task of Google Static Maps API is to load the static images and embed fast and simple Google Maps images in web pages or mobile site without the help of JavaScript.

(4) Google Maps Data API: Able to achieve the use term model and map item which are used to view, store and update the map data.

Among the four versions of the Google Maps API, Google Maps JavaScript API is the most useful and well-known one. However, the application scope of the other three is very limited. The Google Maps API which people often say refers to Google Maps JavaScript API. It is also same in the following content of this paper. The mentioned Google Maps API refers to the Google Maps JavaScript API.

Currently, Google Maps API has been updated to version 3. In terms of function, the new version of Google Maps API can be divided into five categories: core class and event class and control class, layout class and service class. Core class GMap2 is no doubt the most significant part of Google Maps API. It is the core and foundation of all other elements, and all the other elements are built based on the GMap2.

GMap2 is the foundation of the introduction of the Google Maps into the web page, which runs through the entire application of the project including both the programming process and the debugging process. Usually the first step in the development of web applications based on Google Maps API is to create a div element as the container for the GMap2 object. Then the developer can make use of the strong function of the object to meet the various needs of the applications. The method of GMap2 includes basic method, control method, map type method, map status method, layer method, information window method and so on, which covers the most basic requirements for the development of maps. The important methods of classification are as follows:

(1) Basic method

There are a series of basic methods, including dragging and zooming of the map, pop-up of the information window and also the influence of the mouse click and scroll wheel to zooming effects and other functions.

(2) Control method

GMap2 control method means the method to operate the button and drag bar displayed in the Google Maps. This can control the operation scale, direction button.

(3) Map type method

The so-called map type refers to the different kinds of maps, such as satellite image map, map of color reproduction and so on. There are a total 5 types of GMap2 map type method, which is used to get, set, increase and delete the map types of the application.

(4) Map status method

GMap2 provides map status method to access to the current map scale, the center coordinates, map border points of latitude and longitude. In addition, it also provides the method to access to the status of the map image itself. Such as the size of the map object on the screen, to determination of whether a map object is loaded and so on.

(5) Layer method

GMap2 object provides four layer operation method: add, delete, remove and Pane object for returning to the map.

(6) Information window method

There are many attractions of Google Maps to users, in addition to the precision of satellite image, is the landmark. Generally, the landmark information need to be displayed through the information window. The information window not only can display the test, but also the HTML element which display the text, image and other

GPS Projectile Vehicle Tracking System

data in the form of web page.

Chapter 3

GPS Projectile Vehicle Tracking System

Traffic accidents take away almost one million people's lives every year, which brings more and more attention to the society. Many methods have been done to change the situation: more strict laws to be established, high-tech devices taken into use and so on. When it comes to the suspected vehicle, a tracking device is needed to locate the target and send the meaningful information to the police. This vehicle tracking system is designed for the police to track the suspected vehicle, in order to get the information of the vehicle (longitude, latitude, speed, direction).

3.1 Introduction of GPS Projectile Vehicle Tracking System

All around the world, the high-speed pursuits come to be an important factor in traffic accidents, which lead to millions of deaths every year and cost the government millions of dollars in damages, lawsuits and medical bills. The GPS projectile vehicle tracking system technology may offer a new way to track the crooks and catch them.

The GPS projectile vehicle tracking system intends to see a sticky tracking device as a GPS "bullet" which is used to shoot onto the suspect vehicle. After the device sticks on the suspect vehicle, the police are able to receive the detail information including location speed and direction sent from the tracking device which helps them to track the suspect vehicle and intercept it. Besides, the police also have a receiver to convert the information sent from the tracking device into the location on the map.

The Figure 3.1^[14] below shows basic idea of how the system intends to work.

GPS Projectile Vehicle Tracking System

Figure 3.1 Work flow of the tracking system

1) Tag It

Tag the tracking device onto the suspect vehicle shot from the police car.

2) Fall Back

After tagging the tracking device onto the suspect vehicle, use the receiver to activate the tracking device in order to let the device send back detail information of the targeted vehicle.

3) Track It

After receiving the information sent from the tracking device, the receiver is able to display the location information on the map which is more straightforward for the police to track the suspect vehicle.

4) Intercept

According the information, police are able to get a full knowledge of the suspect

vehicle which will help them to do the final interception.

3.2 Three Proposed Plans for the Tracking System

At the beginning, there are three possible plans proposed to design the vehicle tracking system.

(1) Plan A: Based On Single-chip Microcomputer

The so-called single-chip microcomputer is the integration of processor, memory, timer/counter, serial parallel I/O ports, interrupt control, the system clock and system bus on one chip. Single-chip microcomputer has been widely applied in actual production owing to its low cost, flexibility, convenience, easy debugging and simple maintenance. In the process of navigation and positioning, there is the need to store a large number of historical position data. However, the built-in flash in common used single-chip microcomputer is far less than the requirement of storage capacity, which needs to increase storage space. So the single-chip microcomputer will not take any advantage in terms of anti-interference and cost. In addition, the single-chip microcomputer is very sensitive to the interference when it is under process. The stability of the system can't get enough guarantees.

(2) Plan B: Based On the Embedded System

Generally, embedded system (ES) means non-PC system, which consists of hardware and software. The hardware mainly includes CPU, RAM, ROM, I/O port, peripherals, graphic processor and so on; The software consists of two parts: operating system software and application program^[15]. Most of the embedded systems take ARM and DSP as their processors. The operating system of the embedded system is mainly Windows CE or Linux. In the embedded operating system, there will be many challenges in the development, because the Linux or Windows CE operating system has not been widely used by people. In addition, each operating system has its own set of integrated development environment, which is quite different from the widely

used PC integrated development environment. Therefore, the development difficulty is relatively large and the development cycle is relatively long. Besides, it will lead to more human and financial resource consumption. When it comes to simple and low cost tracking system, this method is easy to cause the waste of resources.

(3)Plan C: Based On Android App

Android App refers to the software application running on the Android platform. Usually, the Android apps are programming in Java language. However, with the development of Android platform, the programming for the development of the Android app is achievable to more languages, which attracts more and more application developers. The Android app is based on the mobile phone which is able to fulfill many requirements of the tracking device. Because the mobile phone has already built in many functional modules, such as GSM module, GPS module, display module and so on, this will bring much convenience to the software development.

3.3 Determine the Final Plan

The devices based on single-chip microcomputer are easily influenced by many factors including the board making process, layout structure and device quality. This will lead to a poor anti-interference ability and a high failure rate. In addition, the single-chip microcomputer has a strong dependence on the development environment and requires a long development cycle. It is rather difficult to form a real product based on the single-chip microcomputer without a continuous development through long time. So this paper eliminates the Plan A for designing the vehicle tracking system.

3.3.1 Comparison of Plan B and Plan C

As the vehicle tracking system is designed for the police to track suspected vehicles,

it is necessary to compare the two proposed plans: Plan B and Plan C above, in terms of size, cost, and system stability.

1) Size

As the device is used for tracking vehicle using GPS, an extra antenna is demanded in Plan B. In addition, power supply module is also necessary in the tracking device. After the search in the market, there is no chip integrated with antenna and power supply, which will calls for extra space to for designing the device. However, there is a variety of mobile phones in the market in different size, which is able to fulfill the size requirement. In addition, the mobile phone already has the required built-in modules for designing the tracking system. Therefore, there is no need to add other modules, which ensure the mobile phone an integrated tracking device.

2) Cost

After the search in the market, the table below gives the cost of each plan discussed above. As there is no chip integrated with antenna and power supply, it is necessary to two items to the device which is also shown in the table below.

Device for Plan B: GSM-GPS Playground Shield for Arduino, Lithium Ion Polymer Battery 860mAh, Mini GPS Antenna Embedded UFL;

Device for Plan C: SAMSUNG S5310 Pocket NEO.

Table 3.1 Cost of Plan A and Plan B

	Plan C	Plan B	
Device (\$)	149	274	
Extra Device (\$)	None	Antenna	10.4
		Power Supply	11.4
Total (\$)	149	295.8	

It can be seen from the Table 3.1 that the total cost of Plan B is almost twice as much

as that of Plan C. Therefore, compared with Plan B, Plan C has an advantage in terms of reducing the development cost.

3) System Stability

Actually, an Android mobile phone can be seen as an integrated embedded system with more modules. Both the mobile phone and embedded system have a good performance in system stability, which will meet the requirements of the tracking system.

4) Other Concerns

In addition to the three factors discussed above, there still remain some other important concerns for the development of the tracking system. For example, it is necessary to package the chip with the extra antenna and power supply to an integrated device in Plan B. However Plan C doesn't have this problem. And it is also necessary to take the further development of the system into account. The ability for further continuous development is a very significant characteristic of a system. In terms of this, the Plan C has an advantage than Plan B, as Plan C is based on the mobile phone which will ensure the App development have an solid hardware base. However, when the system based on embedded system calls for more functions, more modules need to be added on the chip, which is not convenient for the further development and also brings the size issue.

As discussed above, it can be seen that Plan C offers many advantages than the Plan B in terms of size, cost and some other aspects, which is more suitable for designing the GPS projectile vehicle tracking system. Therefore, Plan C is chosen to the final decision for the system design.

3.3.2 The Feasibility of Plan C

After determine the Plan C as the final plan for designing the tracking system, it is

also necessary to discuss the feasibility of Plan C.

In this dissertation, Plan C is an Android software development based on GPS and Google Maps API, which aims to achieve various functions and fulfill the design requirements without spending a lot of human and economic resources. This brings a high practical efficiency and has a good feasibility. The feasibility of the system in this paper is discussed in two following aspects:

(1) Technical feasibility

In terms of technology, the system in this paper is based on GPS technology which is fully mature technology and has formed a worldwide range of business applications. Google Maps API is also launched by the famous company-Google, which has the outstanding advantages and good reputation. It also offers many flexible and powerful functions. All the characteristics discussed above provide a solid theoretical basis for the practical feasibility of the tracking system.

(2) Economic feasibility

Plan C is Android software based system, which reduces the redundancy and hardware requirements. This characteristic of the tracking system leads to a low development cost. In addition, the structure of the system is very straightforward, which is composed of several modules. Different modules have a clear division of responsibilities. The maintenance cost is relatively low which nearly doesn't need the extra cost.

3.4 Working Principle of GPS Projectile Vehicle Tracking System

In this dissertation, a vehicle tracking system that involves two Android mobile phones with built-in Android Apps is proposed and developed. The details on the phone setup and Apps developed are described below:

Devices: In designing the GPS projectile vehicle tracking system, two Android mobile phones are used. One is served as the tracking device, and the other one is served as the receiver.

Apps: Two different Android Apps will be written to fulfill the system’s requirements. One App is used for tracking the suspect vehicle and sending the information to the receiver, this App will be built in the tracking device. The other one is used for converting the information sent from the tracking device into the location information on the Google map, this App will be built in the receiver.

The diagram below shows the basic structure of the vehicle tracking system’s working principle.

Device A and Device B: Android mobile phones

Figure 3.2 Structure of the working principle

As can be seen from the diagram, there are two devices in the vehicle tracking

system: Device A and Device B, both of which are Android mobile phones.

In the vehicle tracking system, Device B is served as the tracking device which is tagged onto the suspect vehicle and sends the GPS information of the target vehicle to Device A through SMS. And Device A is served as the police's receiver which could receive the SMS containing the GPS information sent from the tracking device and could also display the information on the Google map.

In addition, the connection between the Device A and Device B is just through SMS.

(1) Device A could activate Device B by sending a "start" SMS. In other words, when Device B receives the "start" SMS sent from Device A, the App in Device B will start up automatically. After that, Device B begins to locate the target vehicle and sends the GPS information in the form of "longitude: xxxxxxxx; latitude: xxxxxxxx" to the Device A through SMS.

(2) When Device A receives the SMS containing the GPS information, the App in Device A will start up automatically. After that, Device A will display the GPS information on the Google map, which helps the police to track the target vehicle.

It can be seen that both the Apps in Device A and Device B are controlled by SMS, which is very convenient to operate. And this system will offer the user a high automaticity, which benefits the user a lot.

3.5 Function Descriptions of Device A and Device B

In this GPS projectile vehicle tracking system, Device A is considered to be the Control Device, and Device B is considered to be the Tracking Device. These two devices offer different functions to fulfill the vehicle tracking system's requirements.

3.5.1 Functions of Control Device

The functions of the Control Device are shown in the diagram below.

Figure 3.3 Functions of Control Device

(1) Auto Start

The Control Device has an auto start function, which means when the Control Device receives the SMS containing the GPS information sent from the Tracking Device, the App in Control Device will start automatically. However, it also indicates that the software needs to check the incoming SMS first in terms of two aspects: phone number and message content. If the SMS is sent from the Tracking Device’s phone number and the message content is the GPS information in the form of “longitude: xxxxxxxx; latitude: xxxxxxxx”, the App in Control Device will start up automatically. This auto start function brings much convenience for the user’s operation in Control Device.

(2) Location Display on Map

This function is the main function in Control Device. The App in Control Device is able to display the GPS information on the Google map. So it is a software development based on Google Maps API. The software will first extract the longitude and latitude information from the SMS sent from Tracking Device, and then converts these figures into location on the Google map. In the App, there will be a red sign to point out the location of the target vehicle on the map.

3.5.2 Functions of Tracking Device

The functions of the Tracking Device are shown in the diagram below.

Figure 3.4 Functions of Tracking Device

(1) Auto Start

This function of the Tracking Device is similar to that of the Control Device. When the Tracking Device receives the “Start” SMS sent from the Control Device, the App in the Tracking Device will start up automatically and begin to track the target vehicle. It also needs to have the message filtering function in terms of two aspects: message content and phone number, which is same to the Control Device.

(2) Phone Number Setting

The Tracking Device is able to set the phone number. In this function, there are two phone numbers to be set up in the Tracking Device system.

a. From

The first phone number is called “from” in the system, which means the phone number of the “Start” SMS coming from. This first phone number refers to that of the Control Device in this paper.

b. To

The second phone number is called “to” in the system, which means the phone

number of the SMS containing the GPS information of the target vehicle sent to. This second first phone number also refers to that of the Control Device in this paper.

The reason why to set two numbers in the phone number setting function is in case that the phone numbers of the controller and the receiver are different in practical use.

(3) Time Interval Setting

There is a Time Interval Setting function in the Tracking Device, which is to set up the time interval of sending GPS information to the Control Device. The time unit is in minute. For example, if the time interval is set to 1 minute, the Tracking Device will send the SMS containing the GPS information of the target vehicle every one minute.

Chapter 4

Designing App in Tracking Device

Last chapter discusses the main functions of the Tracking Device and Control Device, this chapter mainly focuses on the core function modules of the tracking system, the system working flow and the final development of App in the Tracking Device. In addition, this chapter also shows the testing results of the Tracking Device at last.

4.1 Function Modules of the Tracking Device

The tracking system aims to establish a positioning service in Android system. This tracking system is based on the positioning and navigation service provided by the GPS, which could locate the device’s position and convert the GPS information into longitude and latitude information. After achieving the longitude and latitude of the device, the system will send this information to the Control device through SMS. The core function modules of the Tracking Device are shown in the diagram below.

Figure 4.1 Function modules in Tracking Device

(1) GPS Module

Figure 4.2 GPS module

GPS module is a built-in module in Android system, which can be called simply by code in the application programming. GPS module could acquire the positioning and navigation information of the device.

(2) Data Processing Module

Figure 4.3 Data processing module

As the GPS module could provide a series information of the device, such as longitude, latitude, UTC, height and so on. The form of the GPS information is rather complicated. In the Tracking Device system, the data processing module is able to extract the longitude and latitude information of the device.

(3) Setting Module

Figure 4.4 Setting module

In the Tracking Device system, there are four parameters to be set in the setting

module: “From”, “To”, “Interval”, “auto text”. The functions of “From”, “To” and “Interval” have been described in last Chapter. “Auto Text” setting aims to determine whether the Tracking Device sends the SMS to the Control Device automatically or not. After every change of the setting, the setting module will save these four parameters as the default setting for the use of next activation.

(4) GSM Module

Figure 4.5 GSM module

The GSM module in the Tracking Device can be divided into two parts: receiving SMS and sending SMS.

a. Receiving SMS

In this part of GSM module, the system acts like a message filter. When the Tracking Device receives a SMS, the system will check the SMS first in terms of two aspects: phone number and SMS content. If the phone number is same to the default setting discussed in the setting module, and also the SMS content is “Start”, the App will be activated automatically. This function has been discussed in last Chapter.

b. Sending SMS

In the Tracking Device system, the GSM module could send SMS under specified commend. Before sending the SMS, two properties of the SMS are required: the phone number of the target phone and the message content. In the Tracking Device system, the longitude and latitude of the Tracking Device will be assigned to the message content, and the phone number is the default setting according to the setting module.

4.2 Work Flow of the Tracking Device System

The diagram below shows the work flow of the Tracking Device system.

Figure 4.6 Work flow of Tracking Device system

It can be seen from the Figure 4.6 that there are two way to start the system. One is auto-start which is activated by specified SMS. The other one is just like the common software which is activated by clicking the button. After starting the App in the Tracking device, the main interface will show up and the GPS module begins to work to achieve the GPS information of the Tracking Device. The Data Processing Module will extract the “longitude: x; latitude: x.” information out from the GPS information and assign them to message content. In the meantime, the “longitude: x; latitude: x.” information will also be displayed on “My Location” in the main interface. After the GSM module achieves the “longitude: x; latitude: x.” information and the target phone number from the default setting. There will be a SMS containing the “longitude: x; latitude: x.” information of the Tracking Device sent to the target mobile phone. Besides, there is also a setting interface for the user to set the required parameters which will be saved as default setting. This is the whole work flow how the Tracking Device system works.

4.3 App Development

After getting enough knowledge of the App’s function and work flow, it comes to the final development of the App in the Tracking Device.

4.3.1 Android App Development Environment

It is necessary to establish the Android App development environment first before developing the App.

- (1)Step 1: Download SDK (Software Development Kit) and set the environment variables;
- (2)Step 2: Download JDK (Java Development Kit) and set the environment variables;
- (3)Step 3: Download Eclipse;

(4) Step 4: Download ADT (Android Development Tools) and import ADT into Eclipse;

(5) Step 5: Set up Eclipse and SDK directory.

4.3.2 App Development in Eclipse

In Computer programming, Eclipse refers to the IDE (Integrated Development environment), which is written mostly in Java. Eclipse can be used to develop applications. Most Android App developments are based on Eclipse. In this paper, both the Tracking Device system and Control Device system develop in Eclipse.

The following shows the steps to develop an Android App based on Eclipse IDE.

(1) Step 1: Create an Android Project

The ADT plug-in provides a new project wizard to help the rapid establishment of creating a new Android project and editing the existing Android code. ADT plug-in will establish storage directories for src code file and res resource file directory. In addition, there is also a configuration file for the androidManifest.xml application engineering.

(2) Step 2: Create a launch configuration

It is necessary to create a launch configuration for the project before debugging based on Eclipse.

(3) Step 3: Debugging Applications

Once established the project launch configuration, the Eclipse is able to debug the program. Eclipse can also reconfigure the boot parameters, for example select another application interface as the main interface for starting.

4.3.3 Configuration of Google Maps

As both the development of the Tracking Device system and Control Device system is based on Google Maps. The configuration of Google Maps in Eclipse is necessary.

(1) Step 1: Download Google Map API

In Android App development, the API to fulfill the map function is in a specified Google library. It is necessary to download the corresponding API version of Google Map API before the SDK development.

(2) Step 2: Apply For Key of Google Map API

If developers need to use Google map function in their applications, they need to Google's web site to apply for the API key. The rule of generating the API Key rule is to obtain the signature of the MD5 value. On the Google registration website, input the MD5 value to generate API key for application development. After the registration and application, the Google Map Service is ready. Just add the API key into the main.xml file, and the Google Map Service is able to be applied into your application development.

(3) Step 3: Create the Project Based On the Google MAP API

When creating the project, select the corresponding Android SDK version of Google API version.

4.3.4 Programming

Before programming, it is necessary to make the statement of corresponding permissions in the androidManifest.xml file. Because the application must declare the permissions which will be applied in the application to the Android system before running, otherwise the Android will reject the application to access through the content of permissions.

The programming of the Tracking Device system is based on Java language which is the most commonly used in Android App development.

The programming of the Tracking Device can be divided into four main parts.

(1) MainActivity

Main Activity is the main part of the App programming, which contributes the main function of the Tracking Device system. This part is mainly based on the GPS module, GSM module and GSM module to achieve the intended function.

a. Acquire the GPS information

Based on GPS module, the Main Activity could locate the Tracking Device in order to get the GPS information of the target vehicle. In addition, use the Data Processing Module to extract the longitude and latitude information out from the GPS information. This part of code in this paper is shown below.

In this part, the programming of Main Activity aims to fulfill the function of getting the GPS information of Tracking Device and extracting the longitude and latitude from the GPS information. The part of code is shown below:

```
public void onLocationChanged(Location location) {  
  
    double latitude = location.getLatitude();  
  
    double longitude = location.getLongitude();  
  
    JSONObject object = new JSONObject();  
  
    try {object.put("latitude", latitude);  
  
        object.put("longitude", longitude);  
  
    } catch (JSONException e) {  
  
        e.printStackTrace();  
    }  
}
```


b. Sending SMS

This part of code is mainly based on the GSM module. The message content is according to the longitude and latitude information achieved by the Data Processing Module. The target phone number is according to the default setting of the Setting Module which will be discussed later. After achieving these two properties, the main activity utilizes the GSM Module to send the SMS containing the longitude and latitude of the Tracking Device to the target mobile phone. This part of code is shown below.

```
private void sendMessage(String phoneNumber){
    SmsManager smsManager = SmsManager.getDefault();
    String msg = mMessageView.getText().toString();
    if(msg == null || "".equals(msg)){
        msg = " ";
    }
    smsManager.sendTextMessage( phoneNumber, null, msg, null, null);
}
```

(2) SettingActivity

The setting Activity is to fulfill the function of Setting Module, to set up four parameters through the phone. The four parameters are “From”, “To”, “Interval” and “Auto Text” which have been discussed above in this paper. After setting the four parameters, their values will be saved as the default settings which will be called for every new start.

(3) SMSReceiver

This part will be functional when the Tracking Device receives a SMS. The SMSReceiver mainly focuses on the receiving SMS, it will check the phone number of the receiving SMS and the message content. If the phone number is same as the default setting and the message content is “Start”, the SMSReceiver will activate the

Main Activity which means the App will be activated.

(4) SharedPreferencesManager

This part is used to save the default settings, which will be called for every new start.

4.4 Demo On Visual Machine

After the App programming and debugging, the Tracking Device system is able to demo on the visual machine in the Eclipse. It can be seen from the figure below, the visual machine interface is almost the same as the common Android mobile phone.

Figure 4.7 Visual machine interface

(1) Main Interface

In this paper, the App of Tracking Device is called SMS which can be found in the applications menu. (Figure 4.8)

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Figure 4.8 Applications menu

Click the SMS and the App will be activated. The figure below shows the main interface of the SMS app.

Figure 4.9 Main interface

It can be seen from the figure, the location of the Tracking Device will display in the

box below “MY LOCATION” on the main interface. The location information is in the form of “longitude: xxxxxxxx; latitude: xxxxxxxx” which will also be sent to the target mobile phone.

(2) Setting Interface

In addition to the Main Interface, the SMS app also has the setting interface for the user to set the required parameters.

It can be seen in the Figure 4.10 below, after clicking the menu button, there will be a setting selection coming out at the bottom of the screen which is the selection to open the Setting Interface.

Figure 4.10 Setting selection

Click on the setting button, the SMS App will open the setting interface shown below.

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Figure 4.11 Setting interface

In the Setting Interface, there are four parameters to be set. Type in the two phone numbers and the time interval in the box, and press the “back” button to save the setting as the default settings.

Figure 4.12 Parameters setting

Figure 4.13 Save settings

After finishing setting the parameters, the Android App is ready to be used to track the Tracking Device and send SMS containing the longitude and latitude information of the vehicle to the target phone.

4.5 App APK Generation

APK is the abbreviation of the AndroidPackage which is the Android installation package. Download the APK files directly to the Android emulator or Android mobile phone, the APK can be installed in the Android emulator or Android mobile phone. After the steps above, Eclipse is able to generate the App APK for the mobile phone to install the software. The generation of the App APK is as the following steps.

(1) Step 1:

Right click the SMS package --> Android tools --> Export Signed Application Package

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Figure 4.14 APK generation 1

(2) Step 2

Click Next --> Browse the Key file applied on the Google website and enter the password.

Figure 4.15 APK generation 2

Click Next --> Enter the same password again.

Figure 4.16 APK generation 3

(3) Step 3

Enter destination for the APK file

Figure 4.17 APK generation 4

After these steps, the generation of the APK is successful already.

4.6 Phone Testing

After the generation of the APK, it is ready to do the testing on the Tracking Device. The Tracking Device in the GPS projectile vehicle tracking system is Android mobile phone, so the App will fulfill the function in the Tracking Device. The Tracking Device testing can be done in the following steps.

(1) Step 1: App Installation

Download the APK to the Tracking Device, the file's name is Sms.apk which can be seen in Figure 4.18. Open this file to start the installation of the App.

Figure 4.18 App installation

(2) Step 2: App Setting

After the App installation, the Tracking Device is ready to work. However, it is necessary to set the required parameters for the first time use.

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Figure 4.19 Main interface

Open the App, the main interface of the App can be seen in the figure above. The location information of the Tracking Device will display in the box under “MY LOCATION” in the form of “longitude: xxxxxxxx; latitude: xxxxxxxx”. Press the menu button, the setting selection will come out at the bottom of the screen. And click the setting button, the App will shift to the Setting interface.

Figure 4.20 Setting interface

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After entering the setting interface, just type in the phone number and time interval as required, also click on the auto text. When finish the settings, press the “back” button to save these settings as the default settings. In other words, the user doesn’t need to set the parameters every time unless they want to change the settings.

(3) Step 3: Function Testing

Use the common mobile phone to send a “start” SMS to the Tracking Device, which will activate the App in Tracking Device. And also use the same mobile to receive the SMS containing the GPS information from the Tracking Device. The testing results can be seen in the figures below.

(a) Send Start

(b) After 1 minute

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Figure 4.21 Testing results

The testing results above shows that the mobile phone will receive the location information in the form of “longitude: xxxxxxxx; latitude: xxxxxxxx” of the Tracking Device every one minute after sending a “start” SMS to it. The time interval, one minute, was set in the setting interface beforehand.

After the Phone Testing, it can conclude that the Tracking Device can fulfill the required function and meet the basic tracking requirements.

Chapter 5

Designing App in Control Device

Similar to the Chapter 4, this chapter will give an introduction of the App in Control Device and show the testing results at last.

5.1 Function Modules of Control Device

The main function of the Control Device is to convert the SMS sent from the Tracking Device into the location displayed on the Google map. The App of the Control Device is similar to the common positioning software, however this App should be able to extract the longitude and latitude information from the receiving SMS from the Tracking Device. The core function modules are shown in the diagram below.

Figure 5.1 Function modules in Control Device

(1) GSM Module

Figure 5.2 GSM module

Different from the GSM module in Tracking Device system, the GSM module in the Control Device only focuses on the part of receiving SMS. When the Control Device receives the SMS, the system acts like a message filter which is similar to that of the Tracking Device. The GSM Module will check the receiving SMS in terms of message content. If the content of the SMS is in the form of “longitude: xxxxxxxx; latitude: xxxxxxxx”, the App in the Control Device will start up automatically and begin to display the location of target vehicle on the Google Map.

(2) Google Map Module

Figure 5.3 Google Map module

After achieving longitude and latitude information of the Tracking Device, the Google Map Module will convert these statics into the display on the Google Map. The user will see clearly the location of the Tracking Device. The App also have the zoom-out and zoom-in functions to fulfill the basic requirements of the user.

5.2 Work Flow of the Control Device System

The Figure 5.4 shows the basic structure of the work flow of the Control Device system. It can be seen from the diagram, there are also two different ways to start the App in the Control Device which have been discussed in last chapter. After activating the App, the GSM Module will assign the receiving message content, longitude and latitude, into two different parameters. The main interface will have the longitude and latitude data displayed on the top of the screen. In addition, the Google Map Module will convert the longitude and latitude information into the sign on the map which will be also displayed in the main interface on the bottom of the screen. When

the Control Device receives a new message, the GSM Module and Google Map Module will do the same work again, and the main interface will display the new location information on the map and refresh the longitude and latitude data on the top of the Screen.

Figure 5.4 Work flow of Control Device system

5.3 App Development

Last chapter has already introduced the establishment of the Android App development environment and the configuration of the Google Maps. So the chapter mainly focuses on the programming of App in the Control Device.

The programming of the App in the Control Device can be divided into two parts.

(1) SMSReceiver

This part is based on the GSM module, when the Control Device receives the SMS sent from the Tracking Device, the App in the Control Device will start up automatically. And the GPS information in the SMS will be extracted and assigned into two specific parameters. These two parameters will be applied in the main activity which will be discussed later. The code for this part is shown below.

```
public void onReceive(Context context, Intent intent){

    Bundle bundle = intent.getExtras();

    Object messages[] = (Object[]) bundle.get("pdus");

    SmsMessage smsMessage[] = new SmsMessage[messages.length];

    for (int n = 0; n < messages.length; n++){

        smsMessage[n] = SmsMessage.createFromPdu((byte[])
messages[n]);

    }
```

(2) MapActivity

The MapActivity is the main part of the App in Control device, which utilize the GSM module and Google Map module. It aims to achieve the following functions.

a. Display the longitude and latitude data

This part is based on the GSM module. After achieving the longitude and latitude information, the data will be displayed on the main interface of the App. The code for this part is shown below.

```
private LatLng getLatLng(String msg){  
  
    double latitude = 0;  
  
    double longitude = 0;  
  
    try {  
  
        JSONObject object = new JSONObject(msg);  
  
        latitude = object.getDouble("latitude");  
  
        longitude = object.getDouble("longitude");  
  
    } catch (JSONException e) {  
  
        e.printStackTrace();  
  
        Toast.makeText(this, "Location data is Error! ",  
Toast.LENGTH_SHORT).show();  
  
    }  
  
    return new LatLng(latitude,longitude);  
  
}
```

b. Display the location on the map

This part is based on Google Map module. In addition to display the data on the map, the Google Map module will also convert the longitude and latitude into the display on the map. The fulfillment of this function is based on the Google Map Service which has been discussed before. On the map, there will be a sign to point out the

current location of the target vehicle. The code for this part is shown below.

```
private void setUpMapIfNeeded(LatLng lg) {

    if (mMap != null) {

        mMap.moveCamera(CameraUpdateFactory.newLatLngZoom(lg, 11));

        mMap.addMarker(new MarkerOptions()

            .position(lg)

            .title("The location is Here!")

            .icon(BitmapDescriptorFactory.defaultMarker(BitmapDescriptorFactory.HUE_RED)));

    }

}
```

5.4 Phone Testing

As this App is based on the Google Maps Service, it is not able to demo on the visual machine without this software. So this chapter will mainly provide the phone testing of the App in Control Device. The APK generation of this App in Control Device is same as that of the Tracking Device. After the APK generation, it is ready to do the testing on the Control Device.

(1) Step 1: App Installation

Download the APK to the Control Device, the file's name is googlemap.apk which can be seen in Figure 7.5. Open this file to start the installation of the App.

Figure 5.5 App installation

(2) Step 2 Function Testing

After installation, open the App, the main interface of the App in Control Device is show in the figure below

Figure 5.6 Main interface

As shown in Figure 5.6, the main interface is divided into two parts. The top half of the screen is used to display the longitude and latitude data acquired from the receiving SMS. The bottom half is used to display the location on the map. In addition, at the right corner of the bottom, the positive and negative button is to achieve the zoom-in and zoom-out functions respectively.

After finishing the setting in Tracking Device, use the Control Device send a “start” SMS to the Tracking Device to activate the App in it. The Tracking Device will send the SMS containing the GPS information to the Control Device. After receiving the SMS from Tracking Device, the Control Device will display the location on the map. The testing results are shown below.

Figure 5.7 Testing results 1

It can be seen from the figure above, the Control Device will display the longitude and latitude data sent from the Tracking Device in the box below “Location From

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SMS". And it will also fulfill the function of positioning and display the location on the map. The figure below shows the function of positioning, the red arrow points out the current location of the target.

Figure 5.8 Testing results 2

During the testing, the Control Device will receive the message from the Tracking Device every 1 minute to 1.5 minutes. However, this receiving time interval mainly depends on the strength of the signal.

It can conclude that the combination of Control Device and Tracking Device can meet the requirements of the GPS projectile vehicle tracking system.

Chapter 6

Conclusion and Recommendations

6.1 Conclusion

A solution based on the Android App has been proposed for the GPS projectile vehicle tracking system in this dissertation. This vehicle tracking system aims to support the police to have a better control of the suspect vehicles, which has the merits of low cost, convenient and multi-functional. The system is divided into two parts: Tracking Device and Control Device, both of which are Android mobile phones. And each of them has its specific functions. The Tracking Device is used to stick on the target vehicle and achieve the GPS information of the vehicle. It is also able to send the SMS containing the GPS information to the Control Device every specific time. The Control Device will convert the location information in the SMS into the display on the Google Map. The designing of the two different Apps is using the Eclipse software in Java language. And both of the two Apps developments are base on service provided by Google Maps. After the phone testing, it can be concluded that both the two devices work well and can meet the requirements of the tracking system.

6.2 Recommendations for Further Research

Owing to the constraint of time, there are more meaningful functions remaining to be developed. The recommendations for further research are summarized as follows.

(1) In this dissertation, the information of the target vehicle given to police is only the location information. It is necessary to provide a more detail information to the police to help them have a better knowledge of the target vehicle. The extra information can be speed, time, direction and so on.

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(2) As the two devices are highly influenced by the GPS signal, it is necessary to add the function of predicting the location under no GPS signal. This function will make the tracking system more powerful. The prediction of the location of the target vehicle under no GPS signal can base on the previous speed and direction information of the vehicle under GPS signal.

(3) The system can also add a “stop” control function to the Tracking Device. In addition to activate the Tracking Device under SMS control, the “stop” function will also benefit the police a lot.

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