Application of Web-GIS Technique to Developing the Management Platform of Traffic Control Devices

Chao-Hui Chen [a], Chia-Ming Ai [b], Chia-Chun Yen [c], Ho-Sheng Chang [d]

[a,b] *Associate Professor, Department of Transportation Technology and Managemen, Feng Chia University, Taichung, Taiwan 407 , R.O.C.*
[a] *E-mail:chhchen@fcu.edu.tw*
[b] *E-mail: cmai@fcu.du.tw*
[c] *PhD Student, PhD Program in Civil and Hydraulic Engineering, Feng Chia University, Taichung, Taiwan 407, R.O.C.; E-mail: p0100212@fcu.edu.tw*
[d] *Same as the first author; Graduate Student, E-mail: nowachang @mail.fcu.edu.tw*

Abstract: To efficiently manage the information of road-side devices, this research takes Geospatial standards of OGC, Open GIS Consortium, as basis, and uses MVC (Model/View/Controller) architecture to develop the management system. The cost of developing is lowered with free software and open source software, where (1) OpenLayers is tooled to generate background maps and foreground devices' maps; (2) GeoServer with Web Map Service (WMS) and Web Feature Service (WFS) are applied to deal with map data; (3) Ext.Net is applied to develop user interface. PostgresSQL+PostGIS and Microsoft SQL Server2008 are used to store spatial and device data, respectively, to promote efficiency of data processing. Detecting function of connection status, 3-by-3 grid inquiry of CCTV, and dynamic signal light display are also developed. Using Internet as platform, it offers inquiring interface with GIS, centralizing management data and remote maintenance. The results are put in use as they are provided to the authorities.

Keywords: Traffic Control Devices, Web-GIS, WMS/WFS, OpenLayers, Ext.NET, RIA

1. INTRODUCTION

The traffic authorities develop intelligent transportation systems (ITS) to enhance the efficiency of transportation system. Urban traffic control system consists of road-side device, central-side device and software. The former includes signal controller (SC), vehicle detector (VD), closed circuit television (CCTV), changeable message sign (CMS) and automatic vehicle identification (AVI). They gather traffic information and data, send and receive data

with the communication server and broadcast server of the traffic management center (TMC) through the Internet. The data are then sent back to the platform and software of the center to provide information inquiry. Data analysis and calculation are done and the results are then used to develop suitable traffic strategies which will be sent to the road-side device or announced at CMS for road users. People are also informed of the information through real-time traffic information sites.

Traditional platforms are constructed as single-user mode which could be used by only one person in the meantime. It is made up of text-mode interface which is unfriendly to users. The Data are complicated and dispersed in various database due to different constructing companies and time period, such platform is not able to cope with each device efficiently.

Geographic information system (GIS) is a set of geographic database which puts maps and real world together. They integrate geographical information. Users are able to gather, revise, renew, save, inquire, process, analyze and show with it. This enhances the affinity and efficiency of collecting information. The idea of Web-GIS is to extend the GIS to the sharing environment, the internet. People in need can browse through personal computers to spread and exchange figure data. With the use of the fast convey of the internet, property data, figures and relevant information can be efficiently transmit with the interactions of the users available. Currently, the typical Web-GIS is composed of map display, map inquiry, displacement, zoom-in/out of the map, characteristic inquiry, spatial analysis, environmental analysis and printing.

Therefore, this research aims to develop a Web-GIS traffic control platform which provides multiple users on-line inquiry, editing through authority management, and develop a thorough road-side devices' database for systemic managing and maintenance.

The current status of traffic control system is introduced first. In section 3~5, the system analysis, design and implementation are introduced respectively. Finally, conclusions and suggestions are shown in section 6.

2. LITERATURE REVIEW AND CURRENT SITUATION

2.1 Literature Review

The decision making by Geographic Information Systems has several benefits, include: 1) Encourages partnerships and data sharing; 2) Helps identify potential problems early in the planning process; 3) Provides users with access to quality data; 4) Improves feedback with maps and summary reports. (FHWA-GIS 2006)

The applications of Web-GIS are well established in many domains such as urban planning, resources management, ubiquitous monitoring, and traffic management. And it had many practical examples in transportation field are listed below. In Arkansas State (AHTD) constructed a system to recording and analyzing crash information by GIS. In the City of New Haven, it developed a comprehensive, interactive planning tool to help their staff maintain its bridge program and effectively manage infrastructure resources. The Georgia DOT's establish pavement management system contains thousands of Arc/Info route features for each county which have been calibrated and quality checked. And this statewide map layers can offer to authority. (FHWA-GIS website)

However, above mentioned literature are only introduced the advantage of GIS and its application. Therefore this paper is concentrated on technically aspects on Web-GIS can not only enhance future extension but reduce the cost of platform development.

2.2 Current Status of Traffic Control System

As urban development is rapidly growing, traffic management center are built in cities to deal with the urban traffic problems, which are getting more and more complicated. Traffic control system is composed of road-side device, center device and software. The system in study area is constructed as Fig.1.
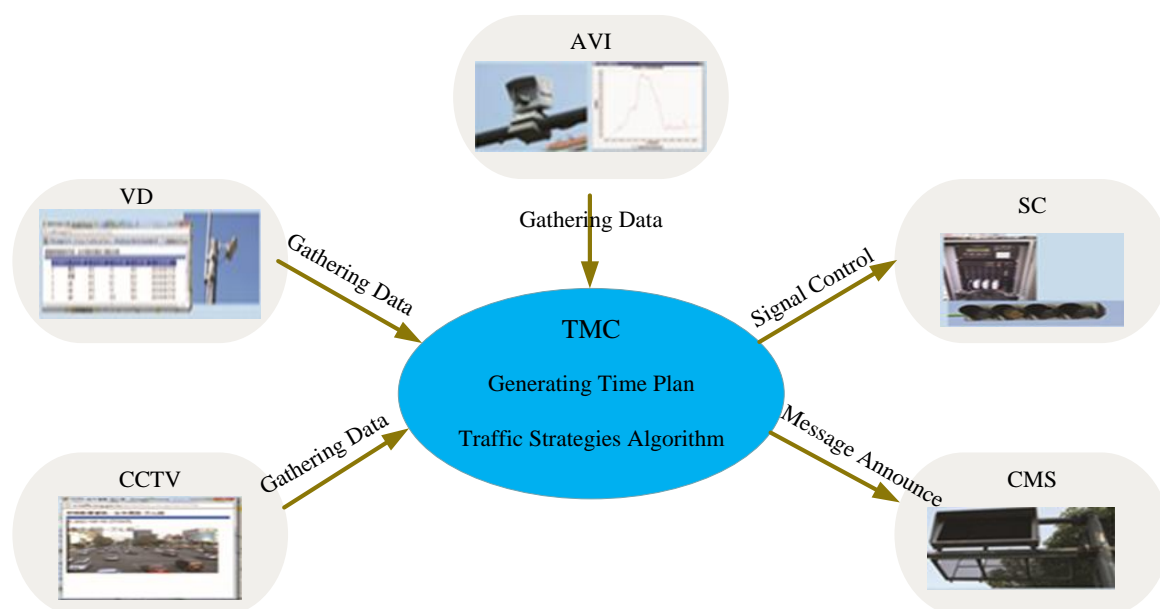

Figure 1. Urban traffic control system

VDs are set up on arterials and freeways by the urban traffic management center to send back traffic data such as flow, velocity and occupancy. AVIs are set up on major transportation corridors to detect the time and the license plates when vehicles pass the specific sites. With

two sets of AVIs, travel time can be got by pairing the license plates. CCTVs are set up at major intersections, camera rotating in 360 degrees, to monitor traffic status from all directions. All these traffic flow data are then processed with signal software such as Synchro and TRANSYT to develop the time plans. They are downloaded to SC at the intersections to dredge the flows in time of day (TOD) mode. Through algorithmic traffic data retrieved by the TMC, it could generate traffic management strategies. They can dynamically make adjustments on time plan and observe the effects through remote observation. Traffic control system put the traffic flow status or path-directed information announced into CMS for the road users.

2.3 Operation of Road-side Device

Signal controller (SC) is universal devices which use time and phase to allocate the use of roads to each approach for avoidance of traffic conflicts at intersections. Memory is installed inside the SC to save/load time plan, time segment and time phase to control the traffic signals. With the well-established traffic control system, signal step change can be sent back to it through general packet radio service (GPRS) module by connecting to the center. Then TMC could realize the status of signal. Duty persons are also able to finely adjust according to the situation at the intersections, and new time plan are downloaded to SC through GPRS. The device and the center work in bi-directional approach, and the functioning flow chart is shown as Fig.2.
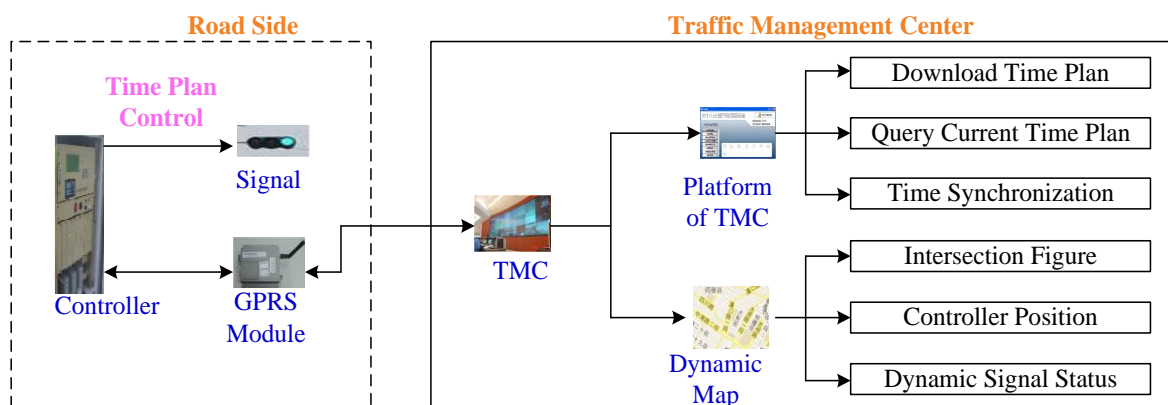

Figure 2. Operation of signal controller

CCTV at intersections are meant for real-time monitor in the traffic control system. They are installed at bottleneck intersections on urban arterials and the real-time images are sent back through asymmetric digital subscriber line (ADSL) or 3.5G wireless approach. Managers in the center can thereby confirm incidents or the severity of the traffic jams and give commands when necessary. The functioning of CCTV is shown as Fig.3. First, images are recorded by monitors at high sites at the intersection. They are then sent to the image server, processed by it and transformed into packets. The packets are sent back to the

communication server in the traffic control system through the internet and then to the broadcast server. The image data can be inquired by people using real-time websites besides the use of the TMC manager in traffic management system.
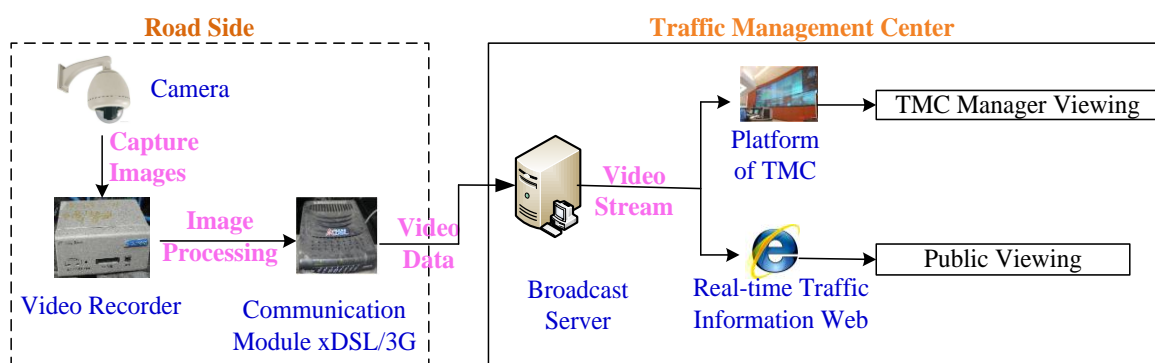

Figure 3. Operation of CCTV

Currently, there are several types of VD being widely used. They detect in circular circuit, ultrasound, micro-wave, infrared-ray, imaging, and magnetic ways. VD detects flow, velocity, occupancy in each lane every minute. The raw data are sent back through GPRS module. After the traffic management center retrieves them, it will compile them into traffic flow information in 5-minute and 15-minute sets for manager inquiry.

AVI are used to calculate travel time of a vehicle to pass two different sites. First, the camera at the road-side server capture the image of a license plate, and the road-side image processor recognizes it and send back time data to the center and save them into database. By pairing the identical license plates at two different sites, excluding the time outliers, the average travel time can be calculated. Traffic managers inquire these data through traffic control platform. They are also connected to CMS to make travel time announcement for the users to be informed of the traffic flow on the way.

CMS is the device provided to the road users with travel time information. Directions, warnings, advocates and traffic management are achieved. Controllers offer real-time traffic information with this device, while road users make options by referring to it. CMS are often set at plain roads in the urban area, urban avenues ahead of ramps and on the freeways. Information such as traffic jams, incidents, accidents, road-side constructions on the way are provided to the road users. The data gathered from AVIs and VDs, such as travel time, the severity of crowdedness, are announced to road users as well. Duty person at the center type in the announcements to traffic control platform, send to the CMS controller through center GPRS module. Then the CMS can display the contents to the road users.

2.4 Current Status of Traffic Control Platform

The platform is made up of database software and traffic control system software. The former is in charge of data saving and operating; while the latter consists of 7 major parts including

traffic strategies, dynamic maps, system operation and maintenance, data processing, device control, device configuration managements and maintenance reporting system. The main functions include signal time plans management, CCTV monitoring, information inquiry and download of VD, AVI travel time pairing, CMS parameter management, device configuration management, system functioning status monitoring, signal light display, warning alarms when device breaks down and time synchronizing of the whole system.

2.5 Improvement Alternative

Traditional traffic control platform is constructed in personal edition and is developed with Java object-oriented program. That is to say, the platform can be used by only one person in the mean time, being unable to provide multiple users. The function requirements of different roles in the system such as TMC traffic managers, traffic engineers / duty persons and maintenance providers are not achieved. Besides, such platform uses text-mode interface processing traffic control management and divided the functions of SC, AVI, VD, CMS, CCTV road-side device into different interface. Functions are provided with each interface respectively. Device locations are set up on dynamic map inquiry interface with GIS materials, and intersections are put on the map for device location inquiry.

As for the basic data of each device including serial number, address, longitude and latitude, GPRS number, constructing year and device provider, districts, device type number, sim card number and ADSL number. These are complicated and dispersed into various database due to different constructing companies and time period. As a result, such traffic control platform is unable to cope with details of each road-side device data efficiently. They send back data through wired/wireless manner and show device condition. However, only whether they are connected is shown, without mentioning whether there is a breakdown, let alone the reasons of breakdown.

In order to efficiently cope with road-side devices' complicated information for management, reduce the time it takes to inquire details and enhance the coherence and consistency of device data, this research develops a Web-GIS platform which uses the internet and map user interface, enabling multiple persons to inquire the information at the same time. This research is part of the project "2011 Integration of Traffic Information Management Center and Implementation of Time Plan Restructuring in Taichung City", and aims to make traffic control data in a systematic approach, in order to make data management and maintenance conveniently.

3. SYSTEM ANALYSES

This research develops traffic control device management platform with Web-GIS. The constructions of it will be introduced first, and the function requirements analysis of platform users will be done and confirmed as well.

3.1 Basic Structures of Web-GIS Platform

The integrative application of spatial information include GIS, global positioning system(GPS) and remote sensing(RS) techniques. Web-GIS is widely applied in land, disaster prevention and transportation such as dynamic bus system, taxi dispatching system. This segment will briefly explain Web-GIS.

Established by open geospatial consortium (OGC), the standard of Web-GIS system accelerates the processing time of web maps and ahieves the goal of information sharing. Among them, (1)The web map service (WMS) standard defines the service format of web maps. No matter the data are vector or raster ones, they can be transformed to displayable image on common browsers. The format are the common ones such as JPG/GIF/PNG. In this way, users can freely superposition GIS map image of various format from various sources with general HTTP protocol. (2) Web Feature Service (WFS) standard defines the service format of internet characteristics. Users can retrieve vector map features or inquire feature attribution with HTTP protocol. And this is a more abundant inquiry interface compared with WMS. WFS also defines the transactional capability of web data, which is called WFS-T. The functions include adding, delete, renew, retrieval or inquiry of attribute data. And the widely-use format is geography markup language (GML). (Chou, 2007; Steiniger and Hunter, 2012)

Generally, a Web-GIS platform is developed with OpenGeo architecture. Its basic structure is shown as Fig.4. It is divided to 4 parts as explained in the followings.
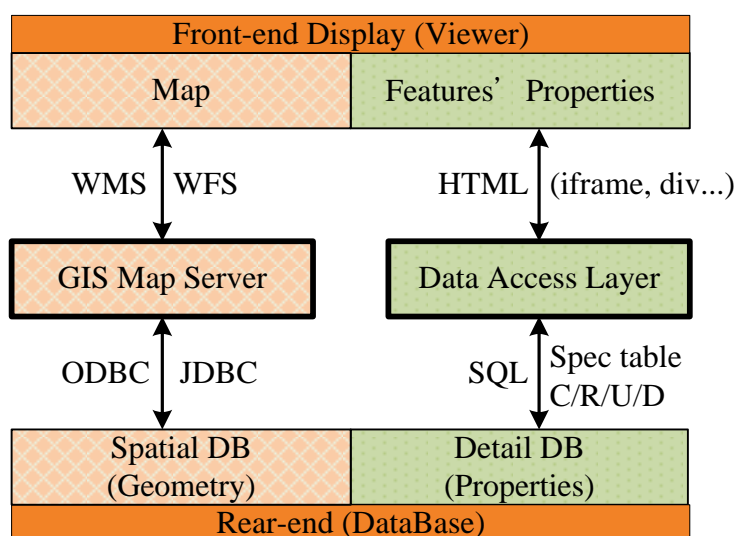

Figure 4. Architecture of Web-GIS platform

(1) Platform rear-end database. It is used to save feature data. They are usually separated as spatial data (longitude and latitude) and non-spatial data (feature properties). PostgreSQL, SQL Server 2008 are common database software.

(2) GIS Server. Feature spatial data communicate with GIS server through the standard established by OGC, WMS and WFS, by using map webpages. The GIS server searches data according to the spatial data processing needs and analyzes them. The final results are sent back and e-maps are generated to the platform on http webpages.

(3) Platform data access layer. It is used to process all the actions taken on the e-Maps. When users are doing data managements on e-Maps, it will connect to the platform database in search of the feature data and send back the results according to the user's operation.

(4) Platform front-end display. Adopting Google Map API or Openlayers constructions, it provides mapping management interface, including background maps and foreground feature maps. ASP.Net or Ext.Net is adopted to develop user interface for the latter. In order to enhance the fluency of operation, it adopts asynchronous Javascript and XML (Ajax) to process the massive display of feature data on the maps.

3.2 Function Requirements Analysis

Function requirements analysis are performed first by interviewing various users of the device management platform. The needs are compiled with the use of use-case diagram. User's roles include TMC traffic managers, traffic engineers / duty persons, system engineers and maintenance providers, as shown in Fig.5.

(1) TMC traffic managers. They are informed of the details of road-side device through traffic control device management platform, including authorization, traffic control device configuration, device characteristics (producer, model) and device producer information (they need to contact the corresponding company when the device breaks down.) and record dispatch contracts and device repair/maintenance.

(2) Traffic engineers / duty persons. They inquire the details of traffic control device through management platform. Contents include traffic control device configuration, device characteristics and device producer information as well.

(3) System engineers. They set the authorization of the platform, including authorization information, maintenance of parameter information and the maintenance of the traffic control device database. They also deal with any abnormal situations on the GIS.

(4) Maintenance providers. They inquire the data through management platform and fill

in the basic information into the platform. They also fill in repair records after the work is done for future reference.
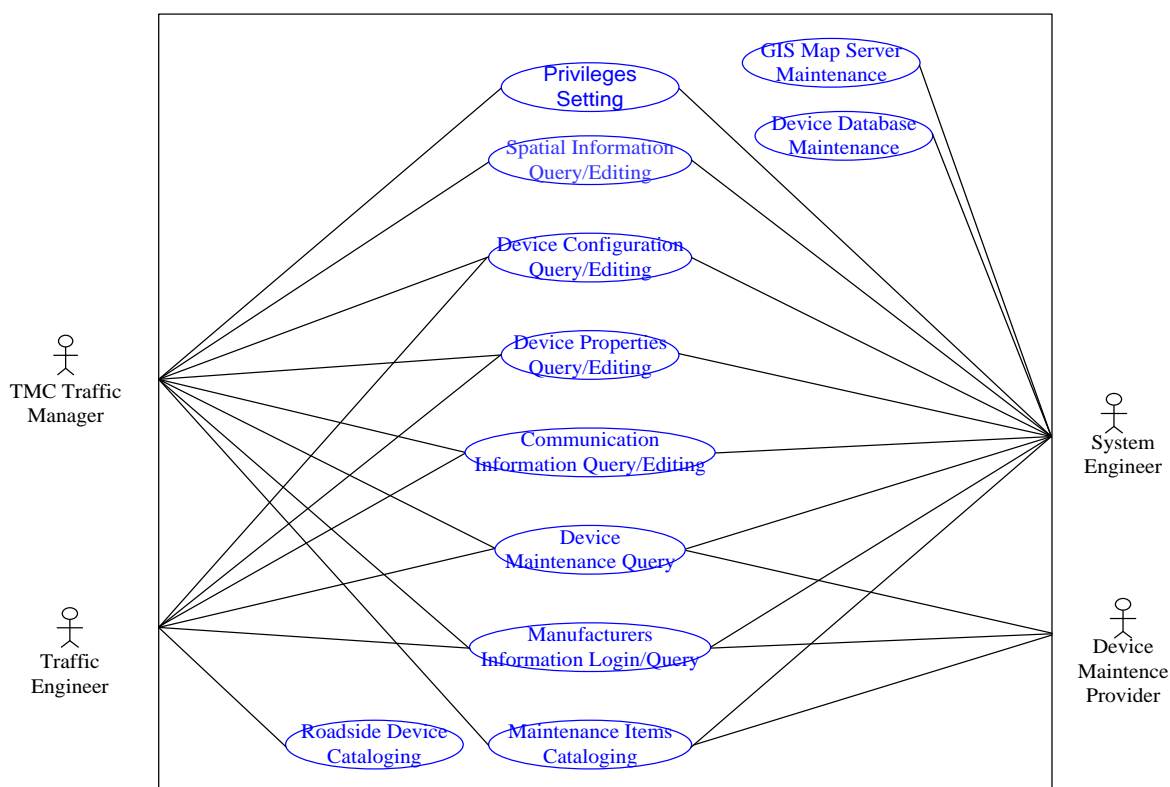

Figure 5. Use-case diagram of function requirements analysis

4. SYSTEM DESIGN

The constructions of the traffic control device management platform including design of the database, server, map interface, inquiry interface and data access logic are presented in this chapter.

4.1 Constructions of the Traffic Control Device Management Platform

Based on OpenGeo, this research takes the standard defined by OGC to develop Web-GIS device management platform under Visual Studio.NET environment. The device data are centralized in a database, combined with mapping interface for the various users to achieve maintenance at different places on line. The MVC constructions adopted in the platform are presented as the followings.

(1) Model – data tier. To accelerate the GIS, data are separated to spatial and non-spatial ones and they are processed by PostgreSQL and SQL Server2008, respectively.

(2) View – present tier. In recent years, the Web-GIS platforms are developed mainly

with Google Map API. Although Google provides free operating platform, the free software, OpenLayers, regulated by OpenGIS is applied considering the extension of our platform software. They included background and foreground maps are used as tools to the design of map interface. Ext.Net is applied by foreground maps to combine graphic user interface, enabling users to carry out management (adding, delete, inquire, revise of device data) on e-Maps. In order to enhance fluency, Ajax is adopted to process the massive data display asynchronously.

(3) Controller – middle tier. The geographical information of the device is processed with Web-GIS server. The source comes from spatial database. The free software, GeoServer, is used as GIS server to release map data. Users are allowed to renew/ delete/ add operations to the feature data on the maps. Non-spatial information is designed for the details of the device distinguished to data access layer and logic layer for data synchronization and system management. ADO.NET technique provided by .NET is used for communication with non-spatial database.

The main operating process of the whole platform is to send client end's request to web server. The request is transmitted to Web-GIS server and connected to spatial database. The results are then given to the users. The design diagram is shown as Fig.6, and the functioning process is as the following.
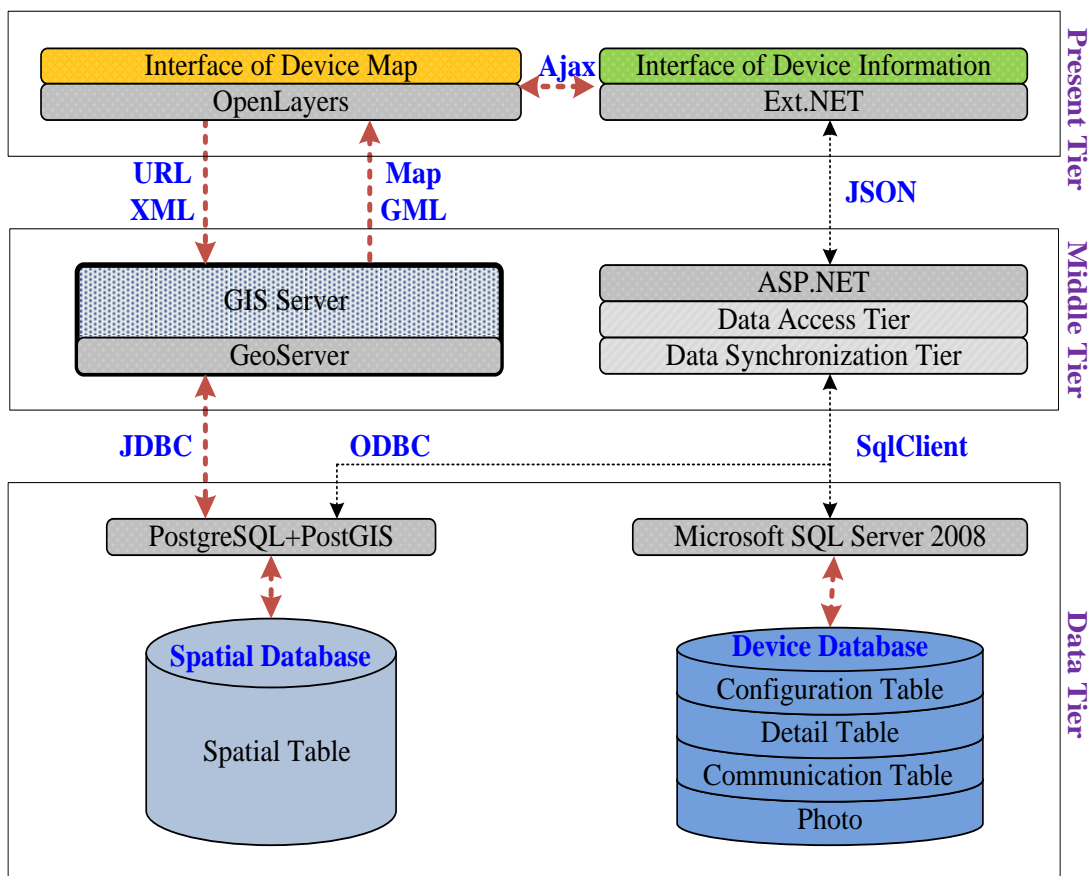

Figure 6.Management platform of traffic control devices

(1) HTML webpages are applied in this platform. The authorized users approach directly.

(2) When managers are process device feature points, a URL request to GeoServer of spatial data is sent.

(3) After the GeoServer receives it, DataProvider of .NET uses ODBC/JDBC to connect to spatial database to capture data. Finally, the analyzed ones are sent back to the map interface in GML format.

(4) Ajax techniques analyze the GML data and use SqlClinet to connect to the non-spatial database to select the data. They are sent back to be displayed in the management interface (HTTP).

4.2 Database Design

The data of traffic control device are divided to 6 parts. They are spatial data, device configuration data, device information data, related communication data, maintenance data and photo data. They are interpreted as the followings.

(1) Spatial table. The data are access with PostgreSQL database. They include device number, the displayed longitude and latitude, the measured longitude and latitude and device address. These are provided to the GIS server of the management platform.

(2) Device configuration table. Access to the common data including device number, device pattern, device producer, intersection information, intersection number, intersection name, the measured longitude and latitude and intersection figures.

(3) Device detail table. Access to the road-side device character data. Take SC for example, device provider, signal state, software version, whether there are pedestrian signals… etc. are recorded. Take CCTV for example, device number, center configuration number, connecting manner, camera producer, image server producer, set up year, image resolution format (CIF/QCIF), image return web address, exporting web address of output image on the image server, script of the output image, script of the output image on the image server and script of the output image from the camera are included.

(4) Related communication table. There is difference among various devices. Take SC for example, communication module pattern, SIM card number, telephone number, software version of communication module, communication module date, communication module ver. , proximal port and distal port are included. Take CCTV for example, camera channel, communication telephone number, ADSL number, software version and its date of communication device, server IP address, connection speed, communication gateway, proximal port and distal port are all recorded.

(5) Maintenance record table. Access to device number, repair date, cause of damage,

content of repair, and maintenance provider.

(6) Photo data. The photos contains location of device and inside structure, are uploaded and displayed on the system. Since they take large amount of memory, photo files are accessed with independent folders for fear of lowering the transmission efficiency.

The purpose of constructing spatial database is to make inquiry of the device data available. Given the warrant cost of commercial database, this research applies PostgreSQL and PostGIS to database construction in order to bring up the optimal benefits of geographic spatial data and operative efficacy of the map feature. Free software costs down the prices of geographic spatial data processing. As for the device data (non-spatial data), database is constructed with Microsoft SQL Server2008 due to the massive contents and diverse types.

4.3 Design of the Device Map Interface

OpenLayers permits third party maps to serve as background maps. Google Map is chosen and 4 types of Google Map are designed to provide users for looking up the device location in the real world. It is presented for application such as inquiry and dragging in future extension. The default longitude and latitude format in OpenLayers maps is "EPSG:4326" while Google Map is made with Mercator projection. So setting projection coordinate, map resolution, map scale, user map control option…etc. are required to initiate background maps. The 4 types of Google Map are terrain map, street map, satellite street map and satellite maps.

Web maps service (WMS) of OpenLayers is used to design device maps and geographic spatial communication such as exchange of data latitude and longitude is carried out with Geoserver. Through WMS of OGC, the map data released in WMS format are loaded to the well-established bakground maps.

The platform provides operative functions to the users. When a user clicks a device figure of the device, a user interface then pops out. Such click events needs to be registered previously to carry out this operation. With the communication between the Ajax techniques provided by OpenLayers and service of WMS GetFeatureInf function, the GML data sent back are interpreted. The device longitude/latitude and the number are presented as bubble windows on the map.

FramedCloud function provided by OpenLayers is used to carry out the feature/device bubble window popping-out and close. The jQuery technique of Document Object Module (DOM) is used as well to join non-spatial table to device bubble windows in div-blocks.

4.4 Design of Device Inquiry Interface

Ext.NET is kind of JavaScript framework which provides many stable/ execellent components and tools. Besides the default appearance of the framework, abundant DOM operation and

selector functions like jQuery are provided. Drag-and-drop function, Ajax and diagram function are also available. As Ext.Net applies rigorous object-oriented program, JavaScript, system cutting, design and implementation significantly increase the reusability and maintenance of the programs. (Chung, 2011) So Ext.NET is served as the design tool of device inquiry.

When the user select a feature of some device on the map, the user interface pops out in a bubble window. FormPanel class inside Ext.NET is used for panel design. The MVC design is applied by FormPanel. Model is the store object of Ext.NET; View is the FormPanel; while the controller are the SelectParameters of SqlDataSource. The founction of FormPanel derived from that of Panel, so multiple Panel are inside FormPanel. Every table is made as a FormPanel in the research.

4.5 Design of Device Data Tier

Data tier are separated to synchrnous layer and access layer, which enables simulataneous data processing inside layers of device database. Ext.NET is used for implementation with ASP.NET tools. When a event occurs, data flow captures data inside spatial database and device database with the logic layer designed through ODBC or JDBC and the inquiry results are sent back.

DataSet object of ADO.Net is used in the access layer of the platform to optimize the access speed, and the access is achieved in Structural Query Language (SQL). PostgreSQL database and Microsoft SQL Server database are connected first and DataAdapter object provided by .Net environment is then used to fill in the inquired results to DataTable object and finally send back the entry of DataTable according to SQLCommand (that is, processing the restriction of the inquired device). On the other hand, synchronous processing layer designs a spatial reference system identifier (SRID) function to exchange the coordinate "EPSG:900913" in Google map and "EPSG:3826" in Taiwan TWD97 maps.

When an insert into or update action is taken on the platform, the corresponding content inside the database are updated synchronously. Finally, the connection to the spatial database will be disconnected.

5. IMPLEMENTATION

The authorization management is generally carried out according to the user roles. Various operations are authorized once certificated. For example, traffic managers are qualified to insert into/ delete/ modify while duty person and maintenance provider are only warranted to inquire. The device inquiry is briefly introduced in this chapter.

5.1 Layer Display and Device Inquiry

OpenLayers with WMS are used to display the maps. The third party maps(Google/ Yahoo Map) are cited as background maps. Google satellite maps/ street maps/ satellite street maps/ terrain maps are used.

After identity verification, the system permit users to carry out insert into/ inquire/ modify/ renew of the chosen 5 road-side device, SC, AVI, CMS, VD, CCTV. The distribution diagram of the 5 items is shown as Fig.7.
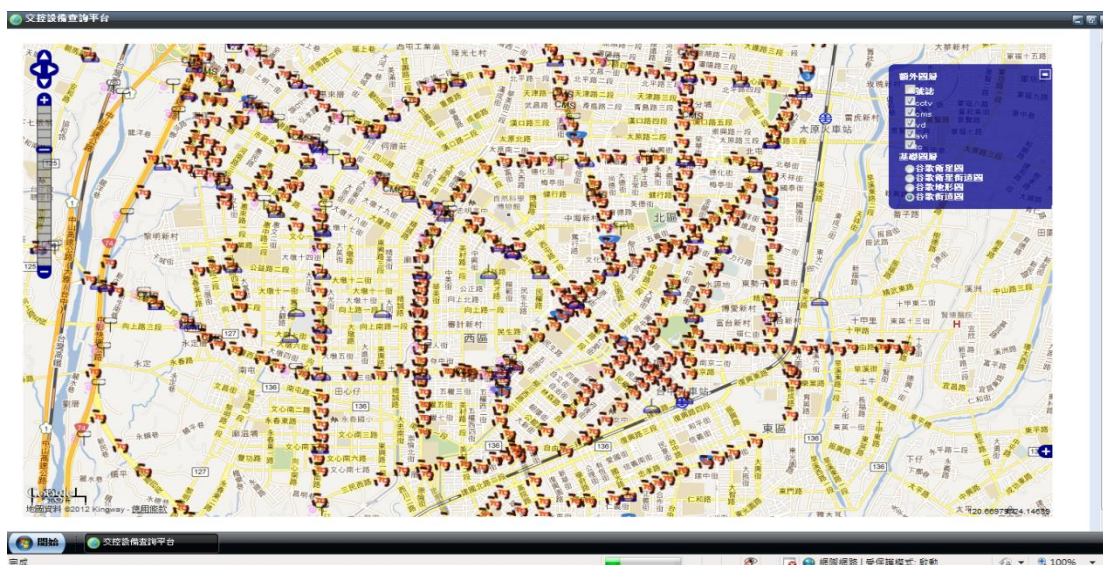

Figure 7. Traffic control devices map

5.2 Inquiry Function

This Web-GIS platform provides various inquiring ways. By clicking the device icon, users can inquire the details of the selected device. Multiple panel design is applied to put all the functions together to be displayed on a device FormPanel interface. The inquiry interface is shown as fig.8, with the SC at TaichungPort-Honan intersection as example.

(1) Spatial data. The device number and specific location of it are provided. Other data include coordinate and transaction remarks.

(2) Device data. Basic data provided with SC include measured coordinates, pedestrian signals, device manufacturer, device type, center configuration number, set-up year and transaction remarks.

(3) Communication data. Inquiry for SC communication module. Date version, telephone number, proximal and distal port, connection IP, communication module, SIM card number, software version, date,…etc are included.

(4) Photos. The functions of upload and download are provided. The device allocation and location are photographed for maintainer.

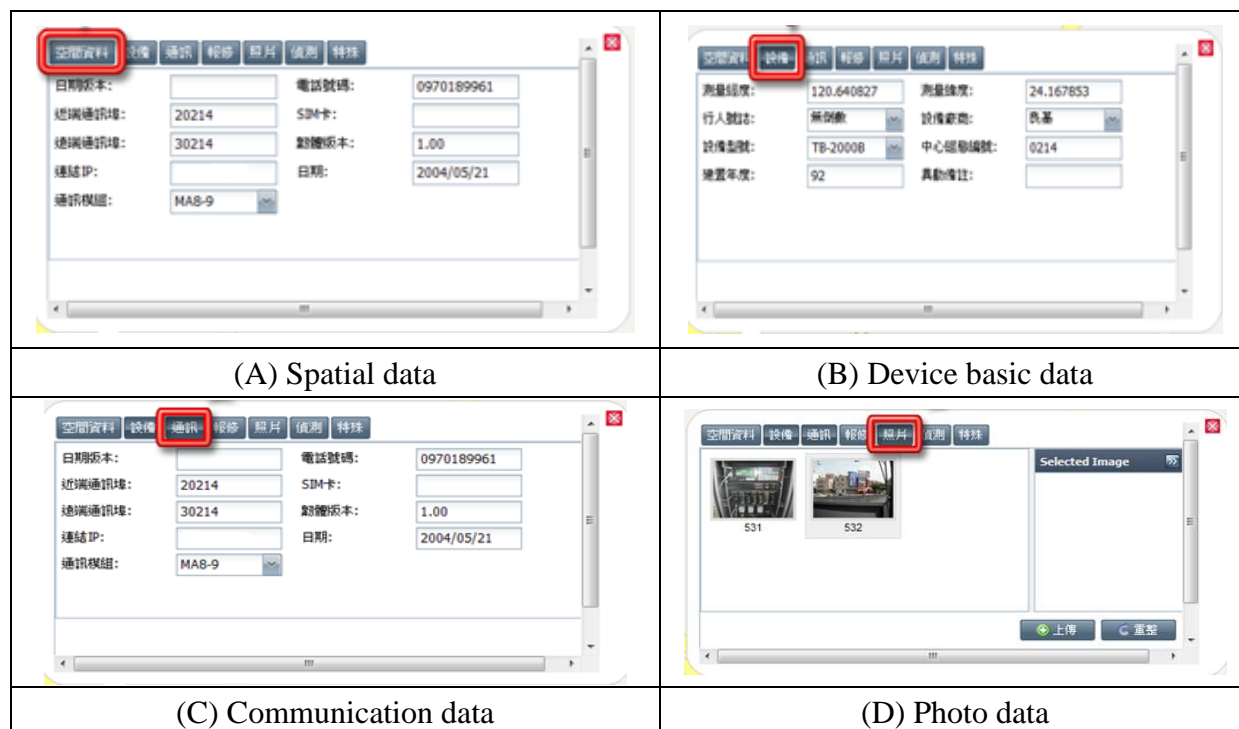|	
(A) Spatial data	(B) Device basic data
(C) Communication data	(D) Photo data

Figure 8. Inquiry interface of device properties

Next, users are able to carry out inquiry in tree-form expansion. As traffic management centers are constructed in different periods since year 92, all road-side devices are constructed in a 5-layer manner (counties, module, road section/intersection, device type and device). Besides, devices are not sequenced in accordance with road sections and intersections. These cause difficulty in inquiry in real practice. Therefore, tree-form structures are re-constructed in three-layer constructions(device type, road section name, device), which is convinient for the users to take device as the main point, road as the second point, and in the order of intersections (from urban area to suburban area). This makes inquiry more efficient.

In addition, users inquires integratively by framing a chosen area. The framing function is implemented with GIS and the results are presented in a 3 by 3 grid using device number as QueryString, and they are sent into the iframe of inquiry. Then, the kind of device is looked up according to the serial number sent-in. Take CCTV management interface for example, status button is added to show connection status for availability inquiry and hint the need for repairment otherwise. As an example, the monitor inquiry of road information at consecutive intersections is shown as Fig.9.

Figfure 9.   3-by-3 grid inquiry of CCTV

5.3 Detection of the Road-Side Device's Connecting Status

Information of the road-side device are transmitted through telecom internet with communication module which enables entry to the firewall of traffic management center. Traffic control software of server are applied to save the data into the database. The schematic diagram of the connection is shown as Fig.10.
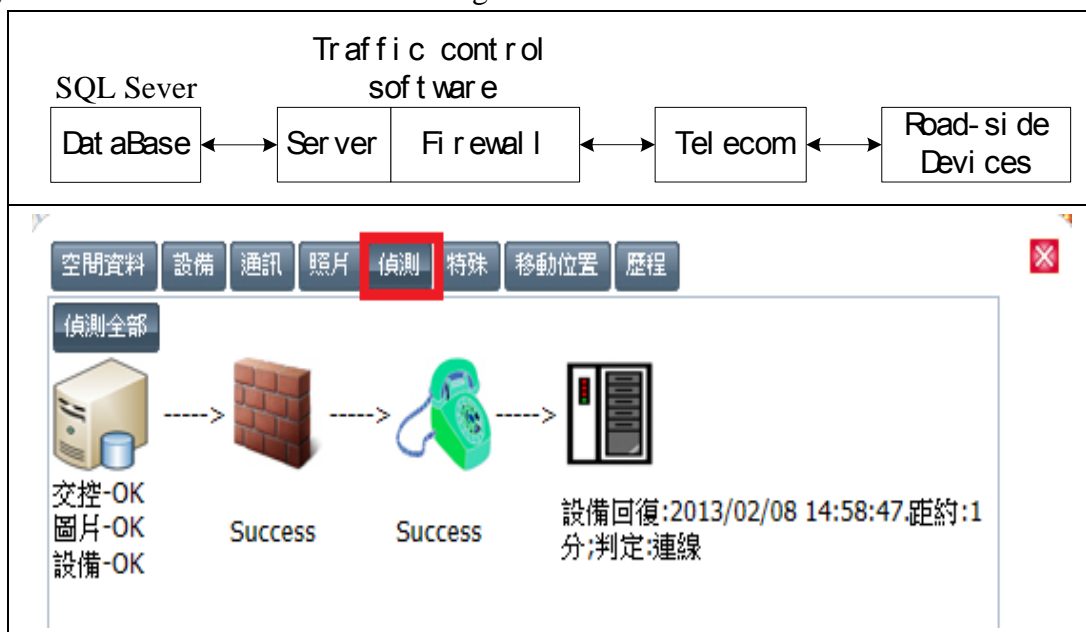

Figure 10. Device connection detecting flowchart

Instrument panel of traffic device detection shows whether it is connected in current TMC platform. However, the part in error is not told apart. All the followings are possible scenarios: the traffic device doesn't send back data, the server shut down, the firewall breaks down and disconnect the inside and outside internet or the internet service of telecom company is not function at all. Therefore, in order to let the traffic manager be informed of the functioning status, connections are detected at every point in the manner of internet communication protocol.

On the database end, database components (ODBC, JDBC) are applied to detect the connections. As for the firewall (server end) and telecom company end, PING IP is used as detector. As many road-side devices are transmmited through GPRS without a fixed IP, PING is not applicable to show the status. API of Java remote method invocation (RMI) released by the traffic management center is used directly to detect the connection, by which a shut down is judged.

5.4 Signal Light Display in Platform

The traffic managers understand the traffic information and whether a main avenue is chained on the basis of the signal light display of signal controller. In addition to data establishment and inquiry, real-time display of signal is provided and its flowchart is shown as Fig.11. First, the signal is received and saved into queue with the "receive program." The message packet is shown in a 8-bit manner (pedestrian red/ pedestrian green/ right-turn green/ straight green/ left-turn green/ round green/ round yellow/ round red) through logic program analysis communication protocol on middle-ware which was written in Windows Communication Foundation (WCF) in this project. For example, the message reads 01000100 in the case of pedestrian green plus round green. After data analysis, the data of traffic signals are stored in Hash table. Socket is then used to display the data in it on Web-base GIS.
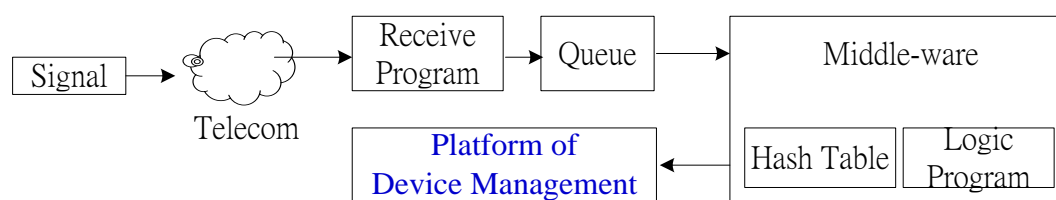

Figure 11. Message transfer process of SC

Editing function of feature point and the drag-and-drop of device map are provided in this platform. Through background maps, execution of insert into/ modify and saving after dragging the device to the correct location are available. Each slot of about 500 sets of SC are corresponded with each approach, signal pattern combination in controller boxes. More than 2000 sets of lamp position are registered in the platform, and the real-time information is sent back in accordance with the standardized protocol set by Institute of Transportation, MOTC.

(2008)

The time phase conversion for the real-time display shown on Web-GIS webpages are often too massive to perform and the changes are too frequent. And signal light message transfer to TMC has event-driven characteristics. Therefore, the rich internet application (RIA) is applied in this research. (Doush et al., 2013) This not only displays a large range of real-time signal change but also provides a panel interface for management shown as Fig.12.
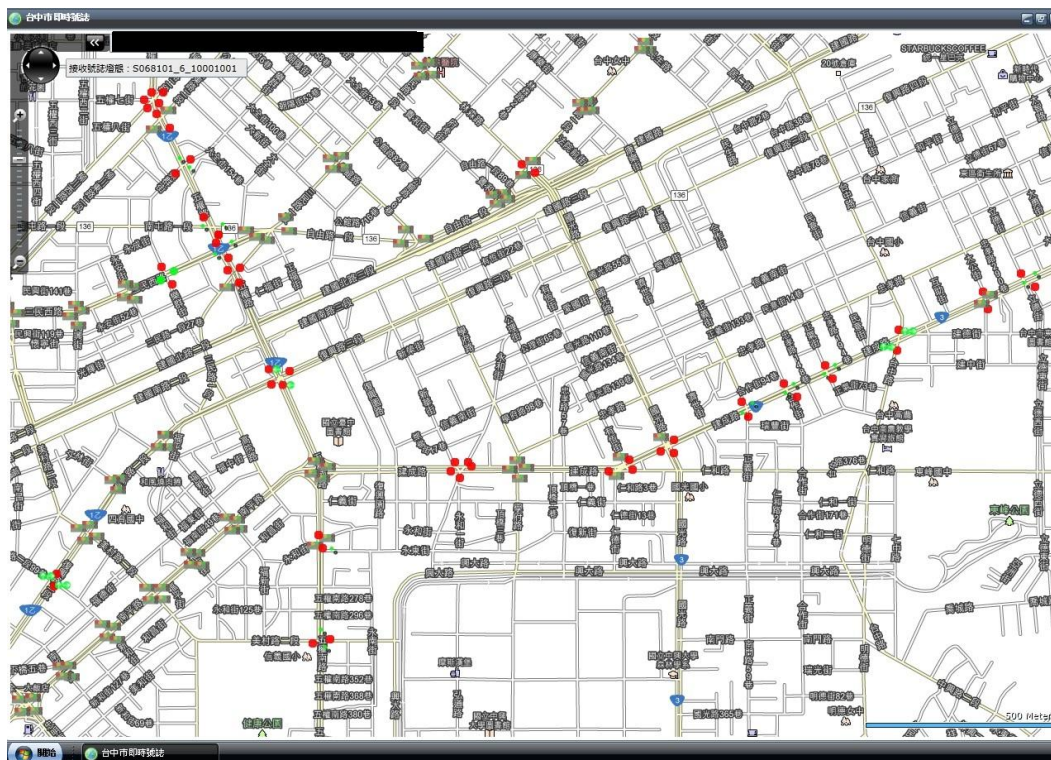

Figure12. Dynamic signal light display

6. CONCLUSIONS AND SUGGESTIONS

6.1 Conclusions

OpenGIS of OGC is adopted in this research to construct a geographic information system of traffic control devices. The MVC(Model/View/Controller) architecture is combined to achieve the development of the management platform. Users connect to the platform with internet and carry out operations of the system after identity verification. The conclusions derived from this research are as the followings.

(1) The developed platform is provided to TMC managers, traffic engineers/ duty persons, maintenance provider to simultaneously insert into/ delete/ inquire the information of the traffic control system as authorized on webpage map user interface.

(2) The developed platform is arranged in accordance with the geographic information service regulated by OGC to enhance future extension; OpenLayers is adopted with free software, GeoServer to greatly lowering the cost of GIS development.

(3) Management of device data of spatial character through spatial database enhances the variability of data interface. PostgreSQL database is adopted to process spatial data to accelerate processing speed between maps and coordinates. Microsoft SQL Server2008 database access is applied to massive details for efficiency.

(4) Free software, Ext.NET, is applied to develop user-friendly interface. This includes tree-form structures of device, multiple-panel user inquiry interface, which promotes efficacy of platform operation.

(5) Through device connection detection and tree-form structures of the device, traffic managers are informed of the device status rapidly. The 3 by 3 grid interface of CCTV inquiry enables monitoring of the traffic flow at consecutive intersections.

(6) The signal lights status of SC are sent back to the center with specific communication analysis module benefits traffic managers to deal with the functioning status of SC at intersections.

6.2 Suggestions

The management platform of Web-GIS derived from this research can be further investigated in the following aspects.

(1) The signal light and image sent back with SC and CCTV are well dealt with on this platform. The extended applications of the remaining ones can continue. For example, pairing the license plates according to the data form AVI and obtaining travel time through specific logic analysis, and finally putting the results in the form of charts on the maps of the platform. Another example is display of average speed, average flow on the map interface according to the data from VD.

(2) Combination of dispatch system, maintenance records registration to the platform. When users look up the device on the maps of the platform, traffic managers or maintenance providers are then informed of the maintenance record to reduce dealing time of dispatch process.

(3) The device management interface has been put in clouds in this platform. In order to cope with the massive data, future researches are recommended to design in cloud data structure, which benefits the decision maker to carry out analysis of the massive data.

ACKNOWLEDGEMENTS

REFERENCES

Chou, J.C (2007), Open Geographic Information System in the Area of GML and Its Applications to Intelligent Transportation System. *Research Projects, Institute of Transportation.* (in Chinese)

Chung, H. L. (2011), *ExtJS Establishing.* Delight Press.

Insitute of Transportation, MOTC (2008) Communication protocol and software for urban traffic management. *Ministry of transportation and communication, R.O.C.* (in Chinese)

Doush, I. A., Alkhateeb, F., Maghayreh, E.A. and Betar, M. A. A. (2013), The design of RIA accessibility evaluation tool, *Journal of Advances in Engineering Software Volume 57, Pages 1–7*

Jiang, T.Z and Shih, T.Y(2004), Exploring the WebGIS Implementation with MapServer. *Journal of Cadastral Survey,* 23(4):43-79.(in Chinese)

Steiniger, S. and Hunter, A. J. S. (2012), The 2012 free and open source GIS software map–A guide to facilitate research, development,and adoption. *Computers, Environment and Urban Systems (2012),*

Website:

Ext.Net Sample

  http://examples.ext.net/#/Desktop/Introduction/Overview/

FHWA-GIS

  http://www.gis.fhwa.dot.gov/

GEOCYBER BLOG, GIS Web Service: WMS and WFS.

  http://geocyber.org/blog/?p=236

Microsoft MSDN Library

  http://msdn.microsoft.com/zh-tw/library/default.aspx

OpenLayers Sample

  http://openlayers.org/dev/examples/

PostgreSQL 8.0.0

  http://twpug.net/docs/postgresql-doc-8.0-zh_TW/index.html