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A Study of Geographic Information System Combining with GPS and 3G for Parking Guidance and Information System

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***Abstract*—**With the increase of economic behavior and the upgrade of living standar, the ratio for people in Taiwan who own automobiles and motorcycles have recently increased with multiples. Therefore, parking issues will be a big challenge to facilitate traffic network and ensure urban life quality. The Parking Guidance and Information System is one of important systems for Advanced Traveler Information Services (ATIS). This research proposes a parking guidance and information system which integrates GPS and 3G network for a map on the Geographic Information System to solution inadequate of roadside information kanban. The system proposed in this study mainly includes Parking Host, Parking Guidance and Information Server, Geographic Map and Information System as well as Parking Guidance and Information Browser. The study results show this system can increase driver's efficiency to find parking space and efficiently enhance parking convenience in comparison with roadside kanban system.

***Keywords*—**Geographic Information System, 3G, GPS, parking information

I. Introduction

IN metropolis, Parking lot not only facilitates the public to solve the parking requirements, and also plays an important role in upgrading the quality of life, efficiently adjustment the urban traffic and upgrade local prosperity. There is not correlation between parking lots. For drivers, seeking parking space will take a chance. Many people line up to wait for parking outside parking lot, especially at more prosperous area. When a driver urgently seeks for parking space, a parking management system can demonstrate the importance if it can show the most efficient way to meet the requirements of a driver within the shortest time. Using each kind of technology to assist management systems has been a trend.

The rate to own a car in Taiwan has been increasingly enhanced, leading to a big problem metropolitan traffic. How the parking space available can efficiently and correctly transmit to drivers has been one of important issues for the urban development. According to a study report from the institute of transportation .ROC [6], seeking parking space shared about 30% in detour traffic. Therefore, how to efficiently provide the parking information to drivers will be an important issue. As shown in previous study, what drivers most concerned was parking space available in a trip when arriving the parking lot, but not parking information before the departure [8]. Therefore, we must establish a real-time and accurate parking guidance and information system for drivers. The Parking and Guidance Information System, developed in advanced countries for many years, had been recently available in each city. The parking information, such as the location of parking lot, direction, availability and so on, can be transmitted to drivers by each kind of channel via this system to solve parking issues. From a study paper [1], the Parking Guidance and Information System would be beneficial to solve the parking problem and enhance the utilization rate for each city in the world would.

However, the most of parking guidance information are displayed by roadside signboard as shown in Fig. 1. Therefore, this study expects to establish a real-time Parking Guidance and Information System, including Parking Lot Host, Parking Guidance and Information Server as well as Internet Browser. Drivers can acquire real-time parking information provided by this system via Internet Browser. Drivers not only can acquire the information from roadside signboard in the future, but also directly obtain a lot of information on parking lots via this system.

Fig. 1. Roadside signboard

II. System Architecture

The Parking Guidance and Information System proposed in this study consists of Parking Lot Host, Parking Guidance and Information Server as well as Internet Browser. Fig. 2 shows an integrated architecture of three modules, where Parking Lot Host takes responsibility to acquire the real-time availability information at that parking lot. According to Communication Protocol of Taipei City Parking Lot Information Guidance

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System [7], it will transmit to the database of Parking Guidance and Information Server via Internet after encoded.

Parking Guidance and Information Server not only saves and provides the availability information to Parking Guidance and Information Browser for inquiry, but also plans and produces a parking lot guidance map transmitted to Parking Guidance and Information Browser, so that a user can refer to a guidance map and leave for parking lot.

Internet Browser is not only used for user interface, but also acquires GPS coordinate. A user can connect Parking Guidance and Information Server via 3G/GPRS to browse the availability information and guidance map of parking lot near the destination.

The following will describe Parking Lot Host, Parking Guidance and Information Server and Internet Browser at three subsections.

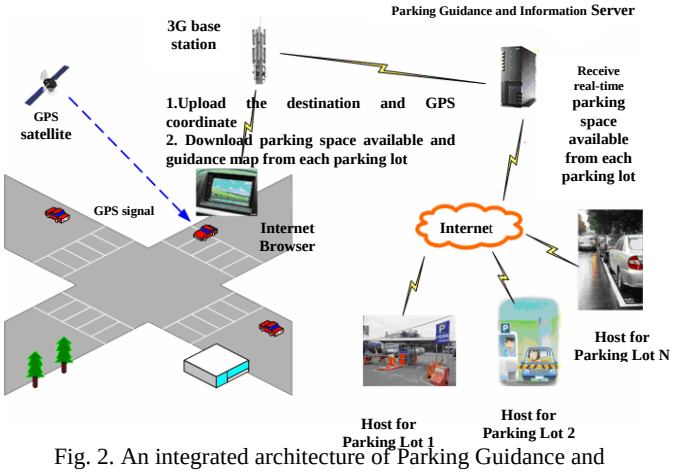


Fig. 2. An integrated architecture of Parking Guidance and Information System

A. *Parking Lot Host*

The mission of Parking Lot Host is to report the total number of parking space and the number of real-time availability to Parking Guidance and Information Server as basic module in this study. The mode to report employs client-server architecture, where Parking Lot Host is server and Parking Guidance and Information Server is client. Parking Guidance and Information Server downloads the real-time information on parking space available via Internet per the fixing interval (3 minutes)

Although there are many parking lots in Taiwan, the public ones which announce parking space available take the majority. In order to allow Parking Guidance and Information System to receive maximum parking lots, this study selects communication protocol most used in parking lot.

Taipei City (as Table 1), sharing a return ratio of 34%, takes the lead to return the number of public parking lots. When Taipei City initially established protocol, the packet was one of consideration points [7]. This can reduce the utilization of network bandwidth, so that network transmission can be more stable. Therefore, this study utilizes Taipei City Parking Lot Information and Guidance System Protocol as a protocol to return parking space.

TABLE I CURRENT SITUATION TO RETURN THE NUMBER OF PARKING SPACE AVAILABLE IN TAIPEI, TAICHUNG AND KAOHSIUNG CITY

	Number of public parking lot	Number to return parking space available	Return ratio
Taipei City	301	104	34 %
Taichung City	65	6	9 %
Kaohsiung City	90	11	12 %

Data source: sorted in this study

B. *Taipei City Parking Lot Information and Guidance System Protocol*

The principle to establish Taipei City Parking Lot Information and Guidance System Protocol is that the system worked out in an early phase is integrated in accordance with packet , cost and stability to establish communication protocol for the Taipei City Parking Lot Information and Guidance System [7].

There are two important tags of the parking lot information of the format please see the protocols as follows:

1) IDParking Lot Code
2) AVAILABLECAR Parking Space Available

For Parking Lot ID: 101, taking parking space available: 8 for example. The data for server are as follows:

```
<?xml version="1.0" encoding="Big5" ?>
<DATA>
  <PARK>
    <ID>101</ID>
    <AVAILABLECAR>8</AVAILABLECAR>
  <PARK>
</DATA>
```

C. *Parking Guidance and Information Server*

Parking Guidance and Information Server is the most important module in this study. There are two functions:

1) Saving and providing the real-time information from each parking lot:

After the real-time information is transmitted from each parking lot, a server will save the real-time parking space information in SQL Server 2000 database for users who can inquire the real-time information from parking lot near the destination.

2) Planning and producing a guidance map of parking lot:

After Parking Guidance and Information Browser sends that coordinate and parking lot, Parking Guidance and Information Server can plan and produce a path map that guides a user to parking lot.

The following will introduce the system architecture of two functions:

D. Saving and providing real-time parking space information

The connection between Parking Guidance and Information Server and Parking Lots Host is based on the client-server architecture. The client is Parking Guidance and Information Server, which not only follows Taipei City Parking Lot Information and Guidance System Protocol but also downloads the number of parking space available in real time via Internet. After receiving the real-time information on parking space available from each parking lot, the number of parking space in SQL Server 2000 database is updated for user inquiry.

E. SQL Server 2000 database

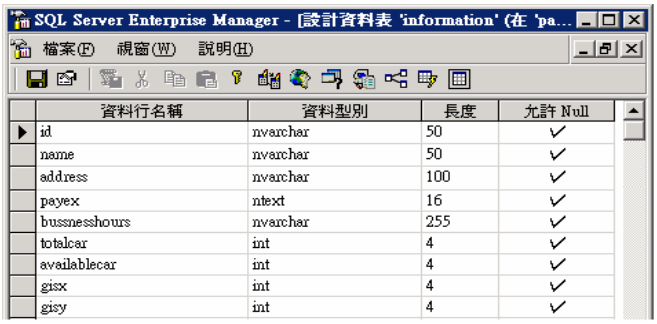
SQL Server 2000 is a correlation database. Its user interface is simple and easy to use as well as supports ANSI SQL-92 structural inquiry language. In circumstances that the number of parking lot and data are not large, they can be enough for data save in this system.

This prototype system is developed with Visual Studio 2005 C# .NET. Owing to C# .NET Framework in coordination with structural inquiry language, correlation database can be accessed. In designing database program, SQL Server 2000 database can be directly accessed through Connection, Command and DataReader components in C# .NET Framework built-in database.

F. Parking lot data table

The parking lot data table saved includes the static and dynamic data. The static data represent invariable data, including the name of parking lot, the total number of parking space, coordinate (longitude and latitude), address, parking fee and business time. These data is one-input and not variable. SQL Server 2000 human-machine interface is used to directly enter the data above-mentioned when establishing database; the dynamic data represent the regular or more variable data, which are the number of parking space available. The number of parking space available is dynamically updated in real time and provided by each parking lot host.

This study will set up the static and dynamic data in the same table. The table name is: information. For each column name, data type and meaning (description), please refer to Fig. 3. The column name of main index key is Id and no repetition is allowed, indicating the code of parking lot; longitude and latitude in the table utilize the format of WGS84 coordinate system. This format can be accurate to 6 digits after a decimal point, converted to calculate as the distance about up to 10 cm and obtain longitude and latitude in the data table after multiplied by 10^6. For example, it is assumed east longitude = 121.528930 and north latitude = 25.037823 in certain parking lot. Longitude and latitude of that parking lot saved in the table will be 121528930 and 25037823, respectively; not only the data table in the columns above-mentioned but also include the name of parking lot, address, parking space, parking fee and business time.



資料行名稱	資料型別	長度	允許 Null
id	nvarchar	50	✓
name	nvarchar	50	✓
address	nvarchar	100	✓
payex	ntext	16	✓
bussnesshours	nvarchar	255	✓
totalcar	int	4	✓
availablecar	int	4	✓
gisx	int	4	✓
gisy	int	4	✓

Fig. 3. Column name and data type in parking lot table

The number of parking space available from Parking Lot Host will update the value in available car. For Parking Lot ID: 101, taking parking space available: 8 for example. After a server receives the data above-mentioned, syntax which updates the number of parking space available in database is:

```
UPDATE information
SET availablecar = 8 WHERE Id = 101
```

G. Planning and producing a guidance map of parking lot

The connection between Internet Browser and Parking Guidance and Information Server is based on the client-server architecture. The client is Internet Browser at user end, which provides the information on current GPS coordinate and destination via Internet; a server is Parking Guidance and Information Server, which receives the information from Internet Browser to return the information of parking space available and a guidance map of parking lot near the destination.

The steps that plan and produce a guidance map of parking lot are as follows:

1) A user can enter the destination he/she want to leave for.
2) Geographic Information System in a server will find out parking lot near the destination and return to a user by illustration.
3) A user can inquire the real-time information on parking space to decide a place where a car parks.
4) After a user selects parking lot, Internet Browser will transmit user coordinate and parking lot to a server.
5) Based on user coordinate as the starting point and selected parking lot as destination, Geographic Information System in a server plans and produces a guidance map of parking lot (as shown in Fig. 4) to send it to a user via Internet by referring to the information in map files.

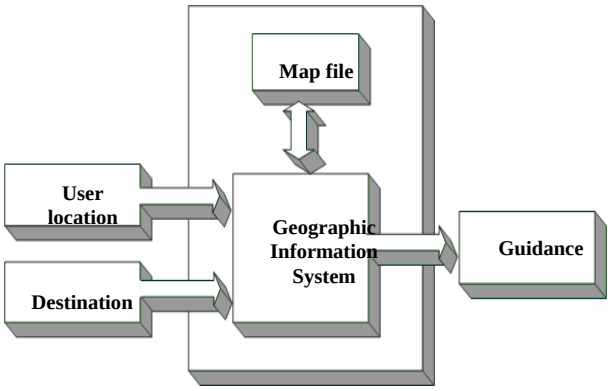


Fig. 4. A functional block diagram of construction module for guidance map

H. Geographic Information System

Geographic Information System (GIS) is a science to integrate geographic math, cartography and computer science, which is used to input, save, inquire, analyze and display geographic data for computer system. Components consisting of Geographic Information System include: map data (space information), electronic map core engine (database engine), analysis tool, demonstration system, operator and decision maker. The applicable fields include all things on the ground such as communications and transportation, land utilization, geologic survey and so on.

The development of electronic map core engine covers many kinds of information engineering technology, including the design of large database, the construction of optimal search engine, optimal route algorithm and coordinate conversion. The map data are a pack of digital data only, which need software to display appropriate human-machine interface. The well-designed system can provide the basis of accurate decision-making and allow a user making the most efficient use of space information [3][4].

Because components developed by PaPaGO! SDK Geographic Information System, Maction Technologies Inc., can be executed in servers, desktop computers and PDAs, the evaluation version is applied for practice in consideration of the future expansion. This study not only makes use of PaPaGO! SDK search engine to find out parking lots near the destination, but also displays with a character of P in a circular frame (as shown in Fig. 5) so that a user can know those parking lots near the destination (the red star displayed in the upper center of Fig. 5); path planning in PaPaGO! SDK is used to produce a guidance map for parking lot (as shown in Fig. 6) for the user reference.

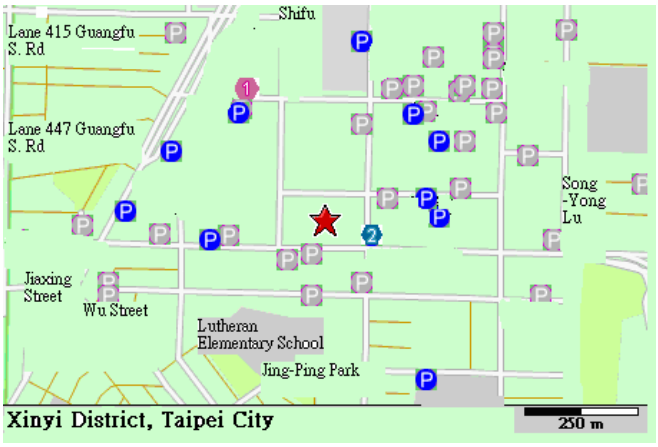


Fig. 5. Geographic map of parking lot adjacent to the destination

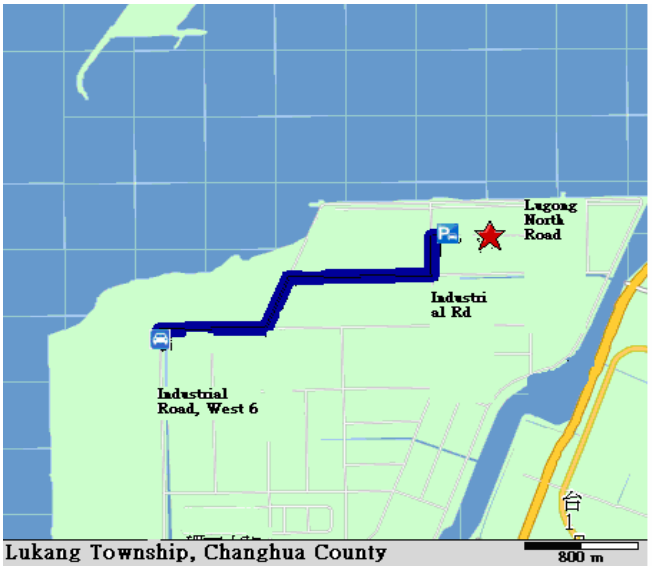


Fig. 6. Parking lot guidance map

I. Internet Browser

All operating systems almost support Internet and build in browsers compliant with HTTP. In order to smoothly execute this system on each platform, this study doesn't program user interface software but uses Internet Browser as user interface. Internet Browser in this system mainly plays a role in data transmission, receiving and screen display. In order to conveniently demonstrate, this study will adopt a notebook computer as a platform of Internet Browser.

J. Introduction to 3G wireless network system

3GPP (Third-Generation Partnership Project) was responsible to work out and maintain the standard of 3G mobile communication. 3GPP was founded in December 1998. The purpose was to establish the third generation mobile communication standard. The coverage included network architectures, 3G terminals and 3G services. In March 2001, 3GPP announced the first version of wireless multimedia streaming services, briefly called as 3G-PSS (Packet-Switched Streaming Services). 3G-PSS worked out an application platform of multimedia wireless transmission related to voice,

image and video with a bandwidth about 2Mbps, which had met the requirements of MPEG-4 video real-time transmission bandwidth. Two parts were specified in 3GPP-PSS, including communication protocol and encoder/decoder. In communication protocol, 3G-PSS mainly adopted the following transmission protocols: SDP (Session Description Protocol), RTSP (Real-Time Streaming Protocol), SMIL (Synchronized Multimedia Integration Language), HTTP/TCP and RTP (Real-time Transfer Protocol). In addition, for decoder, 3GPP supported the following media formats [2]:

1) Video: ITU H.263 and ISO MPEG-4 Simple Profile.
2) Audio: MPEG-4 AAC-LC (low complexity).
3) Voice: Adaptive Multi-Rate (AMR) Speech Codec.
4) Image: JPEG and GIF.
5) Text: XHTML- Encoded and Formatted Text.

The evolution and classification related to 3G network technologies can refer to Table 2. With the increasing demands of bandwidth, this system can transmit more abundant and real-time parking information.

TABLE II EVOLUTION AND CLASSIFICATION OF 3G NETWORK TECHNOLOGIES

Specification	WCDMA	HSDPA	HSUPA
General term	3G	3.5G	3.75G
Standard	3GPP R99/R4	3GPP R5	3GPP R6
Maximum download speed	2Mbps	14.4Mbps	14.4Mbps
Maximum upload speed	64kbps	384Kbps	5.76Mbps

K. Introduction to GPS

The full name of GPS is Global Positioning System, initially developed by the US government for cold war. With the end of cold war, GPS has opened for civil use. One of most important applications is drive navigation. GPS is a system which calculates the user location by receiving GPS satellite signals in space; through GPS and Geographic Information System (GIS), regardless of users on land, sea or air, it can accurately measure the location on a map. The output value related to GPS has annually reached US$20 billion, and increased with 10%~25%. The whole GPS can be roughly classified as three parts below [5]. The rest of detailed GPS output format will not be described in this study:

1) Space satellites:

Consist of 24 satellites revolving around the Earth in six orbits, not only orbiting about 20200 km above the ground. The time to revolve around the Earth in one cycle takes about 12 hours. Each satellite will continuously transmit radio waves with the date and time of satellite orbit, and provide each kind of receiver on the Earth for applications.

2) Ground control:

This is to trace and control the operation of satellites above-mentioned. All control stations installed on the ground take responsibility to correct and maintain each satellite can normally operate to ensure it provides correct messages to GPS receiver.

3) GPS receivers:

Keep track of all of the GPS satellites, and also calculate the coordinate where a receiver is as well as moving speed and time in real time. The civil use and application belong to the third part. The calculation principle is: when each space satellite orbits, there is one coordinate any time to represent the location (the known value). The coordinate where a receiver is located is the unknown value. During the process to transmit messages from a space satellite, the time taken can be calculated in comparison with satellite and receiver clocks. This time difference multiplied by the speed of radio wave (generally defined as the light speed) can calculate a distance between space satellite and user receiver. So a correlation equation can be listed according to triangle vector relation. A receiver we generally use is in accordance with the principle above-mentioned to calculate location coordinate. Whenever a satellite is received, a correlation equation can be listed. After three satellites are received at least, plane coordinates (longitude and latitude) can be calculated. Receiving four satellites can add the elevation value. Over five satellites can enhance accuracy. This is the basic positioning principle of GPS. These data are transmitted to the Geographic Information System. For example, PAPAGO® software developed by Maction Technologies Inc. can display the location of that positioning point. The frequency of GPS receiving signal is refreshed once per second. The position changes before and after one second can evaluate the moving speed and direction. GPS receiver can simultaneously receive signals from 8~12 GPS satellites. Satellite signals received by a receiver include initial coordinate, Greenwich date and time, Earth ephemeris, differential command, satellite ephemeris, satellite ID. After these data are processed by a GPS receiver, the time, latitude, longitude, speed, direction, receiving signal quality, GPS satellite condition, altitude, error estimate and differential reference station code can be converted to output , the frequency is refreshed once per second.

III. EXPERIMENTAL RESULTS

This study employs IBM server with Intel Xeon® E5335 2.00GHz CPU, 2GB RAM and Windows Server 2003® R2 SP2 as Parking Guidance and Information Server. Microsoft SQL Server 2000 is used to save the parking lot information. PaPaGO! SDK developed by Maction Technologies Inc. is used to plan and produce a guidance map. Chunghua Telecom 6M/6M FTTB is used to connect Internet. Parking Lot Host with fixing IP is connected to Internet Browser. The functions of Parking Guidance and Information Server are programmed by C#.

For Internet Browser, a notebook computer with Intel Core 2 Duo T5500 1.66 GHz CPU, 2GB RAM and Window XP® Professional SP3 is used. The model number of GPS receiver is GlobalSat BU-353 (USB interface, SiRF Star III chip). 3G

network module not only selects Huawei E220 HSDPA USB card, but also uses built-in IE 6.0 sp3 as interface software.

For Parking Lot Host, this study doesn't actually make Parking Lot Host but the real-time information on parking space provided by the Parking Management and Development Office, Taipei City as the data source of a server.

Parking Guidance and Information System is based on Taipei City as the test scope and Taipei 101 as the experimental destination to carry out the drive test.

Executing Internet Browser can see the upper and lower half part of main screen with three blocks (as shown in Fig. 7). The upper half part has two blocks, which the right side is a map produced by Parking Guidance Server. After map files are received via Internet and 3G network, they will show on the screen to display the geographic position of the destination and adjacent parking lot. Red star in a figure represents the destination, located in the middle of a map. There is a character of P in a circular frame to represent parking lot. Each color in the frame represents the different meanings, where the green, red and gray color represent parking space available, no parking space available and no real-time parking space available in that parking lot. The right side marks the meanings of each illustration in a map. The lower half part shows the name of parking lot, parking space available, business time and so on.

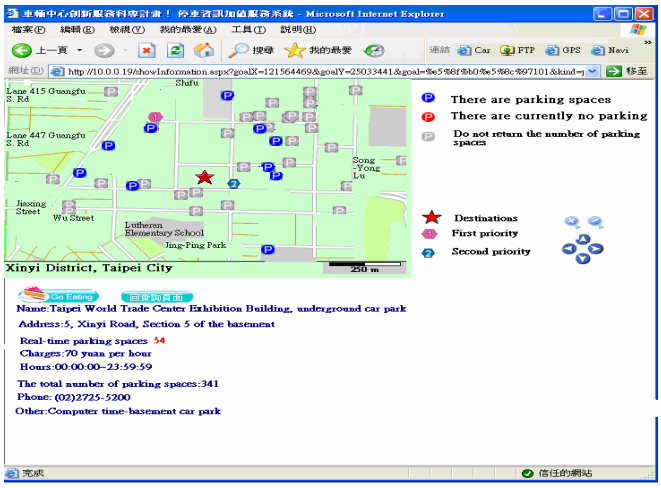


Fig. 7. Real-time parking space inquiry screen by Internet Browser

A user can click an illustration of parking lot in a map. The detailed information on clicked parking lot will be displayed in the lower half part of parking lot information block. The left button on a guidance illustration is pressed to set that parking lot as the destination of guidance map.

After the parking lot you want to leave for is set, Internet Browser will transmit the code of parking lot and current GPS coordinate you want to leave for to a server. When the Parking Guidance and Information Server receives them, it will plan a guidance map and return to Parking Guidance and Internet Browser (as shown in Fig. 8). From Fig. 8, the screen is divided as two blocks. The destination and parking lot information block make no change, but the illustration meaning and map content blocks change. There are different color illustrations of parking lot in illustration block. However, the location of parking lot doesn't display on a guidance map. What replaces is an illustration of guidance destination. What the map contents display is a guidance map from user position to parking lot. The red star represents the destination: Taipei 101. The green star is the destination of path guidance: parking lot you want to stop.

By assistance in Parking Guidance and Information System, a user doesn't make a detour to search for parking lot. It shows Parking Guidance and Information System proposed in this study indeed can reduce the parking time for a driver and efficiently improve the problems to search for parking space. After this system is commercially available, the ratio to find out parking space in a detour [6] should be less than 30%.

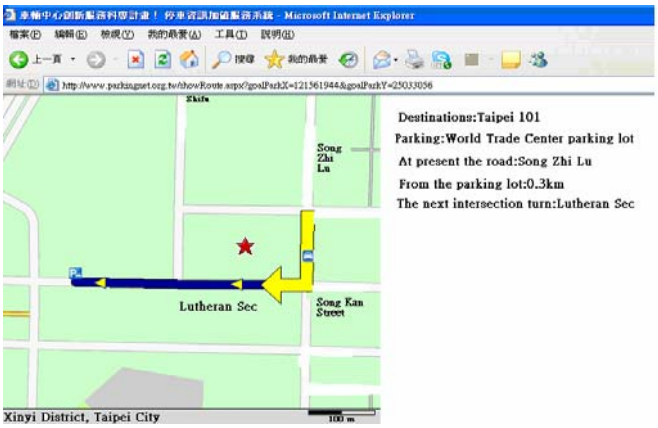


Fig. 8. Map screen guided by Internet Browser

IV. Conclusions

This study has successfully integrated with Geographic Information System as map information. A parking guidance and information system is developed with 3G mobile network and GPS. The whole system includes Parking Lot Host, Parking Guidance and Information Server as well as Internet Browser. From the experimental results, it is indeed practical for the parking information on traveler path provided via 3G network and the guidance path of parking lot for travelers transmitted to Internet Browser. Parking Guidance and Information System, which integrates GPS and 3G networks, not only solves the insufficient number of roadside display unit, but also increases the applications after the parking information is collected. Integrating GPS and 3G technologies proposed in this study with the Parking Guidance and Information System shows the high application value for providing the information on parking lot, reducing the parking time or enhancing the utilization efficiency of parking lot. If most of parking lots can transmit the related information to drivers in the future, this system will move forward to optimal suggestion and appointment of parking space. After the system suggests optimal parking lot by driver preference, the parking space can be appointed. So the traveler information can be more enriched and show no more worry in a trip.

REFERENCES

[1] Zhao-Ming Su, and Wen-Song You (2002), "Construction of Personal Parking Guidance and Information System", *Communications Journal*, No. 1, Vol. 2, pp. 7-28.

[2] Xi-Huang Chen, Shi-Chang Chen, and Jiong Lin (2007), "Study of Using MPEG-4 Dynamic Video Encoder for Image Monitoring in Remote Driving Condition", 12th Vehicle Engineering Workshop, pp. 92.

[3] Tian-Ying Chou (2008), "*Geographic Information System Theory and Practice*", the fourth version, Taipei: Scholars Books.

[4] Liang-Yi Jian, and Chang-Xin Cai (2004), "Theory and Practice of Constructing *Papago!SDK GIS*", the first version, Taipei: Maction Technologies Inc.

[5] Xi-Huang Chen (2008), "Development and Research of 3G Road Video and Real-time Location Report Module for Vehicles", commissioned by Automotive Research & Test Center.

[6] Zhao-Hsiung Xu (1996), "Study of Real-time Information on Parking Lot", commissioned research by the Institute of Transportation, Ministry of Transportation and Communications.

[7] Parking Management and Development Office, Taipei City (2007), Taipei City Parking Lot Information and Guidance System Protocol.

[8] Wen-Min Lin (1994), "Study of Dynamic Parking Guidance and Information System", a master thesis from Institute of Civil Engineering, National Central University.