USE "SMART TECHNOLOGY" TO AID DRIVERS' SEARCH FOR VACANT PARKING IN ITS

Honghong Liu, Zhaosheng Yang
Transportation Research specialist
Jilin Urban Traffic Program
Institute of Transportation Studies
JiLin University, JiLin Province
No.142, Renming Street,
the City of Changchun, JiLin Province, China

Phone: 086-0431-5705767
Fax: 086-0431-5705891
E-mail: wangxinyue2002@yahoo.com.cn

SUMMARY

Advanced Parking Guidance and Information System can inform drivers of parking Location and availability so that they make informed decisions and thus find parking conveniently and efficiently. It will reduce traffic congestion and pollution by lessening the amount of traffic circulating in search of open spaces; or attempting to park at a specific facility that is full. It will also enable more complete use of the total number of parking spaces. The paper describes the background and the technical solutions for the System.

BACKGROUND

As part of ITS deployments in China, Parking Guidance and Information System (PGIS) is drawing attention toward the alleviation of traffic congestion that is made worse by parking search in bigger urban areas. Advanced Parking Guidance and Information System is regarded as one of the most effective traffic management strategies that can control and influence the use of vehicle especially in urban downtown [1]. Beijing has won the right to host the 2008 Games. The Chinese government promises that it will be the most splendid game in Olympic history. One of the factors affects the Olympic Games is traffic system, and Beijing government is determined to provide an on-time, safe and comfortable traffic system. Although today many indexes such as density of road network, registered car and the number of commuters per day have ranked in the first line of the world, Beijing's fundamental facilities in the fields of traffic management are behind of the world.

The characteristics of Olympic traffic is described as the following:

- Short-term event
- Hard intensity
- High demand

One of measures adopted by Beijing city government's Olympic traffic management is traffic planning and control of Olympic park. Since 1997, National Natural Science

Foundation of China has funded two large projects under the research and development initiative called " Urban Traffic Flow Guidance Sytem" [2], Jilin university get one of the funds. Because of these reasons, our group plans to design and build a technically upgraded system (be called advanced parking guidance and information system) for urban parking management and information by our research group.

GOALS AND OBJECTIVES OF THE PROJECT

- Creat an advanced parking system that would communicate real-time parking information to users.
- Creat an advanced parking system that would serve as a "wayfinder" system to those users unfamiliar with urban road.
- Develop an advanced parking system that both architecturally and aesthetically fit within the scheme of urban.
- Integrated parking guidance and information system into urban traffic flow guidance system
- Develop an advanced parking system capable of expanding post –operational test to accommodate the urban's everyday traffic needs.
- Creat an advanced parking system that would have a positive impact on the surface transportation system.

SCHEMATIC OF THE INTEGRATED SYSTEM

An Advanced Parking Guidance and Information is a component of Intelligent Transportation System [3]. To combine it with ITS, Schematic of integrated an advanced parking guidance and information system into urban traffic flow guidance system be described as in Fig. 1.

All communication will be brought back to the traffic control and parking control center. A typical central computer includes a central processing unit, graphics terminal, communication board, printer, and software that allow for central control and management of the system.

The in-vehicle navigation system includes GPS receiver, in-vehicle computer, touch screen, and communication unit. Electric map software and route guidance software were loaded in in-vehicle computer.

Equipment at parking lot includes vehicle counting equipment and a controller interface unit. Existing counting equipment was used wherever possible.

Additionally, the information of each garage (include occupancy, fee, operation time, etc) and real-time traffic information could also be provided as output to the public phone network.

AN ADVANCED PARKING GUIDANCE AND INFORMATION SYSTEM

The city of Beijing installed one of the first dynamic parking guidance system in China in 2001. It can inform drivers the number of real-time available vacant spaces. The system links fourteen parking garages (two thousand nine hundred and ninety five spaces) by using dynamic and static signs. Since then, some studies have been performed to reveal both the traffic related and economic effects of the system. The results of the studies showed that the annual saving is about 1.2 million USD.

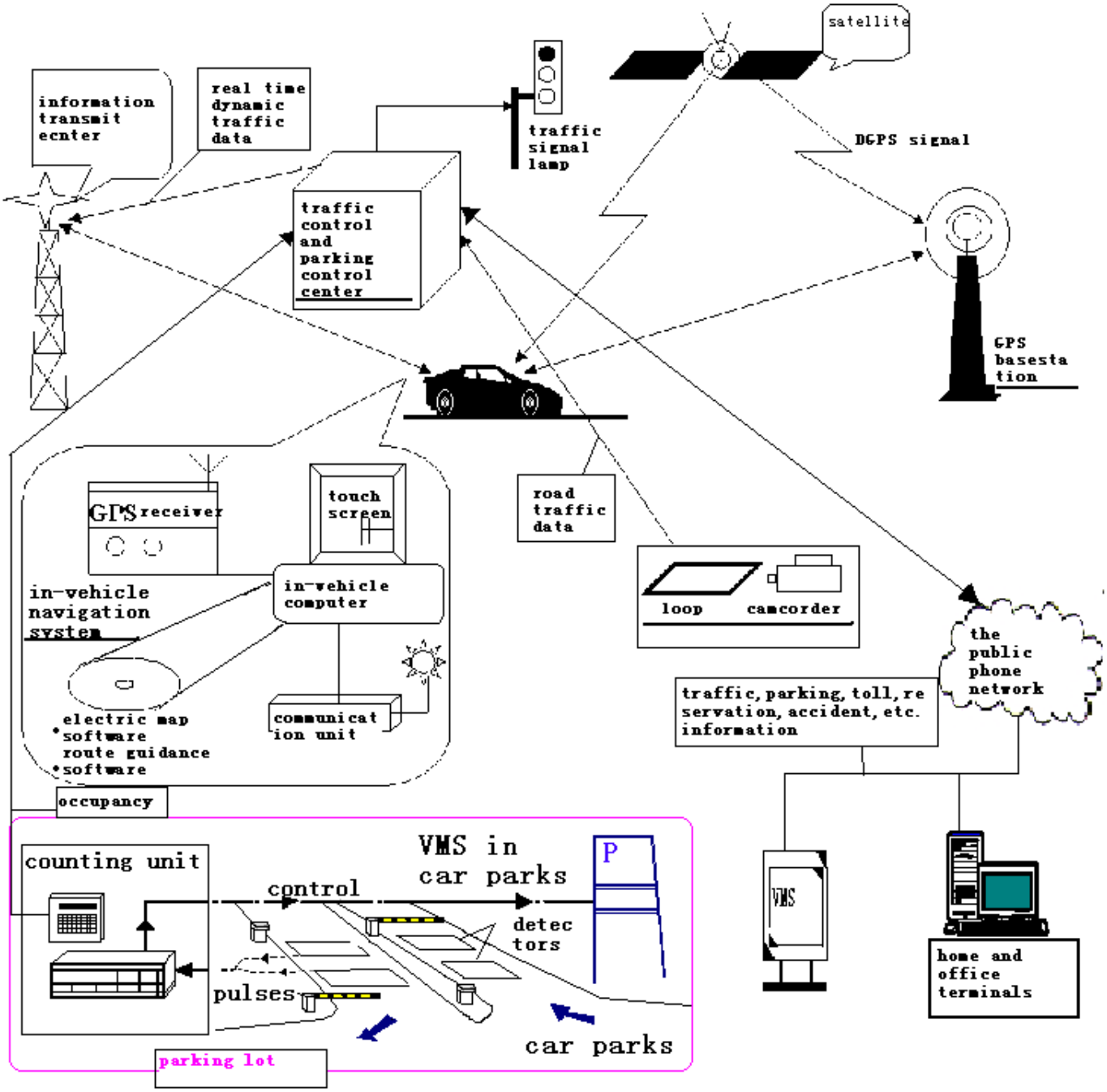

Figure 1 The schematic of integrating parking guidance into traffic flow guidance system in ITS

KEY TECHNOLOGIES FOR THE PROJECT

- **Route guidance for parking purpose using Artificial Intelligence tools**

Route guidance is the core of the advanced parking guidance and traffic information service system. Although there are many kinds of route optimization methods, they are limited to be used in road network. Traditional scheme statement can't meet real-time requirement. Heuristic methods satisfy real-time request, but it is hard to make sure the precision of outcomes [4]. At present, parallel computation is only be used in large-size

computation [5]. The paper adopted Fluid Neural Network (FNN) that is a type of continuous Hopfield neural network for route optimization for parking purpose. It is the first time that the best route problem was solved by neural network that has been a powerfully artificial intelligent tool in many fields. Road network consists of nodes and segments corresponds to a fluid neural network, nodes correspond to nerve unit, reciprocal resistance on road segments (it may be distance, travel time, degree of congestion, road quality or other comprehensive index) correspond to the degree of linkage between two neural units. So we obtain a fluid neural network model suited to traffic network.

$$\begin{cases} du_i / dt = \sum_{j \neq i} T_{ij}(S_j - S_i) + I_i & i, j = 1,2,\Lambda\ N \\ S_i = a(\dfrac{1}{1+e^{-bu_i - 0.5}}) \end{cases}$$

$$I = \begin{cases} I & when \quad I\ is \quad origination \quad node \\ -I & when \quad I\ is \quad destination \quad node \\ 0 & when \quad I\ is \quad other \quad node \end{cases}$$

Where T_{ij} represents resistance on road segments, because the fluid obeys the rules of fast descending and I is a constant, du_i / dt equals to zero when iterative numbers is enough. At this moment, the system attains stable status. The road on which rate of flow is largest is the most possible road among all the roads linking the nodes. On these grounds navigation search the best route from origination to destination. The following is the step of the algorithm:

Step one: set initial status of FNN, let t equal to zero, $S_1(0)$, $S_2(0)$,$\cdots S_N(0)$ equal to S_0, $U_1(0)$,$U_2(0)$,$\cdots U_N(0)$ equal to u_0, compare the input Origination node and Destination node determined by position system, if O is not equal to D, turn to step two. Otherwise, process ends.

Step two: when $U_i(t+1) - U_i(t)$ is equal to zero, the system attain stable status and turn to step three. Otherwise let t+1 replace t and turn to step two.

Step three: mark $T_{ij}(S_j - S_i)$ equal to X_{ij} and mark M is the first node between O and D from origination node, M_1 is equal to the maximum of X_{ij}, then search M_2 from M_1 node beginning according to the same method until M is equal to D.

Step four: mark the best route $O - M_1 - M_2 - \cdots - D$.

The followings are some experiment results of route guidance in personal computer: It spent less than one second to search the best route in the road network with 10000 nodes. Fig. 2 shows the best route from Gonglong Square to Changchun Station in a test experiment of the project. Fig. 3 is an interface of electric map software of GIS for transportation.

● Electronic Toll Collection for parking utilizing DSRC

Usually there occurs traffic congestion around the parking lots in the central of city because it takes time to take cars in and out or to pay tolls. So the national authorities concerned for the DSRC (Dedicated Short Range Communications) experiment. In order to alleviate the concentration of dedicated parking lots and traffic congestion around them and to improve on efficiency, the authorities are planning to form a model of the parking system utilizing DSRC based on the results of the experiment.

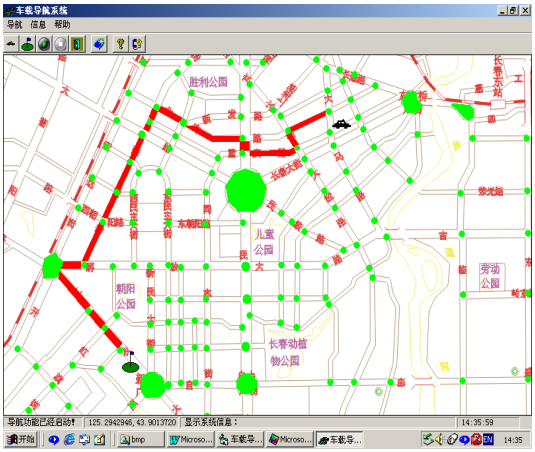

Figure 2 the best route from Gonglong Square to Changchun Station in a test experiment

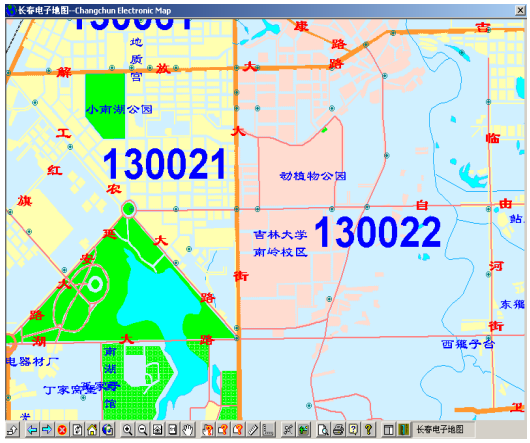

Figure 3 an interface of electric map software

DSRC is a communication system that applies Dedicated Short Range Communication technology. It consists of On-Board Unit (OBU), Road-Side Unit, DSRC Protocol, computer network and background process unit. When a vehicle enters or leaves the garage, Road-Side Unit reads vehicle ID in OBU and records the vehicle entering or leaving time, and transmit them to background process unit which is located in a bank, according to this information, toll collection process which achieving efficient, safe and exact target is finished.

DSRC used in this experiment is a radio communication technology utilizing a frequency of 5.8GHz, which makes the ETC technology become general-purpose. The frequency is adopted as the international standard for DSRC. Fig. 4 shows the structure and the image of information communication in the system utilizing DSRC and ETC.

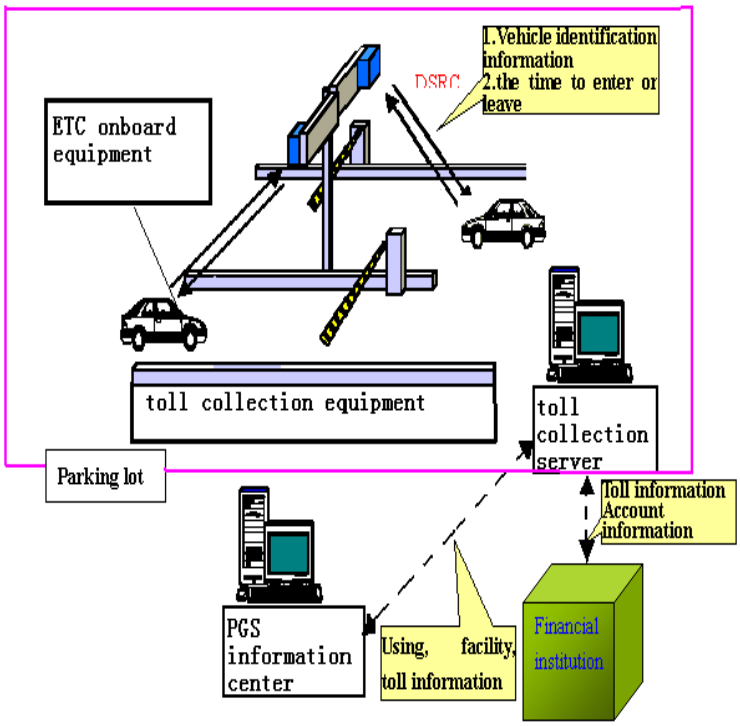

Figure 4 The structure and the image of information Communication in the system utilizing DSRC and ETC

● Mobile Communication Technology for guidance information transmission

Navigation for parking purpose is usually divided into locally determined navigation system and centrally determined navigation system.

The integration of DSRC and wireless communication can accomplish the function of vehicle locating and real-time guidance and information transmission.

For centrally determined navigation system, before leaving homes or offices, the travelers can submit their origination and destination to traffic and parking control center through private terminal such as private computer or mobile telephone or onboard equipment, and the center can provide the optimal traveling route and the selected available garage nearby the destination for travelers based on the real-time road traffic information by transmitting the information to Road-Side Unit through wire or wireless communication network. When the vehicle equipped with OBU passes through the key road antenna, Road-Side Units obtain the vehicle's information (such as vehicle identity, the point identity, the time when the vehicle is passing through the point, etc) to locate it and then the center update the database and provide navigation information by Road-Side Units.

For locally determined navigation system, the system adopted the mobile communication technology. GSM, CDPD, GPRS and CDMA are data communication technologies that have been developed recently. The CDPD can only be used to transmit digital data and can't be used widely all over the world because it has some limitations. The function of GSM is limited in the aspect of data communication and can't meet the requirement of data transmission in ITS.

GPRS (General Packet Radio System) has solved some problems of GSM and has the following technical characteristics [6]:

(1) It can use existing network resource and have the characteristic of high efficient due to General Packet Exchange.

(2) High speed data transmission between 9.05～171.2kb/s.

(3) The connection speed of GPRS is rapid (less than one second) and GPRS can provide seamless connection with current data network.

(4) Fee is based on data flow amount, the type of service and the level of service and is more reasonable.

With the various advantages mentioned above, GPRS was applied to the route guidance for parking and other purposes.

Connected with Web network easily, GPRS can submit real-time traffic and parking information to travelers. At the same time travelers can submit their questions and requirements to the decision-making center and query the parking information.

● Forecast of occupancy of parking spaces in the future time

Before a trip, travelers sometimes want to reserve a parking space in the proximity of an indicated destination by Internet. But if an unexpected event (for example, the planned appointment was shifted or canceled) happens during the journey, the situation should be reported to the center immediately.

For the above reasons an advanced parking guidance and information system should develop a service to meet booking demand of travelers. Travelers can preserve a space, cancel a preserved planning or change the existing reservation with different terminals.

A comprehensive system must incorporate a predictive element which can provide future information (whether or not leaving for the garage have some parking spaces, etc.) when the driver arrives the garage. So it is necessary to calculate the probable space available for the required periods ahead.

The capacity of garage depends on road traffic flow, weather, events, road condition, etc. It follows that the best prediction of available spaces is a combination of short time and historical information [7].

Prediction of available spaces, which shows dynamic change owing to all kinds of factors, is a complex non-linear process. Based on neural network of time series and historical data characteristics, prediction model was made and practised in our experiment system. The calculation results indicate the model is not only reasonable but also simpler than time series statistical model and more useful in function.

Why the selected method of prediction is the neural network model of time series? The reasons are described as the followings:

- Neural network is a non-linear kinetics system with some peculiarities that include high dimension, extensive linkage among neural units, auto-adaptability and auto-organization, etc.
- Neural network is suited to deal with some non-precise and fuzzy process affected by many factors and conditions at the same time.
- Neural network possess self-learning ability.

We must consider the following when using the neural network for prediction.

(1) how to select independent variables

As mentioned above, the capacity of garage depending on road traffic flow, weather, events, road condition, etc. So the network input adopted many factors input. It was considered separately to select one year data, two years data, three years data.

(2) network structure

Models consist of three layers: input layer, implied layer and output layer.

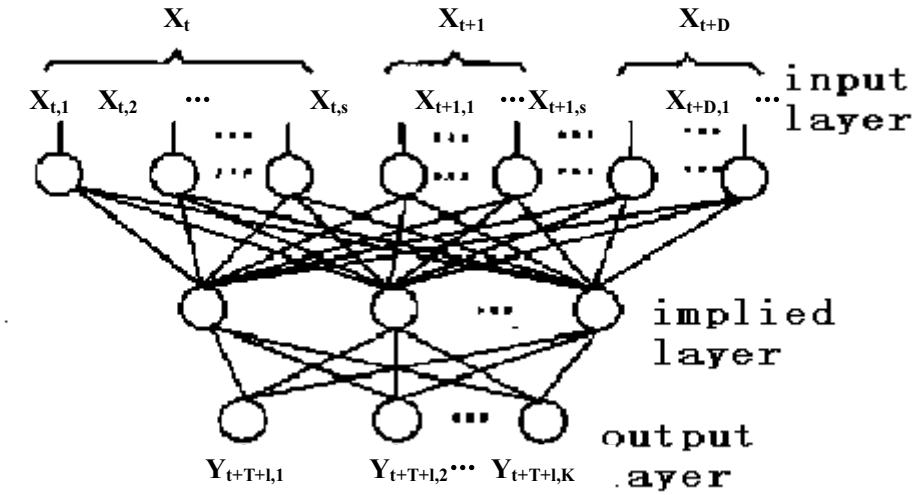

Figure 5 the neural network structure of time series

(3) sample train and weight decision

The learning rate is automatically regulated[3]. If the revised weight can really reduce error function, the situation indicates the selected rate is too small and the system must increase the learning rate. Otherwise, reduce the learning rate.

(4) result analysis

The prediction result shows that much more sample size, error is smaller. But large sample size will cost much time and so affects real-time requirement. In addition, the

appropriate number of implied neural units that affect the learning time, precision and converge is hard to select. Historical data is also necessary for such a system and it requires the car parks have counting systems.

THE EFFECTS OF PGIS

A series of surveys carried out before and after the introduction of the PGIS in Beijing. These surveys suggested that drivers increased their reliance on the PGIS. Overall, 85 percent of drivers claimed to have parked in the facility they intended to use, and of those 50 percent stated that they used the PGIS to reassure themselves of the availability of a space at their intended facility. These surveys also suggested that the PGIS slightly reduced queuing at popular car parks and increased patronage at unpopular car parks.

The PGIS will have many benefits for all travelers in downtown Beijing. The main benefits of PGIS can be categorized as follows:

(1) Traffic benefits: PGIS can reduce traffic congestion and pollution by lessening the amount of traffic circulating in search of open spaces; or attempting to park at a specific facility that is full.

(2) Driver benefits: The provision of real-time occupancy information can enable drivers to make the more efficient parking choice. The signs of PGIS can provide the highway direction information for those visitors who are unfamiliar to the town center.

(3) Management benefits: PGIS can provide an excellent data collection and management monitoring facility.

To quantify the effectiveness of the Wangfujing area PGIS, one of the results of the post-surveys were compared with those of pre-surveys as follows:

Fig. 6 compares the parking time by purpose before and after the introduction of Wangfujing area PGIS. Short-time parking of business vehicle sharply increased after the introduction of the system. Especially, parking time of 30 min or less increased more than twice as compared with the pre-surveys. The introduction of the PGIS and intensifying regulation of illegal on-street parking are considered to have increased the usage of parking lots.

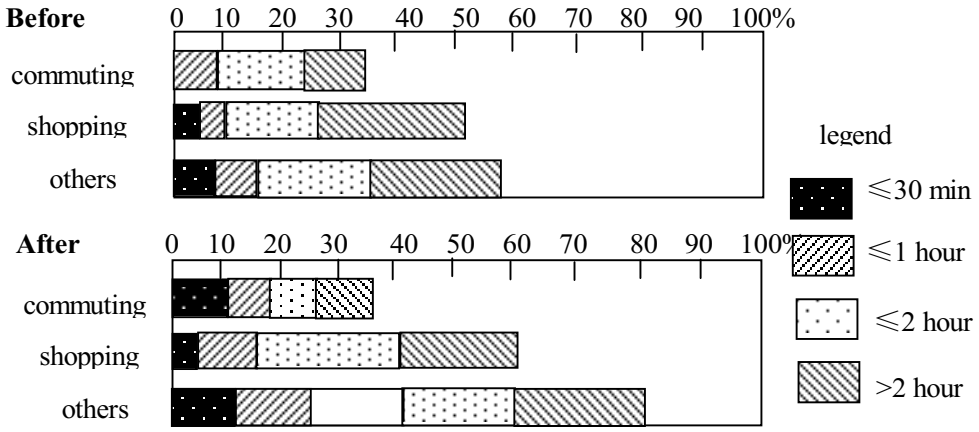

Figure 6 Comparison of parking time by purpose before and after installation of wangfujing area PGIS

CONCLUSION

An advanced Parking Guidance and Information System will have many benefits for all travelers in downtown Beijing. As Beijing's traffic continues to grow, real-time parking management and ITS system elements are needed to manage the increased demand on transportation and parking systems. With the Beijing city's government committed to solve parking and traffic issues affecting downtown workers, residents, and visitors, the PGIS program will become a leading example of how real-time parking management can be integrated with ITS planning.

ACKNOWLEDGEMENTS

The paper was funded by Jilin Province Science and Technology Project (No.20020424). This work was carried out as part of Beijing Olympic traffic program in cooperation with Department of Transportation, Beijing city's government and the Bureau of Beijing Traffic administration. The authors acknowledge the following staff for their support: Professor Wang Yunfei(the Bureau of Beijing Traffic administration), Zhou Yuanying manager (Beijing ITS Limited Corporation), Professor Yang Zhaosheng, my director(Jilin University). Finally the authors are thankful for their support by providing valuable and insightful comments and suggestions.

REFERENCE

[1] Tony Sedgwick, A key role of parking .in an intelligent transport industry, Proceedings of 9th World ITS Congress.

[2] Zhaosheng Yang, Daosun Ma, Study on the Implement Technologies of Urban Traffic Flow Guidance System, ICTTS'2002.

[3] Ministry of Construction: " Parking Lot Information System (Planning and Improving Consideration)," Taisei Shuppan Sha, March 1991.

[4] Hassan A. Karimi. Real-time Optimal-route Compution: a heuristic approach. ITS Journal. 1996.Vol.B(2).PP.111～127

[5] Paige, R. and Kruskal, C.Parallel algorithms for shortest path problems. IEEE Transactions on Computer C-34,14～20,1995. [3] Andreas Dirschl, Karl-Ernst Steinberg,

[6] Zhang Li, Ceng Liansun, Qin Zhengtian. The ITS based on the GPRS network. Transportation World, 2001.12, P32～34.

[7]Winston. P.H.. Artificial Intelligence, Second Edition. Reading MA: Addison-Wesley Publishing Company, 1994.