The Extended Route Service
Based On Dynamic Update Frame: From Design To Deployment

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ABSTRACT:

This paper establishes a dynamic route service framework based on windows socket and .net remoting technology, which ensures the update of extended route service data in time. To improve the quality of urban travel navigation service, the route analysis is extended in several means, including the integration of route service with time information and improving the algorithm in different travel modes. Using the principles of space–time prism concept as a source reference, the problem for choosing the appropriate facility in restrained time cost is discussed. Potential path area model of space-time prism is simplified to find the appropriate facility with a high speed.

1. Introduction

Route service is one of the unique functions in e-map. It bases on the route navigation and supplies the function of Optimal Path Analysis and navigates for users (Goodchild, 1999). Different from other services of e-map, route service requires Timeliness and high accuracy map data (Alan Kwok, 2006), e.g., in the urban traffic field, real-time update traffic information is required. By ensuring the reliability of data, users obtain reliable results of the analysis. To serve the requirements of the Real-time update data in this service, a dynamic update framework was established.

The dynamic update frame is numerous interactive modes between clients and servers. These interactive modes ensure that the synchronization and symmetry of information between clients and servers in network environment. There are many ways to achieve synchronized information between clients and servers. Windows Socket communication frame is one of the solutions widely used (WeiMeng Lee, 2005c). Extra corresponding adjustments were done to make the transportation of geographical data more speediness and safety. . Net Remoting technology is a distributed calling technology, which makes up the limitations of DCOM network communication in the Internet and has the flexibility as Web Service (David Curran, 2002), therefore, .Net Remoting was used to complement the Windows Socket to complete the geographical data of the remote dynamic update is appropriate.

The route services are widely used in vehicle navigation, trip planning, logistics, transportation and other aspects. In this paper, two ways are used to achieve the dynamic expansion of route service, one is by the integration of route service with time information and the other one combines different travel modes in services.

2. The Dynamic Update Frame of Route Service

As mentioned in the introduction, the route service requires geographic data with high timeliness and accuracy, especially the road network data. In order to make a credible path to achieve the results of services, update information is transported to every client when the data has been changed. The transportation requires a series of Interactive modes between client and servers.

2.1 Two communication types between client and server

In the classic three-tier client-server mode, the communication between client and server becomes very critical. The client and server communication is divided into two categories, command communication and data communication. Command communication is established to complete the command transportation between client and server. Data communication enables the data versions in both client and server synchronized. Command communication has small size of data, but the structure of it is variable, while data communication has big size of data with little change in data structure, and it requires higher data security, e.g., in map service, many command communications between client and server are needed before the transportation of map data, and contents of each command communication are completely different. When sending map data to client, server needs to encrypt it to ensure the safety of the map. Then, client need to complete the decryption. No matter what maps the client requests, the communication format of them don't have many changes.

2.2 The Communication Process between client and server

In order to achieve a good effect of command communications and data communications, Windows Socket is used to carry out the transportation of commands between the client and server. .Net Remoting technology was used for the transportation of map data. Figure 1 shows four logical layers between client and server.
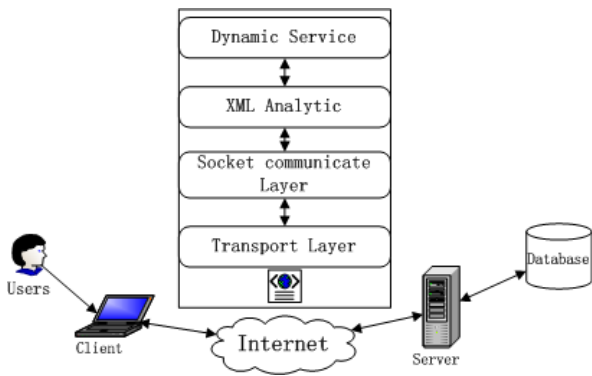
Figure 1 Client and server-side hierarchical model diagram

Both client and server include transport layer, Socket interaction layer, XML parsing layer, and dynamic services layer. Through

the transport layer to carry out the transmission of map data, Socket interaction layer completes the client and server-side command interaction, XML parsing layer is an XML-based interpretation of the map data and finally maps are provided to the dynamic service application layer. Figure 2 shows the logical process when client requires map data from map server. The client publish data request to the server with Socket communications. Socket analytic server captures requests, parses requests, and transmits the request to the data server which is working for these requests. Data server receives data request, and the data is converted to XML files and through Socket server to interact with client. Data Server and the client open the corresponding data transmission channel. We transport the map data from server to client with .Net remoting technology.
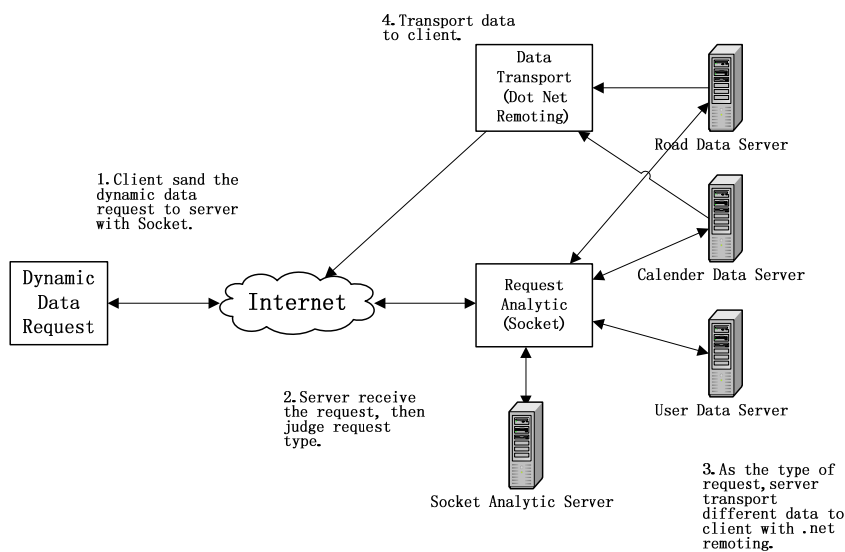

Figure 2 The logical structure diagram of client requesting for map data

In the multi-client data request process, Socket server maintains a list of users to monitor users' status, and achieves the allocation of user requests. As shown in Figure 3, when the client logs on, Socket server assigns a separate thread for each client to complete client request listening (Simon G. M. Koo, 2003). Socket server updates the user list, the user's IP address and data request, and sends request to back-end data server. Through this dynamic update framework, the synchronization of data is completed between client and server.
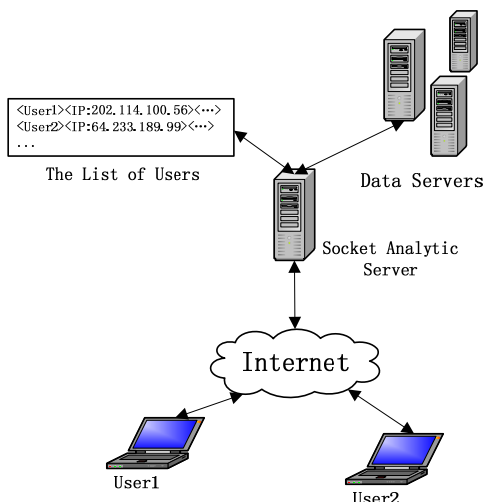

Figure 3 Multi-user data requests

3. The Extended Route Service based on time information

Adding time information into route analysis makes it closer to the real application needs. There are two aspects of this issue, integrating the result of route analysis with schedule and combine time-limited information with route service to improve the accuracy of result.

In the first aspect, using the result of route analysis improves the accuracy of schedule. To consider business hours, gate open and close time of facility with analysis, the result contains exact time information. This information can improve schedule to fit reality. In the second aspect, time-limited information is considered into analysis. The key issue is the facility choice in time-limited information.

3.1 Combine the result of route analysis with schedule

To combine the result of route analysis with schedule, two types of time was considered, the "hard" time, e.g., bank hours, open and close time of gates, and the "soft" time, including the idle time of service points and the time of road traffic jams. Hard time has direct impacts on the route analysis results, e.g., before the gate opens, the gate is a barrier in the path, so another path to get around the gate was chosen in route analysis. The bank becomes a non- reached point out of its business hours, and another solution is achieved. Soft time impacts on the time of

reaching destination. No barriers or non-reached were produced by "soft" time, so it has the indirect impact on the route analysis results.

To improve the route analysis arithmetic, "hard" time information is taken into consideration. There are two solutions when "hard" time exists in a path, waiting until it opens, and choosing another way or changing the facility. Users may feel uncomfortable with the first solution, because no one likes waiting for something. The second solution might not obtain the

best routes from logical view, but users feel satisfied. As shown in Figure 4 (a), a user chooses bank A as a stop point, but bank A is not open, so maybe bank B is a better choice. In Figure 4 (b), there is a gate in path A, and if it isn't 7:30am-23:00pm, the gate is a barrier, so the user will either choose to wait or path B instead. The guide line of different choices is totally time-consuming. The route analysis arithmetic makes the decision to give an optimal path. For the "soft" time, the arithmetic just needs to put this information into schedule and provide the accuracy time information in each point.
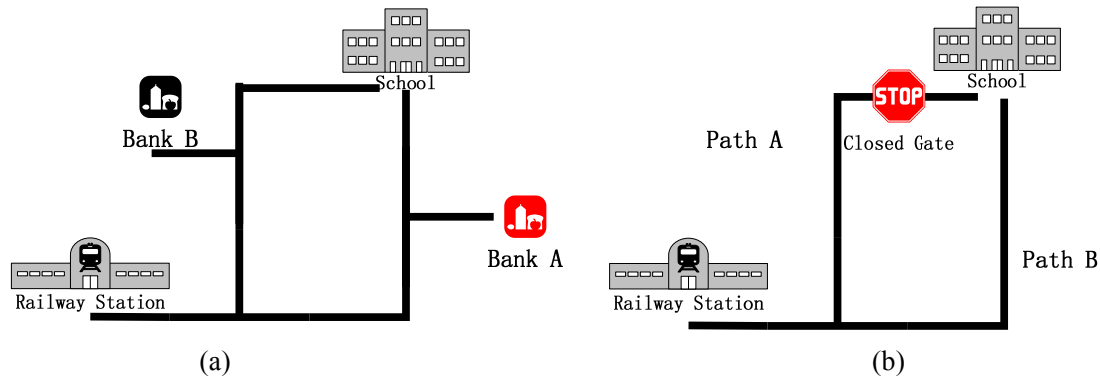

| (a) | (b) |

Figure 4 two solutions in route analysis with "hard" time information

3.2 Combining time-limited with route service

The space–time prism concept in Hagerstrand's time geography provides an effective model to identify the opportunities under spatio-temporal constraints (HongBo Yu, 2008; T.Neutens, 2007). Using the principles of space–time prism (Lenntorp, 1976), the problem of how to choice the appropriate facility in fixed time cost will be discussed. Figure 5 describes the space-time prism with isotropic cost road network. Here XY axis represents geographical space, and the T-axis represents time. Someone starts from T1 point and after a certain period of time reaches the end of T2. Its projection on the 2D plane is a region known as a potential path area (PPA) (Lenntorp 1976) in isotropic cost of network, the PPA is an ellipse. In 3D plane, there is a prism between the origin and ending. All possible routes were contained in this area, and the routes out of this area are forbidden in reality.
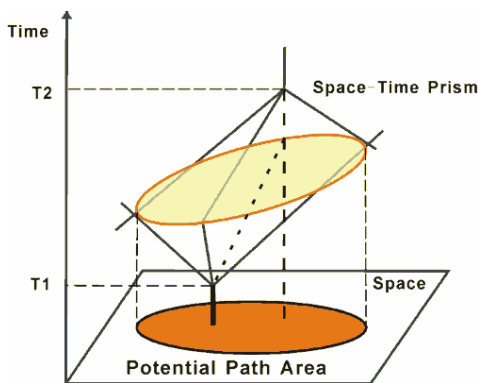
around. Which one is appropriate facility to ensure the total path time less than T? If the cost of road network is isotropic, the theoretical PPA is shown by broken line as an ellipse. In the simplified model of PPA, as start point (school) and end point (train station) as the center, each with T / 2 as the radius, two service areas R and H are drawn, and this map is divided into three regions. The relationship between three facilities and two service areas is described as below. The whole region of map is U.

$$A \in U\text{-}R \cup H$$
$$B \in R \cup H\text{-}R \cap H \qquad (1)$$
$$C \in R \cap H$$

As the figure 6 shows, A is beyond the area of PPA, so facility A is not the appropriate one. Contrarily, C is a facility point in the PPA within the region, so facility C is the appropriate one. Region B might be in the PPA or not, so we need to screen each of these service points, retention to meet the conditions of service points. This simplified model quickly determines whether the service points meet the conditions and finds all the appropriate facilities.
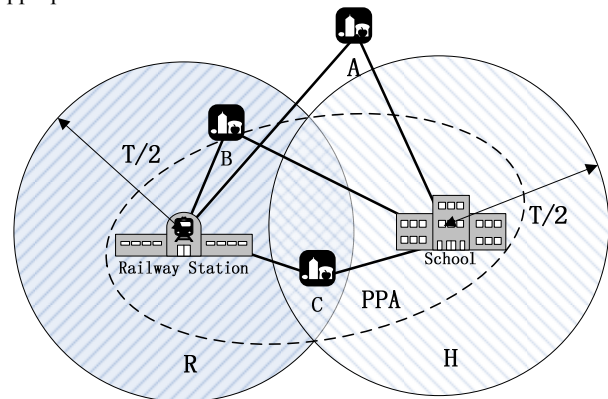

Figure 5 space–time prism models

Figure 6 The simplify model of PPA

In actual geography of the world, due to the complexity of road network data, seeking a PPA is difficult. Figure 6 shows the simplified model of PPA. In this picture, the total time between railway station and school is T, and there are three facilities

4. Path analysis model based on the integration of persons and vehicles

4.1 Vehicle Path Analysis

Numerous roads are closed to traffic on the map. In the process of vehicle navigation, vehicle barriers are dynamically loaded onto the map for analysis. Figure 7 shows the flow chart of the algorithm for vehicle navigation.
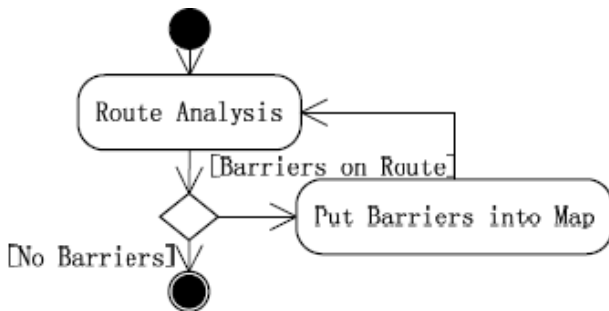

Figure 7 Vehicle Path Analysis Algorithm Process

The algorithm calculates a path after a user sets starting and ending points and checks whether any barriers exists on the path. If any barriers exist, barriers are added to the analysis. Then, the algorithm calculates a path again. Repeating the process above until there is no barrier on the path. This path is the optimal path.

4.2 Route analysis model for the integration of people and vehicles

Sometimes, the path achieved from chapter 4.1 is not the best result. In reality, the locations we get on and off are not always our starting point or destination. In order to obtain a satisfactory path analysis results in this situation, a comprehensive analysis based on the integration of people and vehicles route analysis is introduced. The Vehicle Path Analysis Algorithm showed in chapter 4.1 is improved. When the destination cannot be reached by vehicles, Path analysis model for the integration of persons and vehicles determines the appropriate off location and get the best path. Figure 8 shows the flow chart of the improved algorithm.
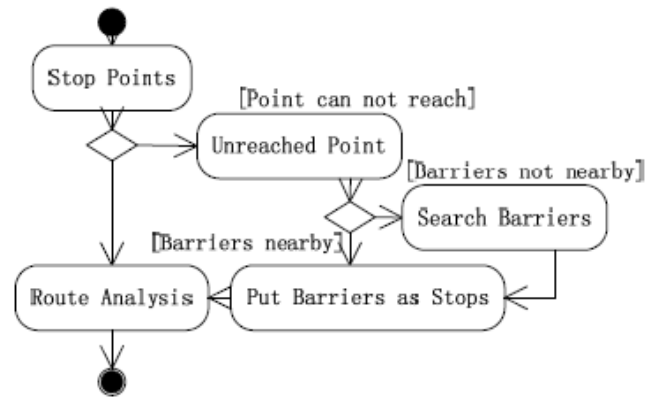

Figure 8 Algorithm Process for Path analysis model based on the integration of people and vehicles

As shown in Figure 8, whether there are any unreachable points in the target points that imported by user. If any, store these points in the queue of unreachable points. Remove the point one by one from the queue, and perform the following procedure. After being removed from the queue, the existence of barriers around the point is determined; if none, broaden the search range, and continue to search until barriers points are found and marked as on and off points. Participate in path analysis as a special target point, when the points in the unreachable points queue have performed the procedure. Then, path analysis based on the integration of people and vehicles has completed. At this point, the location of on and off will appear around the unreachable points on the path, and it is the result of the analysis for integration of persons and vehicles.

5. Experiment and Realization

Wuhan University Navigation System was designed and implemented by using ESRI ArcEngine and Wuhan University campus map data. The platform follows the dynamic-update architecture as discussed in the first section. If the traffic information changes, the server will notify each client to update data. Through a series of interactions between server and client-side, the map data was dynamically updated. The path navigation services of the platform are expanded in time and travel patterns. Users obtain precise time information of each point through the path analysis services, and the results help arrangements of their trips. Path analysis model based on the integration of persons and vehicles discussed in section 4.2 is used in the platform to provide users with more personalized navigation services.
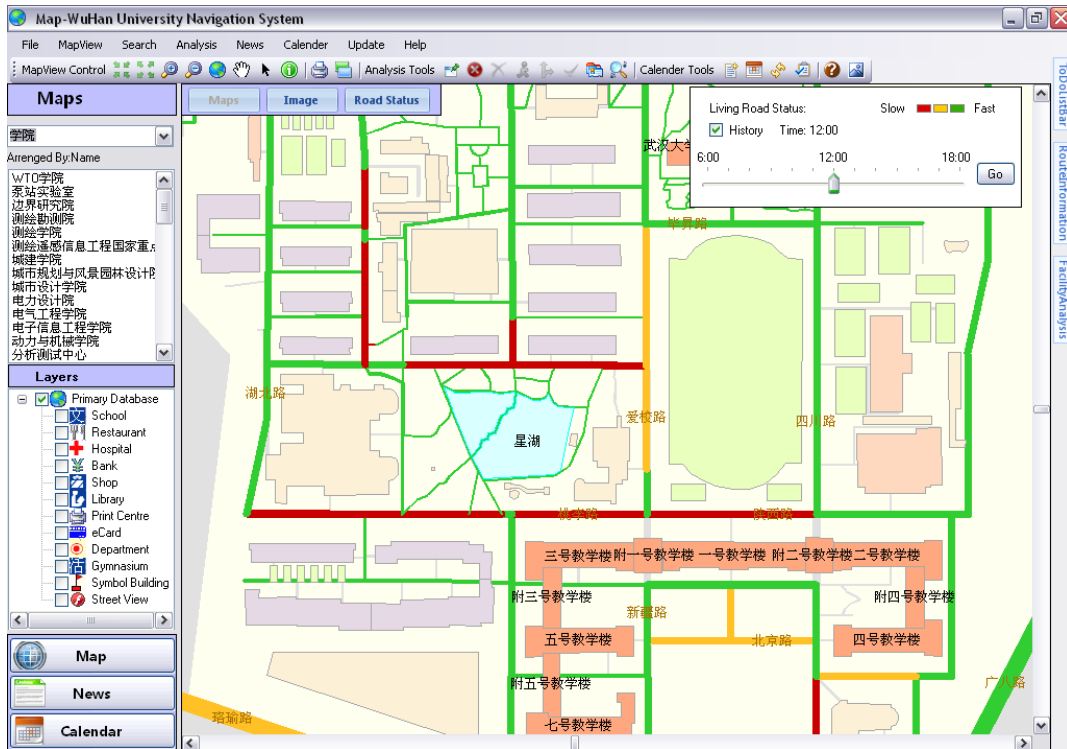
Figure 9 traffic updates under the framework of dynamic-update

In Figure 9, the client requests the server-side the latest traffic information through the dynamic update framework. Figure 10 shows the extension on time of the path analysis, Fig. 10 (a) shows how does the entrance gate switching time impact the path analysis. In this example, a user started from the starting point at 6:40 am. When he arrived in Gate A, Gate A was not open, after further analysis, Gate B was feasible. Fig. 10(b)

shows that the path analysis integrates service time of each service point and users' residence time. Take point No. 3, Wuhan University Press as an example, Wuhan University Press is open from 7:30 am to 18: 00 pm. A user reached the Press at 7:02 am, because there was no second around, so the user need to wait. The process sets the user stayed in the press for 15 minutes, and the user left the press house at 7:45 am.
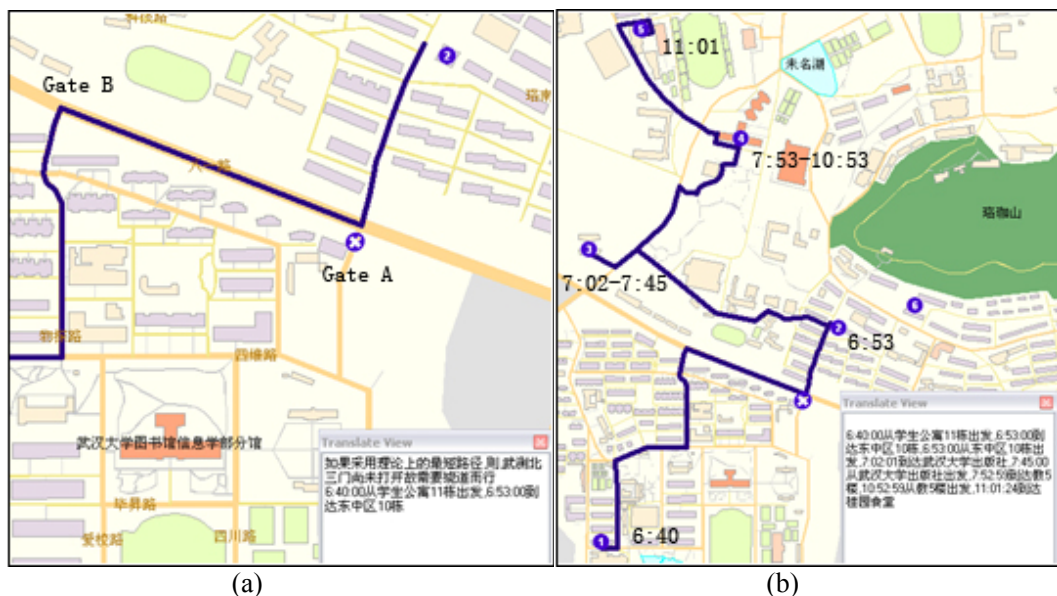

Figure 10 The combination of Path Analysis and time information

Figure 11 (a) shows service-points selection problem under a certain time-limited window. The gray area is simplified as the scope of PPA, and highlight points are the service points satisfying the constraints. The detail time information of each is

provided. Fig. 11(b) shows the solution on the situation about the unreachable mid-points in the path analysis model based on the integration of persons and vehicles. Barriers exist on both sides of the 3rd point, which is unreachable. After the path

analysis model for the integration of persons and vehicles, the 4th point was the best location as a on and off point, so the platform recommends that users get off at the 4th point, walk to

the 3rd point, and get on at the 4th point, drive to next target point。
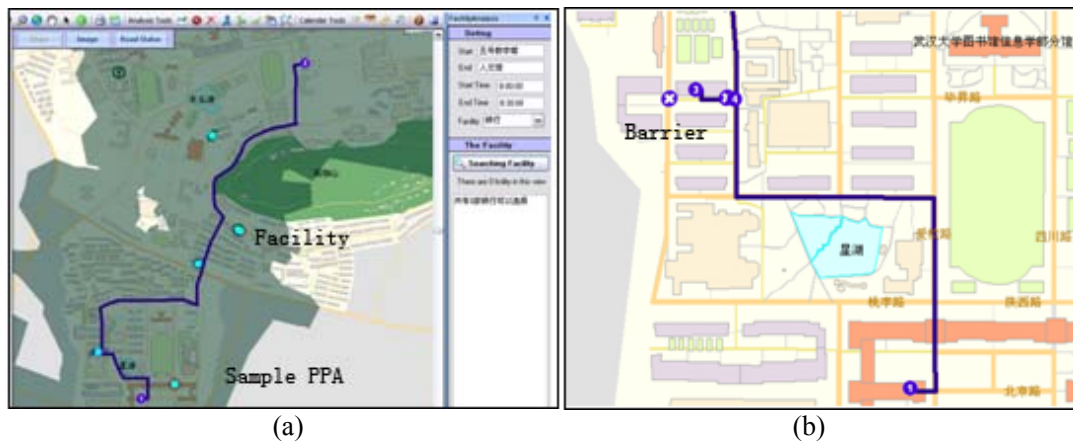

(a)   (b)

Figure 11 Facility Choice under time-limit (Left) and Route analysis model for the integration of people and vehicles (Right)

6. Conclusions

A dynamic route update framework is designed based on Socket and .Net Remoting technology after discussion of dynamic data update in route service, time information and different travel modes. Business hour of service points, open and close time information of gates are added in analysis to extend route service. Selection of proper facility points in a restrained time window is solved by simplifying potential service area in route analysis based on time-space prism concept. Route analysis model based on the integration of persons and vehicles is designed to obtain an optimal route, for which has the problem as existing some points that vehicles cannot reach between the depature point and users' destinations.

The integration of GIS with related subjects and technology may take place with the ongoing research about principles and methodology in dynamic GIS. Web 2.0, cloud computing and grid computing are strong supports of GIS. The dynamic data update method is one of the numerous means, and better results might be gained by a combination of several different ways. With further research of this update framework, perhaps it will be an effective solution of dynamic GIS. To achieve a better solution of persons' requirements in daily life, route service might be further extended in dynamic framework, and dynamic optimized routes and schedules are our ongoing research.

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