WebGIS application based on real-time traffic flow network analysis

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ABSTRACT

Intelligent Transportation System (ITS) is a valid utility to solve the problem of heavy traffic and ensuring safety of traffic and transportation, especially in large city, e.g. Beijing. A WebGIS system functioning to provide real-time road condition information was developed in this paper. In order to ensure the logic and reliability of data management, a uniform GeoDatabase space database was established based on these three factors as below: the difference of travel volume in different time and road, real time dynamic updating traffic database, and the traffic space dataset in Beijing. In this GeoDatabase the right connectivity of multi-layer data was investigated. In the shortest road search routine, some parameters, such as traffic flow and the length of cond path, which may be concerned by many users, were used as weights to determinate an optimal road. The dynamic updating data could be stored in the database in the format of GeoDatabase, the quantitive research to determine the optimal weight coefficient of travel carrying capacity could be available through proper traffic model and real time dynamic updating data. Besides, the final traffic model would be formed considering the length of optimal path. This intelligent transportation WebGIS inquiry system is developed on base of Visual Studio.NET and Arcgis Server platform. The system would publish data through Web server and supply clients with the service to inquire the real time optimal travel path in Beijing.

Keywords: WebGIS, intelligent Transportation System, network analysis

1. INTRODUCTION

Intelligent Transportation System (ITS) is a new direction to solve the problem of heavy traffic and ensuring safety of traffic and transportation(Whittaker, Garside & Lindveld, 1997), especially in large city, e.g. Beijing. Since ITS uses integrated technology(Van Arem, Kirby, Van Der Vlist & Whittaker, 1997), such as traffic control, spatial analysis and artificial intelligence, it will play more important role in the future city traffic management. WebGIS, which is a web-based system to provide spatial-related services, is a useful tool to produce spatial analysis in the application of ITS. A WebGIS system functioning to provide real-time road condition information was developed in this paper. Before the WebGIS is established, in order to ensure the logic and reliability of data management, a uniform GeoDatabase spatial database was established based on these three factors as below(ESRI, 2001): the difference of travel volume in different time and road, real time dynamic updating traffic database, and the traffic space dataset in Beijing. In this GeoDatabase the right connectivity of multi-layer data was investigated. In the shortest road search routine, some parameters, such as traffic flow and the length of cond path, which may be concerned by many users, were used as weights to determinate an optimal road. The dynamic updating data could be stored in the database in the format of GeoDatabase, the quantitive research to determine the optimal weight coefficient of travel carrying capacity could be available through proper traffic model and real time dynamic updating data. Besides, the final traffic model would be formed considering the length of optimal path. This intelligent transportation WebGIS inquiry system is developed on base of Visual Studio.NET and ArcGIS Server platform. The system would publish data through Web server and supply clients with the service to inquire the real time optimal travel path in Beijing.

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2. REAL-TIME TRAFFIC FLOW PREDICTION

The domain of urban traffic is of such complexity that it is impossible to use traditional analytical methods for analysis and control. Modeling and simulation techniques, instead, have shown some success, and they have been gaining popularity in this field, as they allow the analysts to study particular problems using virtual experimentation(Wainer, 2006).

The early efforts in this area used macroscopic models to analyze traffic demand and flows on a traffic network using static parameters (i.e. average of daily traffic or average for peak hours). The goal was to find long-term forecasts that could be used for investments or dimensioning of the traffic net. Microscopic simulations are more recent. They require higher computing power, as they describe both system entities and their interactions at a high level of detail (i.e. a lane change could consider the nearby cars, as well as detailed driver decisions). Nonetheless, they can reproduce the real dynamics of traffic, enabling a modeler to study detailed phenomena as a function of time. Due to the precision of the results they provide, numerous tools for micro-simulation are available, such as HUTSIM, Transims etc(Gabriel, 2007).

In this research, a modeling language was employed to model the traffic flow. This language, called ATLAS (Advanced Traffic Language Specifications), focuses on the detailed specification of traffic behavior from the user's point of view. The language constructions were then mapped into formal constructions using, in this case, the Cell-DEVS and DEVS(Farooq, Wainer & Balya, 2007) formalisms. The output of this model is the traffic flow on the traffic network, so this type of information can be used in the network analysis as a cost weight.

The workflow on the prediction of traffic flow is illustrated as Fig. 1

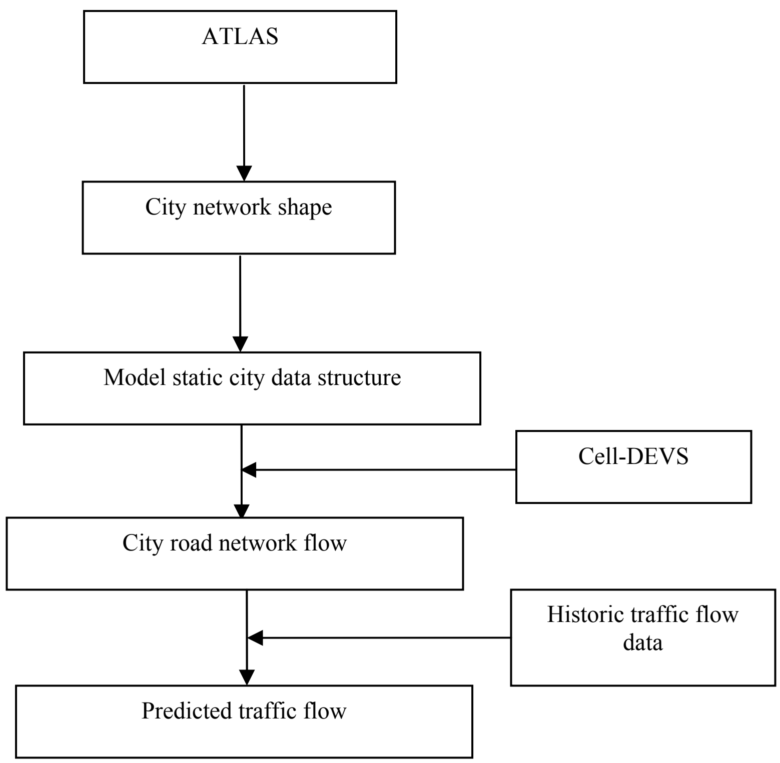

Fig. 1. the work flow to predict city traffic flow.

3. WORKFLOW OF NETWORK ANALYSIS (ESRI, 2001)

3.1 Analysis layer

Network analysis layers are composite layers in ArcMap used to store inputs, parameters, and results of network analysis. A network analysis layer acts as an in-memory workspace for each type of input as well as the result, all of which are stored as in-memory feature classes. The analysis parameters are stored as properties of the analysis layer.

There are four kinds of network analysis layers: Route analysis layer—This layer contains the input network locations (stops and barriers), parameters, and the resultant route or routes of route analysis. Closest facility analysis layer—This layer contains the input network locations (facilities, incidents, and barriers), parameters, and the resultant route or routes of closest facility analysis. Service area analysis layer—This layer contains the input facilities and barriers, parameters, and the resultant service area polygons and service area lines. OD cost matrix analysis layer—This layer contains the input origins and destinations, parameters, and results of OD cost matrix analysis.

3.2 Creating network analysis layers

A network analysis layer is created when you choose a new type of analysis from the ArcGIS Network Analyst menu on the Network Analyst toolbar. The kind of network analysis layer created is based on the type of new network analysis you choose. Each layer represents the various inputs and results that are part of the network analysis layer, and behaves as other feature layers in ArcMap. The layers support labels, joins and relates, symbology, and all other layer properties that are common to feature layers.

3.3 Adding network locations

Network locations are features used as input during network analysis, such as stops and barriers.

Network locations are used as input during network analysis. These include stops, barriers, facilities, incidents, origins, and destinations.

If you have a point in ArcMap that is an origin for a route, a stop (which is a type of network location) is the location on the network that represents that origin. The network location is identified by four fields—SourceID, SourceOID, PosAlong, and SideOfEdge that correspond to a location on a source feature that is in the network dataset. When a network location is added, ArcGIS automatically populates these fields.

A network location (for example, a stop) only references a valid location on the network if its geometry is within the search tolerance of a feature in the network dataset when it was created or moved (or if the four fields were set without using geometry). ArcGIS Network Analyst provides a default search tolerance of 50 units. This search tolerance can be modified to search a smaller or larger area. If no network features are found within the search tolerance, the network location's Status field is set to Unlocated.

There are six kinds of network locations that function as inputs in ArcGIS Network Analysis: stops, barriers, facilities, incidents, origins, and destinations.

Stops are locations between which a route is calculated in a route analysis. You can have more than two stops for which a route can be created that starts at the first stop and ends at the last stop. The intermediary stops are visited en route from the first to the last stop.

Barriers are locations where the analysis should not traverse. Barriers are used in route, closest facility, and service area analyses. Barriers can be used to represent locations where the analysis cannot pass through, for instance, a blocked intersection. You can model road closures or accident sites as barriers if you want the route to avoid that point.

Facilities are locations used in closest facility and service area analyses. In closest facility analysis, you search for the closest set of locations (facilities) from other locations (incidents). In service area analysis, the location for which the service area is being calculated is called the facility.

Incidents are used in closest facility analysis and represent the locations for which the nearest facility is sought.

Origins are locations used in an OD cost matrix as starting stops from where the route costs to destinations are calculated.

Destinations are network locations that are used in an OD cost matrix analysis to generate lines. An OD cost matrix is a table of route costs from origins to destinations.

3.4 Setting analysis parameters

Parameters used for network analysis include the impedance to be used, the restrictions to be obeyed, the U-turn policy, output shape type, accumulation attributes, and parameters for finding network locations. Additionally, each kind of analysis has specific parameters of its own.

3.5 Performing the analysis and displaying the results

Once you have created your analysis layer, added input network locations, and set the parameters for analysis on the Network Analyst toolbar, click the Solve Analysis button to generate the results. These results are part of the network analysis layer. Since the output is a feature layer, it can be symbolized in the same manner as any other feature layer in ArcMap.

The above workflow can be illustrated as Fig. 2.

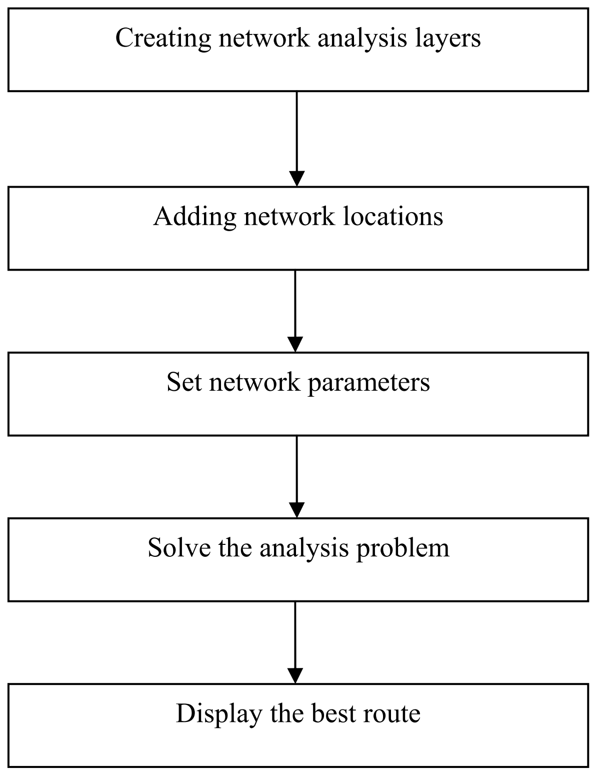

Fig. 2. The workflow of network analysis.

The result of data view after creating network layer is illustrated as Fig. 3.

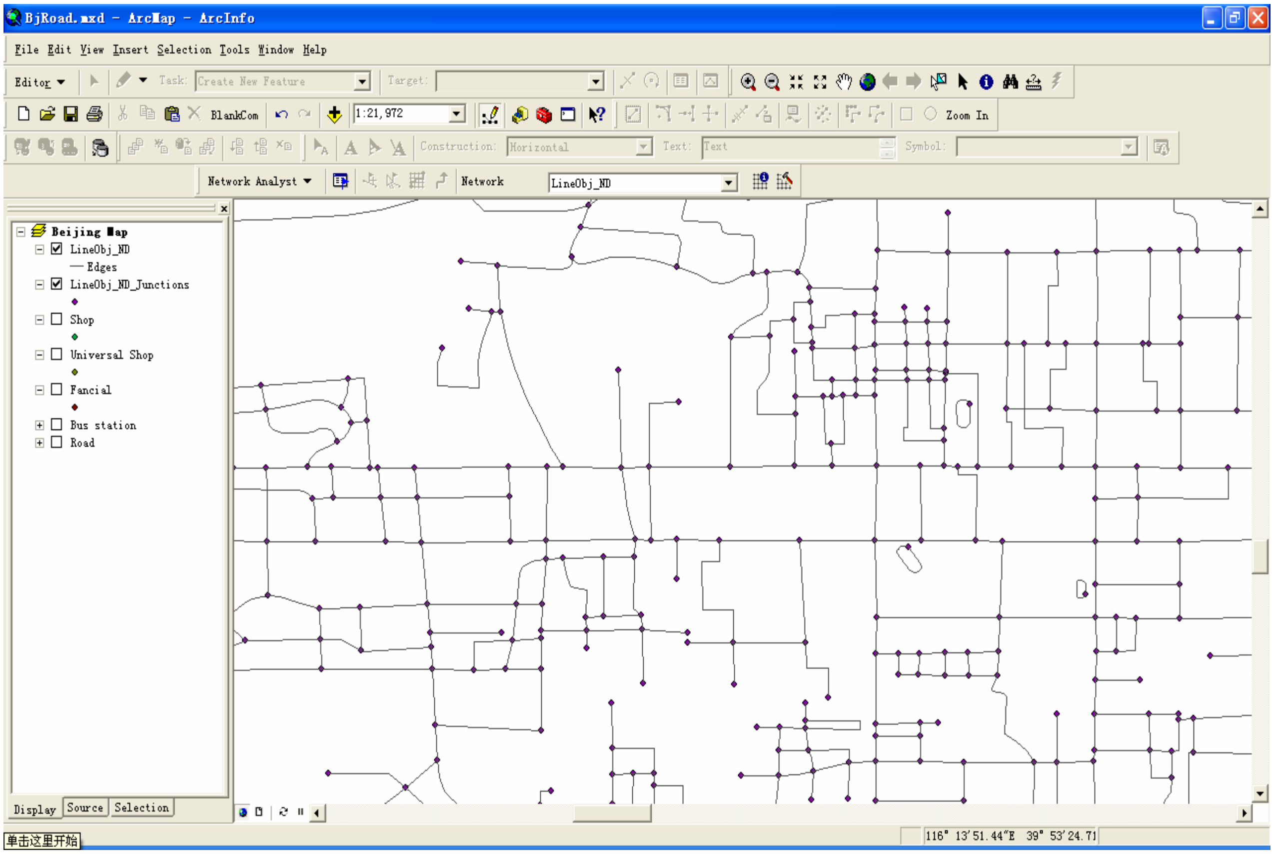

Fig. 3. The data view of network analysis layer.

4. WEBGIS APPLICATION

ArcGIS Server consists of a GIS server and an Application Developer Framework (ADF) for .NET and Java. The Server Object Manager (SOM) and Server Object Container (SOC) are the basic elements to the ArcGIS Server GIS server. The ADFs provide the framework, web controls and convenience classes to build and deploy Web applications and Web services that make use of ArcObjects running in the GIS server.

In this paper, we proposed a framework to publish traffic information to public user on the architecture of ArcGIS Server. In the WebGIS application, user can browse the traffic information of Beijing City with the help of client software, such as Internet Explorer or PDA. Then further information about best route on the condition that the real time traffic flow is considered. All the functions of best route selection are implemented using the network analysis extension module of ArcGIS.

The architecture of the WebGIS is illustrated as Fig. 4.

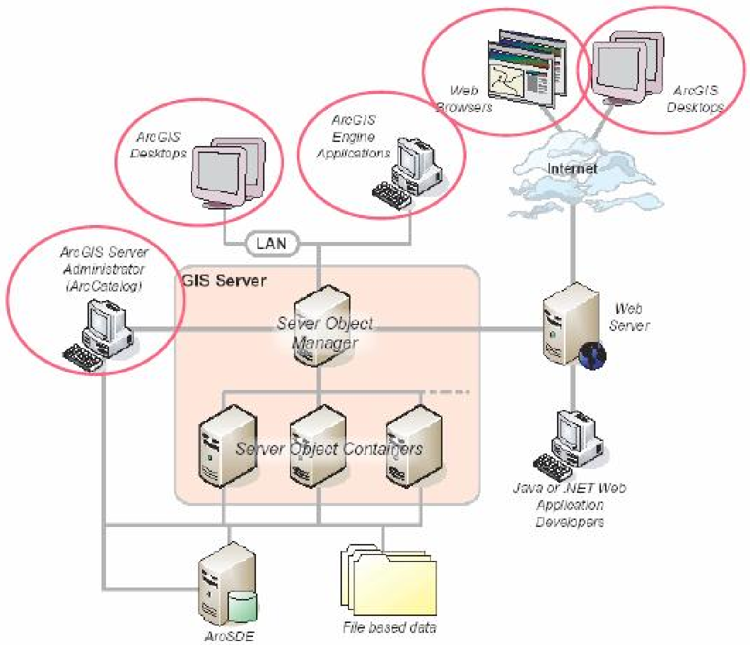

Fig. 4. The architecture of a ArcGIS Server and it WebGIS application.

After the completion of data prepare, then the network dataset can be published as a type GIS resource in the environment of ArcGIS Server. The published result of traffic route selection is illustrated as Fig. 5 and 6.

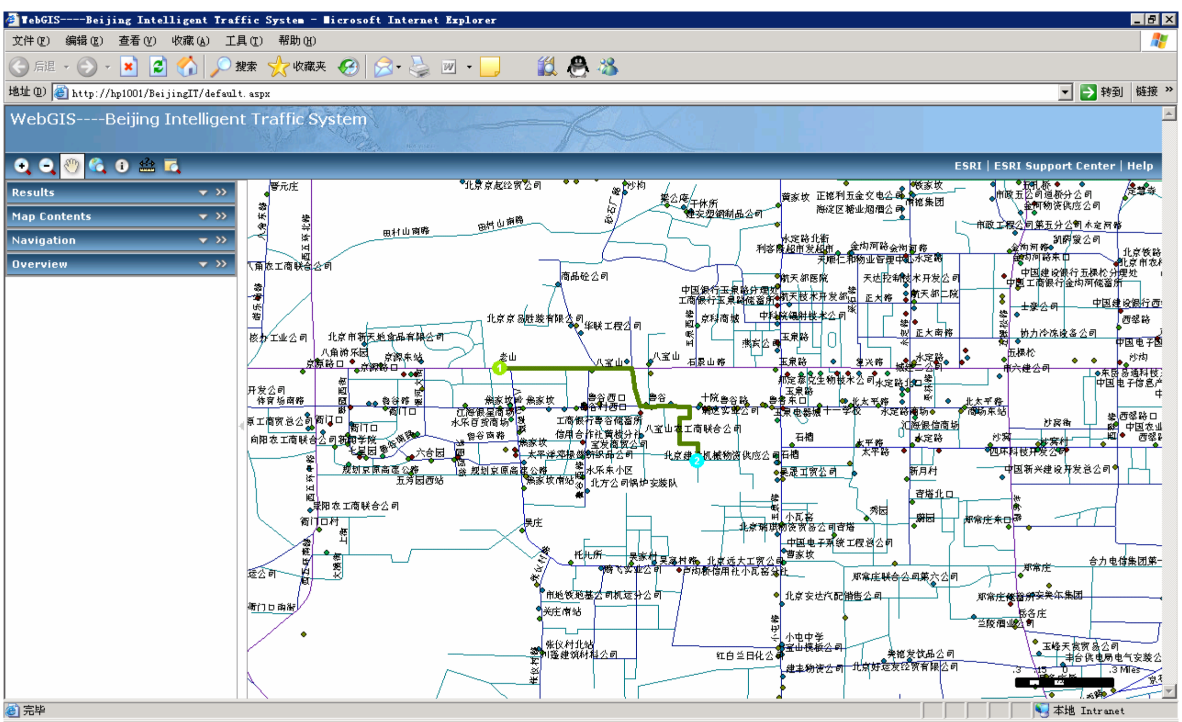

Fig. 5. The result map of route analysis using shape length as weight.

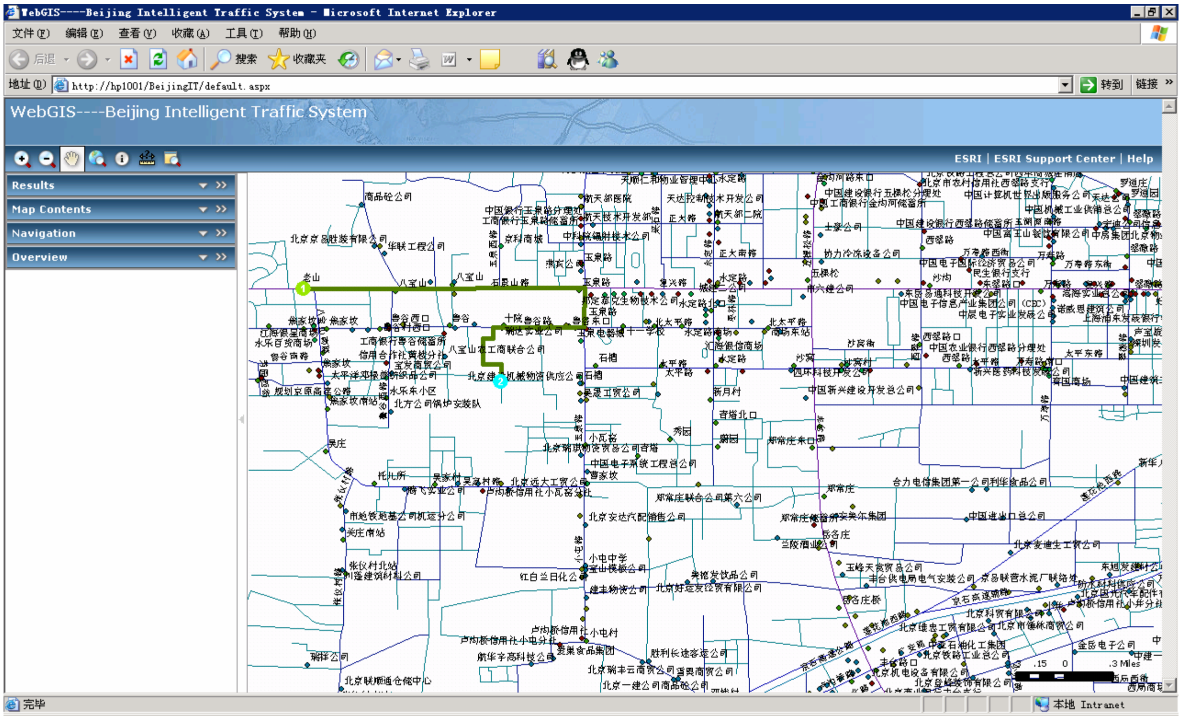

Fig. 6. The result map of route analysis using shape length and traffic flow as weights.

5. REMARKING CONCLUSIONS

In this paper, a traffic flow based route selection method was proposed under the architecture of WebGIS with the support of ArcGIS. In the real traffic prediction, an advanced traffic language named ATLAS was used to model the traffic condition in city. Borrowing this traffic modeling language, it is very easy to produce the traffic flow. And thus the production of ATLAS is used as one of weight of best route selection. So the network analysis result is the integrated result of shape length and the traffic flow. Since it is hard to obtain the real traffic flow data, our proposed method provide a feasible way to consider the real traffic flow in model the a best route selection application.

When the model is completed in the environment of ArcGIS Desktop, then the network dataset containing the information of traffic flow and road distance between starting and ending point can be published under the environment of ArcGIS Server. So the WebGIS application is constructed with the help of ArcGIS Server. When users want to search the best route through the WebGIS application, the input information is the starting point and the current time, which can be easily obtained through the uses login time. Then the best route can be generated and displayed through a general network browser.

In the current research work, only the simply situation was considered when conducting the traffic flow information. In the real world, much more complicated situation, such as the traffic flow influenced by weather or emergency condition will be an import factor to be considered. So in the next research work, more complicated situation will be conducted in the WebGIS application.

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