

DESIGN AND IMPLEMENTATION OF A GIS BASED BICYCLE ROUTING SYSTEM FOR THE WORLD WIDE WEB (WWW)

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ABSTRACT:

Routing systems for motorized vehicles in the internet are well known and widely used. But until recently, there had been no possibility to completely design and individually plan a tourist bicycle tour. This paper describes the conceptual design and implementation of such a bicycle routing system which has been operational since July 2001. Design and implementation of the routing system was done by the Research Center for Geoinformatics and Remote Sensing (FZG) at the University of Vechta in cooperation with the organization 'Verbund Oldenburger Münsterland e.V.'. To achieve the desired goals, a server/client architecture was used which was based on commercial GIS, database system, and internet components. It is planned that in the near future the bicycle routing system 'Fahrradies' will be extended with the data of neighboring tourist regions as well as with new functions. It will also prove necessary to adapt the system to the new developments of the underlying GIS software and emerging internet standards. Other options include the possibility to integrate the routing system with online navigation and positioning data in the field using wireless communication technology.

1. BICYCLE TOURIST REGION 'OLDENBURGER MÜNSTERLAND'

The internet has become a very important medium for communication and provides several ways of using maps and geographic data. Today, maps and data created with Geographic Information systems (GIS) can easily be published on the WWW. Geographic data are a necessary database especially for routing systems which are well known and widely used for motorized vehicles. In contrast to these, the "Fahrradies" is a routing system, which allows the complete design and individual planning of a bicycle route through the tourist region "Oldenburger Münsterland" in Lower Saxony (Northwest of Germany). With little differences in altitude, the area is perfectly suited for people of all ages to go bicycling and has an extensive network of marked bike paths. The organization 'Verbund Oldenburger Münsterland e.V.' is in charge of the regional marketing (culture, tourism, and economy) for the region which is formed by the two counties of Vechta and Cloppenburg. Having used the internet for marketing for several years, the Verbund Oldenburger Münsterland has now expanded its homepage with the bicycle routing system 'Fahrradies' (mixture of the German words 'Paradies' and 'Fahrrad'; engl. paradise/bicycle) for bicyclists interested in touring the region.

2. ARCHITECTURE OF THE 'FAHRRADIES'

Design and implementation of the routing system was done by the Research Center for Geoinformatics and Remote Sensing (FZG) at the University of Vechta. To implement this, a server-side architecture was used which was based on commercial GIS, database system and internet components (Schneeweiss, 2001). The server provides GIS applications and a graphical web user interface based on HTML forms which are enhanced by JavaScript. The software basis for the application is formed by the desktop GIS ArcView 3.2 with the extension Network

Analyst and the ArcView Internet Map Server (IMS). As the source for the necessary stops, the entries from the existing data sets (lists of hosts, list of sights and recreational facilities) in MS Access format are used. These entries are transformed into HTML format and incorporated into the server architecture. The client (= user) accesses the bicycle routing system through a standard internet browser such as Netscape or MS Internet Explorer. The communication is facilitated through HTML forms and JPEG graphics. The GIS based routing analysis, however, is done in vector mode, the results are displayed as raster graphics for standardized communication (Kraak, 2001). The bicycle paths network marked in the analog maps serve as the source for the digital lines. All calculations are performed on the server, the results are transformed into HTML pages and sent to the client. Consequently, there is no need for the internet user to have a GIS installed at his computer.

In contrast to the inflexible way of using an analog map, the user has the possibility to form his own route, with thematic routes and selectable stops (points) taken as a basis. An interactive map and extensive information on sights, recreational and accommodation facilities give the user the possibility to plan an individual bicycle tour. But the "Fahrradies" does not only provide an easy-to-use planning tool, it is also free of charge and available at all times through the World Wide Web. It can be accessed through the homepage of the 'Oldenburger Münsterland' (<http://www.oldenburger-muensterland.de/>) or directly through the homepage which is maintained by the FZG (<http://www.fahrradies.net>). To keep the system up-to-date, it is maintained at a central place using a dedicated server. For better performance, the 'Fahrradies' will be upgraded using a second dedicated server system for data storage.

This bicycle-routing-system is now being newly implemented from a previous version to improve its performance and graphical representation and to extend the functionality. The

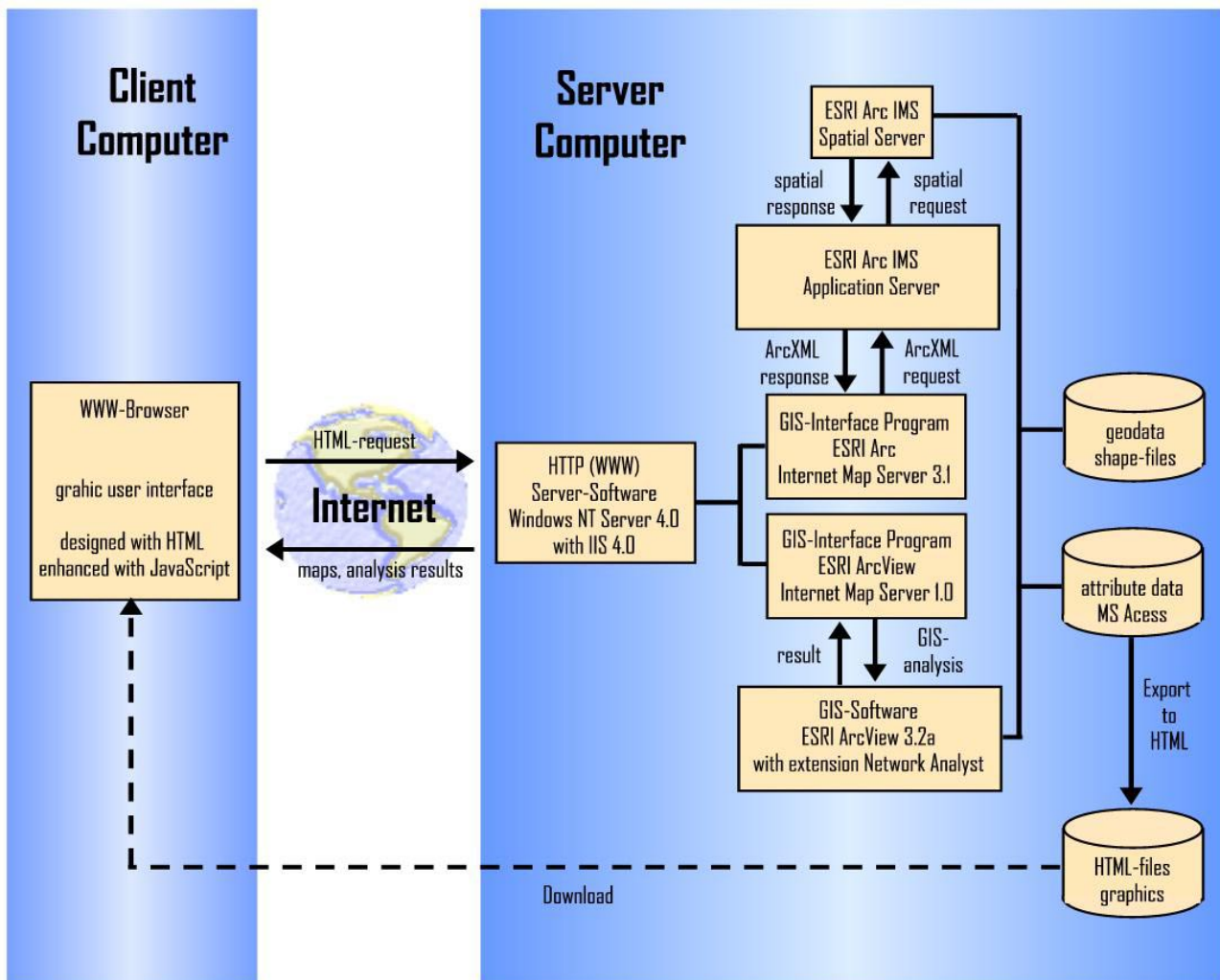


Figure 1. The system architecture of the “Fahrradies”

new system is based on the Arc Internet Map Server (ArcIMS), a software provided by the Environmental Systems Research Institute Inc. (ESRI) for publishing maps on the web. Yet as there is no routing functionality available with ArcIMS at this moment, these functions are taken from the extension Network Analyst via ESRI’s Desktop-GIS ArcView.

The “Fahrradies” consists of a GIS-Application based on the above mentioned software on the server-side and a graphical web user interface based on HTML and JavaScript on the client-side (Fleming, 1998). The architecture of the GIS application consists of three main components: the WebServer, the Application Server and the Spatial Server. The Application Server handles the incoming requests and hands it off to the appropriate Spatial Server, which is the backbone of ArcIMS. It processes the requests for maps and related information, e.g. creates cartographic map image files or streams map features.

Communication between the client and the server is based on requests and responses written in ArcXML. A JavaScript function writes the appropriate ArcXML request which is then sent to the server. The request is then passed via JavaScript on to a frame where it updates a form input value. This form is submitted to the Application Server, which redirects it to the Servlet Connector. The Servlet Connector extracts the submitted

values and the request is streamed on to the appropriate ArcIMS Spatial Server. The ArcXML response from the ArcIMS Spatial Server is sent back to the Servlet Connector. The response, dynamically created HTML-code is written back to the frame which posted the original request. With the help of an appropriate JavaScript function the response is then further processed as needed (Marshall, 2001).

The custom bicycle route is calculated with the help of ArcView Internet Map Server. In this case there are no ArcXML requests involved but the values of an HTML form posted to ArcView IMS (esrimap.dll). The Internet Map Server then sends the request to the GIS ArcView which executes the appropriate Avenue script. The result is streamed back to the client in form of HTML code. This consists of a form with information about the extent of the requested bicycle route and the name of the created route shapefile. An ArcXML request then adds this bicycle route shapefile as acetate layer to the main map. This way, only the calculation of the route is run by ArcView/Avenue scripts. Everything else, e.g. the graphic presentation of the route, is processed via ArcXML requests by ArcIMS.

3. FUNCTIONALITY

The key features of the „Fahrradies“ include display and query functionality, search for route templates, and calculation of individual biking routes with different routing functions (Jung and Schneeweiss, 2001).

The “Fahrradies” includes a comprehensive set of map navigation tools (e.g. pan, zoom). It also contains a query tool which can be used to get information about a specific location or vice versa to get the location for a specific stop. An advantage of the newly implemented “Fahrradies” application in comparison with the previous version is the overview map, which helps the user to still orient himself while he zooms into the main map. In addition to that, there is an assistant designed for inexperienced users. This assistant guides the user through the application to help him and to avoid mistakes. The “Fahrradies” furthermore also offers comprehensive help which explains each button of the system. Moreover, the user has the opportunity to select one of many “ready-made” bicycle routes which are based on the marked bicycle network of the region.

For every single of these so called route templates textual information as well as an overview map are provided.

The biggest difference to other routing systems is the ability for the user to design a completely individual route: It’s possible to change the route templates by adding stops or to select stops for an individual route. For this, there are lists with possible stops, sorted by the categories hosts, sights, recreational facilities, and the towns of the region. For each stop, specific map and addresses or background information is available. Besides, the user can get information about one stop by clicking on its symbol in the main map. After choosing stops from the lists a starting point has to be set for the routing calculation. Then the following calculation process starts and the resulting bicycle route is shown in the main map. After the calculation of a route, more tools are made available to the user. These tools are associated with the route in such a way that he can get a route description which lists all chosen stops in a HTML page. Moreover, the distances between the stops and directions to them are listed and this HTML page can be printed out and taken to the field.

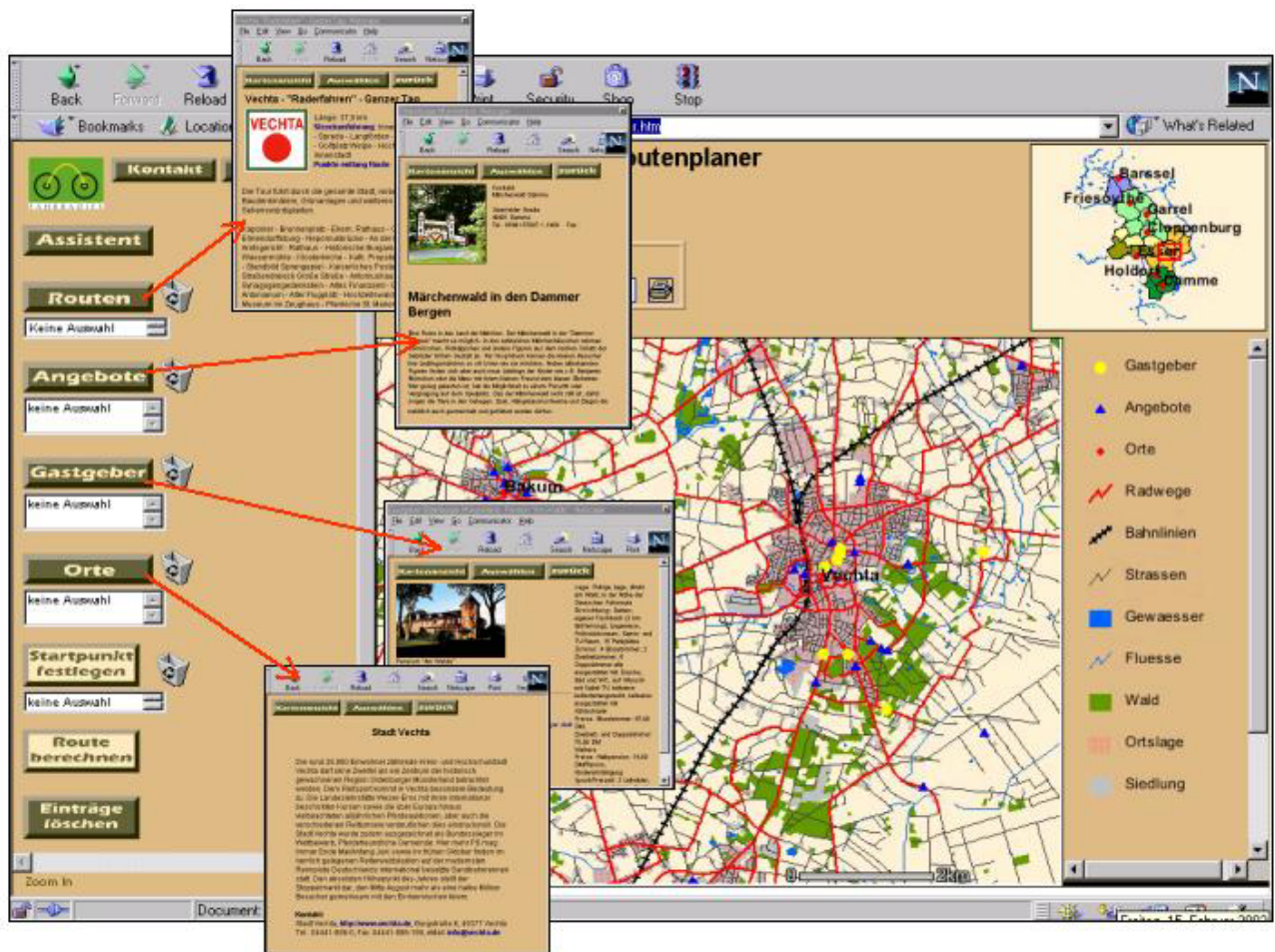


Figure 2. Information about the different stops, sorted by category.

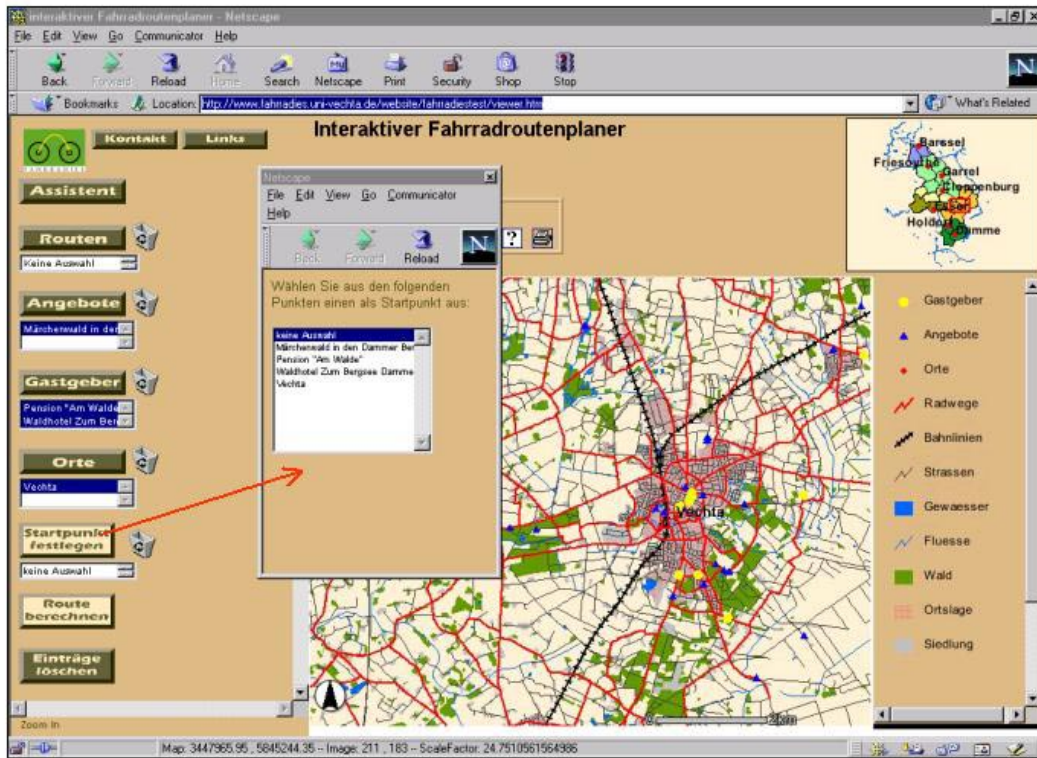


Figure 3. The chosen stops appear in the small lists in the user interface. One of them has to be set to starting point.

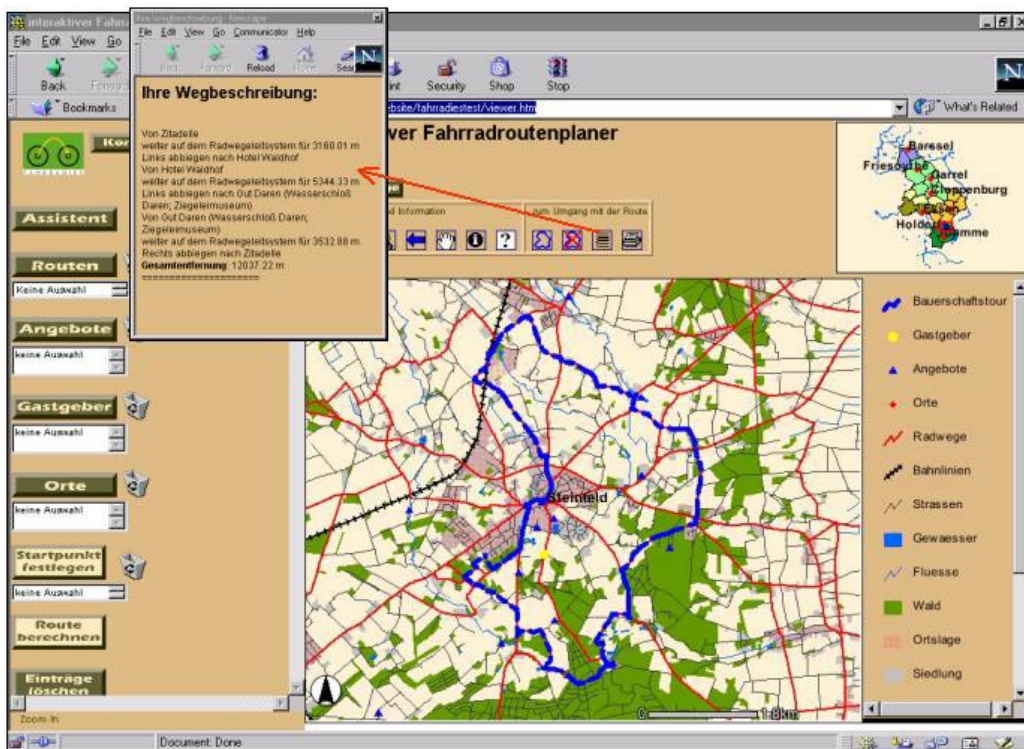


Figure 4. The individual bicycle route shown in the main map. A route description is available as well.

In addition, a print function for the main map exists. The user can choose between printing tiles of the map in the scale of 1:75000, printing the actual display or an overview map of the whole route.

Also, a function is provided for the user to get all stops along the route within a selected radius. It is possible to use these stops to customize a route as well.

4. FUTURE PERSPECTIVES

Currently, only one possible bicycle route can be calculated for the selected stops. The calculated route is always a roundtrip. However, more route functions are planned for the future.

A function will be implemented to let the user choose between a oneway and a roundtrip tour. Also, there will be a possibility to not only select the start but also the end point. Another function will let the user set the start and end point and choose one or more categories of sights, e.g. a recreational sight or a hotel. The system will calculate and suggest the possible routes and the user can select one of them. It is possible to extend this function by setting the duration in hours or the length of the tour in kilometres. For this an average speed has to be assumed.

In addition, it is planned to make the “Fahrradies” available for use with wireless devices. The user will be equipped with a GPS, a handheld computer with a built-in cellular phone for wireless internet access that make real time navigation and tour information possible. For many tourist areas, the necessary bicycle paths are already in digital format or can be easily annotated using analog bike maps. As a picture for the future the “Fahrradies” might be available as a “bikeheld navigator”. With this, it resembles the ones for motorized vehicles which can be used as a wireless application and which display the chosen route on a handheld display depending on the actual location.

In conclusion, it would be desirable to extend the area covered by the “Fahrradies“ application to the other parts of Germany, so that the bicycle routes do not stop at administrative boundaries. This means, however, that adjacent tourist regions have to work more closely together. This might be difficult due to competition between these regions.

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