Guiding Travellers by a Mobile Information System for Public Transportation

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In the last few years many efforts have been taken to guide car drivers. Sophisticated route planning algorithms have been developed which operate on detailed geographic data to select appropriate routes. These are presented together with various points of interest. Under way the driver is guided by the Global Positioning System (GPS) which helps to stay on the preplanned route.

However, when drivers leave their car, e.g. at a park-and-ride place, to go to the city center, no information system is at their disposal. The same is true for travellers arriving by train at a station. As it seems tedious to figure out how to reach the destination by means of public transport, travellers tend to use a taxi instead. This, however, increases the overall cost of the journey and often enough leads to the decision of using one´s own car for the whole journey in order to reduce costs. To avoid this and also to enable the car driver to stay at the P+R place on the outskirts, a mobile system is required which provides information about the public transportation system (trams, buses, underground trains but also places for taxi drivers). This system should „know“ where the user is located and guide him or her to the nearest station. The user should be able to specify where he or she wants to go, ideally by simply typing an address or pointing into a map. Moreover, the system should help the traveller to estimate the time needed to arrive at a certain destination.

We demonstrate a first prototype which provides this kind of support. Two scenarios are under investigation: the pre-journey planning on a (usual) PC yielding a hardcopy with the crucial information about the route selected and the mobile use with a PDA and an optional GPS receiver for positioning information.

Our work is based on the experience gained within the MoBIC project supported by the European Union (Mobility of Blind and Elderly people Interacting with Computers, see PETRIE *et al.* [1996] and STROTHOTTE *et al.* [1996]). With the MoBIC prototype, blind users can plan and explore a route and are guided outdoors by means of GPS signals. The work presented here is targeted on sighted travellers, therefore visualization instead of acoustic signals plays a dominant role. Although the walking to a stop or from a stop to the destination is considered the most important part of our work is information about the public transport system itself.

Author and traveller mode. Our system is designed for two user groups resulting in two modes of operation:

- The first is the company which provides public transportation facilities. These users should be supported in editing the information about the public transportation system. Such information is subject to changes; station names may alter, lines are changed or extended and the timetable changes frequently. Therefore, it is required that this information can easily be modified. We refer to this kind of operation as the *author mode*.
- The second kind of user is the traveller, be it a tourist or a business man, who actually uses the information system. This kind of operation is called *traveller mode*.

Providing information about the public transportation system. For our prototype, geographic data of the city Magdeburg were enriched with information about the public transport system. A dedicated editor for the author mode was developed to edit this information in the context of the street information as available in geographic data. This task is carried out with a usual PC (with a large display).

Searching for information and exploring the public transportation system. In the traveller mode, which is in the focus of our investigations, the following interaction and navigation tasks must be supported:

- Generation of an initial visualization as base for interaction,
- Search of a route,
- Estimate of the required time,
- Guidance from a station to a specified street address,
- Guidance from the current position or another user-specified position to a stop, and
- Exploration of the public transportation system.

The rest of this description is structured according to these tasks.

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[1] While this work has been carried out the first author worked at the University of Magdeburg.

Generation of an initial visualization. The generation of an initial visualization should be oriented on the way manual plans are realized. We investigated plans from smaller cities to large regions (like the Main region with Frankfurt) to find out how lines of public transport are depicted, how stops are labelled, which legends are in use and which additional information is available. It turns out that the visualization must be carefully adapted to the overall amount of information. In some cities it is infeasible to present all lines, instead, trams and busses are omitted, while only underground and city trains are depicted. As a consequence, only the most important lines can be depicted in an initial visualization. Different colors are used for different lines which are reflected in a legend which contains all lines with their start and end point.

When labelling the stations, starting points, crossing stations and terminals are often emphasized. Intermediate stops are often not labelled, small circles, however, indicate the number of stops. Figure 1 shows an initial visualization generated by our prototype. Besides the information about the inner city public transport some kind of contextual information seems to be necessary: The position of train stops and P+R places, the shape and position of rivers and important sights, like cathedrals – in particular for the touristic traveller.

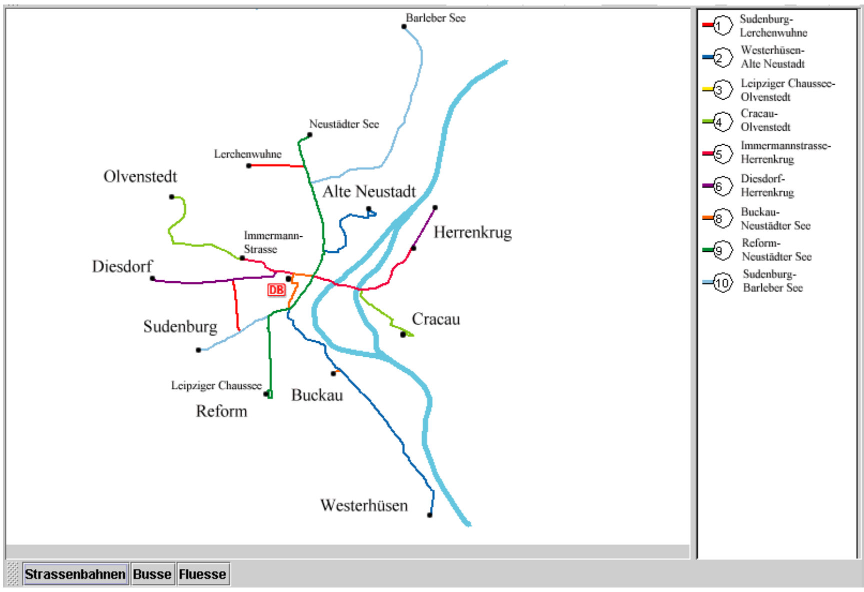

Figure 1: Visualization of lines with labels of the essential stops and together with an interactive legend. For better orientation, the river which subdivides Magdeburg is also included.

Our visualization differs in one important point: it is based on exact geographic data. The polygons which represent the lines are not drawn in as much detail as possible. Instead, algorithms for the simplification of polygons (in particular a variant of the Douglas-Peucker algorithm, see DOUGLAS and PEUCKER [1973] for the original algorithm and MACMASTER [1987] for a discussion of the properties of the arising visualizations) are employed to adapt the presentation to the available screen space. Not only is the appearance of the lines adapted but also the inclusion of labels.

Estimate of the travel time. An important question for travellers is: If I arrive at the station at a certain time, will I arrive at the final destination in time? In other words: How long does it take to get to the destination? As most public transportation systems rely on a fixed frequency (which may alter in the night and on weekends) it is not necessary to include the complete timetable in the system. We employ the frequency (every 10 minutes) and the time it takes to move along the stops of a line. Thus we can estimate the required time (between 30 and 40 minutes using a best case and a worst case calculation) which is often precise enough for the traveller.

Search of a route. A route can be specified by typing the starting and end point. As the keyboard of a PDA with its small keys is not convenient to use, we have incorporated an auto-complete function to reduce keyboard use. This feature is also useful for the PC version to allow the user to specify names he does not in their entirety. In the current version only the names of stops can be selected. The incorporation of arbitrary street addresses is left open. In this case, an appropriate stop in the vicinity must be selected. This is not as simple as it may seem at first glance. The nearest stop might lead to a connection where the traveller has to change several times while from another station nearby the destination can be reached without a change. This problem is similar to the route-finding problem in train information systems where longer connections may come out faster than the shortest way. Moreover one station might belong to a line which runs much more frequently than another line nearby, so that the selection of the infrequent line increases overall travel time.

For the presentation of the selected route it is crucial to combine a compact textual description and a dedicated visualization. The textual description includes the name of the line to use and the direction in which it goes, the points where the traveller has to change. It seems useful to include the names of the stops immediately before the one where the user actually gets out. The following example shall clarify this.

> „Take the tram number 5 (direction Messegelände) or tram number 4 (direction Cracau) from the station to Alleecenter (2 stops), change to tram number 10 (direction Lake Barleber), get out after 6 stops at street Kastanienstraße after place Nikolaiplatz."

Guidance from a station to a specified street address and from a user-specified position to a stop. For these tasks which have not been realized yet, geographic data and information about the public transport system must be integrated. For this purpose the „right" tile of geographic data has to be selected and displayed with the route clearly emphasized. This task is similar to the author mode interaction of editing this information. However, certain routes must be emphasized and the peculiarities of the small display must be considered.

Exploration of the public transport system. As in many other information systems, users do not only search for very precise information but also tend to browse in order to become familiar with an information space. As usual in GIS, exploring maps is supported by panning-and-zooming. Moreover, users can move lenses about the visualization which lead to the display of more precise information in this region, in particular labels are displayed. This interaction follows the fisheye paradigm (FURNAS [1986]) which means that the level of detail is adapted to the user's interest to enable him or her to concentrate on parts of a visualization (see Figure 2).

Legends, which are static descriptions in paper plans, are used for exploration. The selection of a line in the legend is used to selectively include or omit the line in the visualization. Moreover, detailed information about a line is presented in a separate window if a line is selected and included in the visualization.

Implementation. Our system - the mobile version and the desktop version – are realized in Java 1.1. We have experimented with a Windows CE-based PDA by Hewlett Packard with 16 Mbytes of main memory and a 5-inch color display with 640×240 pixels. This environment allows to run our prototype, however at slow display rates (it takes 4 seconds to update the map visualization). With better Java run time environments, however, we expect that the use of the mobile system will become feasible in the near future.

Figure 2: The PDA from Hewlett Packard with the information system. Lenses are used to explore the map visualization, left: the initial visualization, right: user-controlled lenses

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