LBS for real-time navigation: a scenario

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Abstract
Location based services are hot. The telecom industries need attractive applications to sell their next generation network appliances; geographic data providers anticipate a public market for their data; and marketing promises ubiquitous guidance to specified or recommended places. The vision is as fascinating as the service is complex. We argue that such a service is graded based on the benefits it yields for the user. Hence, we show the complexity of a beneficial navigation service in a traveler's scenario. We feel that basic research is needed in several directions.

A traveler's scenario: Public transport

Imagine you just touched down at an airport of an unfamiliar city, let us say, Vienna. You have arranged to stay at the *Hotel Sacher*, one of Vienna's most famous hotels. It is located downtown, close to *Stephansdom* (St. Stephen's Cathedral) and a number of art and music hall buildings such as the *Hofburg* (Emperor's Castle), the *Staatsoper* (Opera House), and the *Musikverein*. The hotel is also famous for its restaurant and pastry shop. However, you are at *Schwechat Airport*, still far from the pastries. How to manage best to find the way from the airport to the hotel, having only a general idea of the location? Your tourist guide recommends using the public transport network, so you decide to try to find your way to the hotel on your own without taking a taxi.

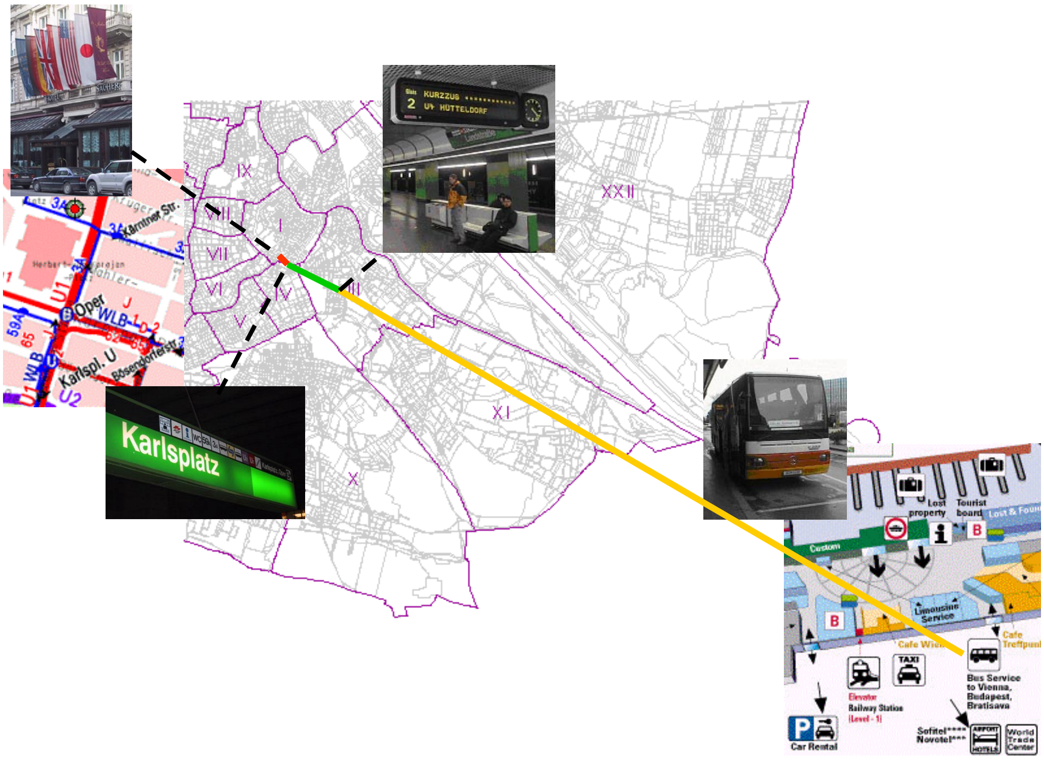

Figure 1: Finding the way from Schwechat Airport (Vienna) to Hotel Sacher. The colors of the route refer to the modes of transport: by bus, by underground, and on foot.

So while you are picking up your suitcase at the baggage claim you …

Traditionally:

… look for signs in order to find out about the transportation modes available from the airport. You can also consult the info desk if manned. It is scheduled to stay open around the clock, but due to lack of personnel at this time, you arbitrarily select the bus as the means of transport.

You need to identify the desired bus destination, as there is more than one option. After thinking, looking at a map, and consulting others, you come to the conclusion that you should take the bus for the *City Air Terminal* and you should ignore the buses to the *Westbahnhof*. Following the signs for the bus, you find the bus stop. The bus is there and you ask the bus driver about the ticket you need in

With a navigation service:

… dial in to your personal navigation service, which remembers that you have reserved at the *Sacher*. The service has also learned from your previous travels that you prefer the adventure of public transport.

It recommends taking the Vienna Airport Lines bus to *City Air Terminal*, following the yellow signs in the hall, and hurrying a little for you do not want to wait for another half hour.

You accept; the service arranges a ticket order to ride the bus. In Vienna, tickets can be purchased from vending machines, tobacco stores, or from the bus driver. In each case, you need Austrian Schillings. And you do have them! You pay for a bus ticket. Now you can relax for a little while as this bus (you still hope it is the right one) goes directly to its destination without intermediate stops.

Leaving the bus, you have to find out that you need to take the metro now. You follow the signs to the adjacent metro station. (Metro stations in Vienna are designated by the letter "U". In other places of the world, this may not be the case. For example, in the USA "M" stands for metro stops.) You enter the metro station and identify the line, the direction, potential transfers, and exit stops. By looking at the map or after asking a fellow passenger, you conclude that you should take the green line towards *Hütteldorf* and exit at *Karlsplatz*, and you should ignore the orange line. The bus ticket you bought earlier in the bus is no longer valid, so you should not forget to buy a metro ticket. Tickets here are only available at vending machines.

You walk to the right platform for entering the metro. In the metro car, you have your ears wide open to pay attention to the loudspeaker announcements where the name of the metro station *Karlsplatz* is mentioned. So you exit the metro car at *Karlsplatz*. Based on your general knowledge about the destination you suspect at this point, that you are in the vicinity of the *Hotel Sacher*.

and displays the necessary information for the bus driver when entering the bus.

The service tells you that the bus is directly going to the *City Air Terminal*, and that you should take the metro there, following the big blue "U" signs. The green line metro train is bound to *Hütteldorf*, and you will take it for two stops to *Karlsplatz*.

The service arranges for a ticket again and holds it for showing. You are guided to the metro line and before arrival reminded to leave at the next station.

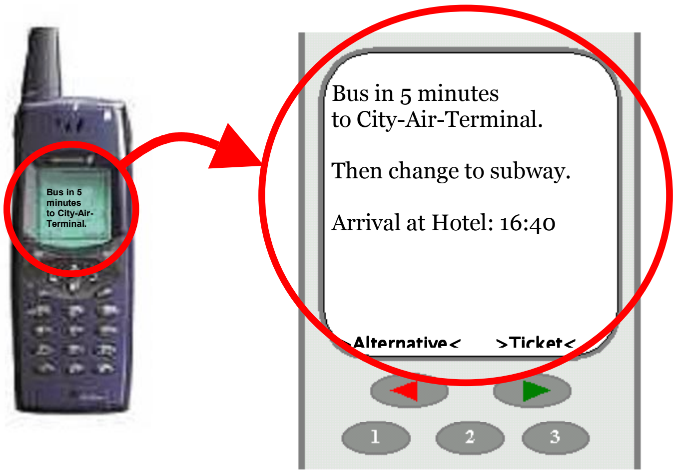

Figure 2: Information on modes of transport through WAP service.

The Next Step: Pedestrian Navigation

When arriving at the underground station *Karlsplatz* you have almost done all the way-finding, being only 200m away from your destination, the *Sacher*. However, the underground station consists of a complex network of paths and passages, connecting three underground lines with buses, trams, and exits close to many attractions. The exits are labeled as *Karlsplatz/Oper* in one direction, and *Resselpark* in the other direction. In a station like *Karlsplatz*, where it can take someone 10-15 min to cross from one end to another, a mobile navigation service can offer significant benefit for the user: which exit from the platform should you take? Where is North, to have an idea for orienting the city map? Which strategy is better: finding the shortest way out and looking around, or following the underground passages to circumvent the traffic on the streets?
The mobile navigation service is already prepared: it locates your position calling the GSM based tracking service. The new mode of traveling, i.e., walking, requires a more detailed dataset with a granularity down to signs on the walls. Hence the navigation service switches from the public transport database to a pedestrian navigation database of downtown Vienna. Then it asks for the most convenient route for you. The called route service adapts its parameters to your requirements, provided by the profile known to the navigation service: you might be interested in tourist attractions, but, carrying a suitcase at the moment, you may prefer the shortest path.

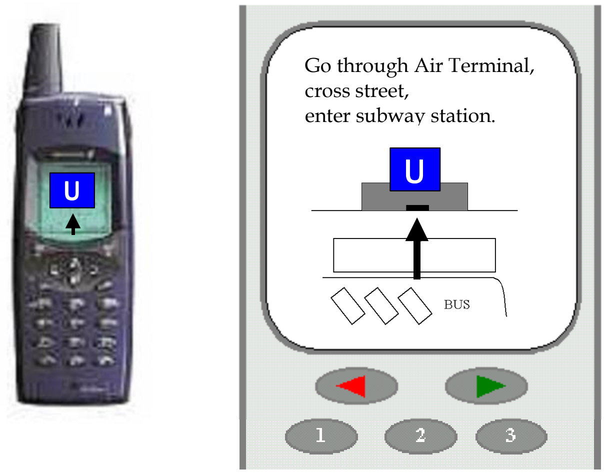

Figure 3: Information on how to go from the City-Air-Terminal to the subway station.

The route returned is a bare list of segments and nodes: the navigation service attaches additional data from the pedestrian database, re-partitions the route by decision points – points where a selection has to be made, or your direction changes – and constructs instructions for every decision point. The instructions will also be processed considering your needs: you speak English and prefer tourist information along the way. The landmarks used in the instructions need to be selected carefully: they need to be visible from your position, eye-catching, and related to the required action. Furthermore, due to dynamic changes in the urban environment, the selection of stable landmarks is recommended. For example, the Opera House has been there for about 120 years, but the sign *Oper* in the passage may change or move during the next refurbishment.

The service prepares a route and contacts you both by voice and text recommending that you take the exit *Oper* and follow the signs through the underground passages. On the way, you may reassure yourself by pressing a button: the actual location will be determined on-the-fly, matched with a position on the route, and an interpolated instruction will be presented. Additionally, the navigation service tracks you: at decision points the next instruction will be sent, and the selected route must be updated in case you leave it[1].

Your expedition was worth it. The navigation service converted you from being novice into an experienced traveler. Not only did you reach your destination in a relaxed manner, but you also enjoyed the gain in time that would have been lost while asking, waiting, looking at the map, and recovering errors. You can now have a piece of the world famous Sacher Torte and a Viennese coffee as a reward!

[1] At the Institute for Geoinformation of TU Vienna, we have experimented with the usability of different route descriptions for mobile services, and off-line versions of a navigation service are available. For both Web and WAP based guidance see http://gi13.geoinfo.tuwien.ac.at.

Research in location based services is still needed

The raise of location based services, such as the one shown in our scenario, has led to the definition of a new discipline of TeleGeoProcessing, which can be defined as a merging of GIS and telecommunications to support decision-making (Laurini 2000). One of the important new challenges in this area is the focus on real-time information. Although companies put different real-time wireless navigation services on the market day by day, many of these services work inefficiently and are difficult to use: Cognitive aspects of real-time spatial decision-making, people's information needs, and data quality aspects are often neglected. Changes in technology happen so fast that research on critical issues is lagging behind. Research in GI Science such as human spatial cognition, user interface design, data quality, and spatial analysis, concerning important aspects of TeleGeoProcessing, is needed to facilitate user interaction with real-time navigation services.

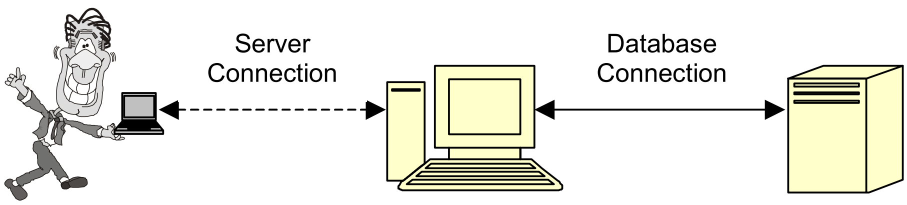

Figure 4: Simplified setup of a real-time navigation service (the broken line represents a wireless connection between client device and server).

The components of a real-time navigation service, i.e., user, client device, server, and database (Figure 4), should fulfill different constraints in order to work efficiently as a whole system. Human spatial cognition and wayfinding are the basis for assigning individual users to user groups. They are both done according to people's personal abilities, tasks, path selection preferences, and information needs. Presentation of information to the user is limited by the capabilities of the client device, i.e., screen size and resolution. Based on rules from generalization and visualization, digital cartography needs to offer alternatives to map modes of communication, e.g., sketches, symbols, or verbal instructions. Issues of data quality are even more complex to handle because contrary to many other GIS applications, real-time navigation services deal with dynamic spatial data, a continuously changing real world, and moving clients. Quality constraints concern both user data (attribute and semantic accuracy of user profile data, resolution of task description, positional accuracy of user localization) and the underlying cartographic data (completeness and currency, as well as positional and attribute accuracy of the represented objects). Dynamic spatial analysis is needed to develop algorithms for real-time calculation of different paths, including user tracking, path corrections, and error adjustment computations.

The traveler's scenario presented in this article shows the need for more research in GI Science regarding aspects of real-time spatial decision-making. Consideration of research results during the design process of real-time navigation services will help to create services that better match users' needs and can therefore be more efficiently used.

References

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