A new dimension for navigation services

By combining the growing amount of user generated geo-content, 3D visualizations and open standards, new vistas can be opened up for mobile navigation services. The possibilities are there, now it is time to integrate these resources into innovative mobile products. This convergence of 3D, mobile and Web2.0 approaches is the first sign that the dream of Ubiquitous GI Services (UbiGIS) finally materializes.

When regarding "openness" in the context of mobile navigation services, there are a few technologies and institutions one cannot get around. Especially the *Open Geospatial Consortium (OGC)* specifies standards for the interoperable management, processing and visualization of spatial data. For those standards we nowadays have both very usable and stable open source libraries as well as commercial products. By combining and enhancing these, innovative new concepts and solutions can be achieved also in the domain of Location Based Services (LBS).

Standards for mobile navigation

The most relevant OGC standard with respect to LBS is the *OpenGIS Location Services* specification, a series of implementation specifications for originally five core services:

- *Directory Service*
- *Gateway Service*
- *Location Utility Service*
- *Presentation Service*
- *Route Service*

While the Utility Service (GeoCoder and Reverse GeoCoder) is moving to the OGC mass market initiative, only recently a sixth service – the Tracking Service – has been defined, that opens the way for a wealth of new interesting LBS applications.

A further draft specification - the *Navigation Service* - has been in discussion since long. In the forthcoming version 1.3 of the OpenLS specification it is planned to add it as an enhancement of the *Route Service*.

Most of these OpenLS core services have been implemented by us and shall be made open source soon. Several enhanced versions of the route service have been applied as spin-offs in a number of scenarios:

- *Emergency Route Service* (ERS) – The ERS is a special OpenLS Route Service, that considers specified areas to be avoided (e.g. flooded or blocked roads, landslides, poisoned areas) while calculating the requested route. (Neis et al. 2007).

- *Accessibility Analysis Service* (AAS) – This is a service that calculates a polygon around a certain start location (e.g.: city, point of interest, address). That polygon represents the area that that is reachable from the start location within a certain time or a defined distance. (Neis & Zipf 2007).

- Further the *Route Service 3D* (RS3D) and *Route Service with Landmarks and Focus Maps* will be explained later, see also Neis et al (2007). It combines both approaches, by integrating 3D Landmarks in a 3D scene and delivered from an OGC W3DS instead of a WMS.

Free, collaboratively collected data

With the recent boom in Web 2.0 and the emergence of user generated geodata, some noticeable projects have showed up on the web. Well known, but especially noteworthy is *OpenStreetMap.org*, a project that provides geodata collected by their user via GPS. This data is not only accessible by their web interface - you can also download their street network and thus employ it for your own application. The amount of free data provided by *OpenStreetMap* is already huge and continuously growing.

It is time to use this large quantity of free information for more than just simple web mapping. The project *OpenRouteService.org* provides free routing based on *OpenStreetMap* data through our implementation of the *OpenLS Route Service* (Neis & Zipf 2008). It also will be made available as Open Source soon. *OpenRouteService.org* will also be available as a service that can be integrated in your own applications – in a completely interoperable way. Currently only Germany is offered, but further countries will be added soon. Through the integration with the Geocoder functionality of the *Location Utility Service* also an interoperable solution for searching for addresses will be offered.

An interesting feature that stems from our work on disaster management is the possibility to avoid areas that are not passable. Originally those areas were defined by the emergency service staff, but we are currently implementing the functionality that lets the user interactively digitize areas to be excluded from the routing algorithm. Thus users are able integrate their local knowledge about construction sites and suchlike into their routes. In a next step, this can be developed into Web 2.0 application of its own, by enabling users to share their knowledge about areas best avoided with others. Figure 1 shows how one bridge has been declared impassable (red polygon) and the route now uses the northern bridge.

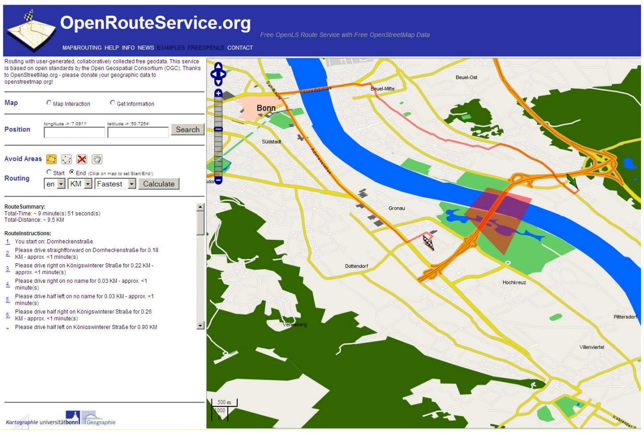

Figure 1: Extended version of OpenRouteService.org: user defined areas are avoided

Interoperable SDI – a fundament for LBS

Interoperability achieved through open specifications is of particular importance in the mobile world of LBS, where users roam through different regions with different providers using an extremely heterogeneous set of devices and clients. In order to keep everything as open and interoperable as possible, we use the specifications of the *OGC*. Networks of such services providing data and functionalities are known as spatial data infrastructures (SDI) and are being set up on a broad basis these days.

The most relevant *OGC* web services next to the OpenLS initiative for our work are:

- *Web Catalogue Service*
- *Web Map Service*
- *Web Feature Service*
- *Web 3D Service*
- *Web Processing Service*

These are used to set up domain specific SDIs, e.g. in the area of disaster management (see www.okgis.de for a project on open source and open SDI-based disaster management) or on 3D-SDI in projects like www.gdi-3d.de (Schilling et al 2006, 2007). A similar approach is taken in our current project on mobile navigation with 3D city models (www.MoNa3D.de).

Some approaches and results from the latter will be presented in the following sections. The conceptual architecture of GDI-3D.de is presented in figure 2.

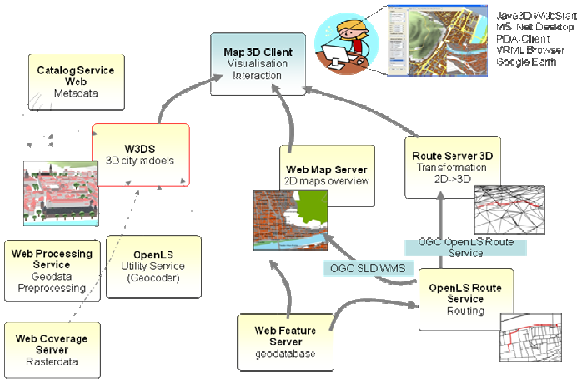

Figure 2: OGC Services in the Heidelberg 3D-SDI (www.gdi-3d.de)

Adding the third dimension

In those 3D projects we use the *Web 3D Service (W3DS)*, another pending OGC specification. It offers the possibility to generate interactive 3D scenes of city models and digital elevation models (DEM) from distributed data sources in various 3D formats. In order to realize a functional 3D routing service it is not enough to intersect the geometry of a route with a DEM, but we need also to consider bridges, tunnels, over- and underpasses etc. This has been successfully realized in a web-based environment (figure 3).

Figure 3: Dynamic OpenLS 3D routing supporting bridges, underpasses etc. (Schilling et al. 2008).

Any appropriate client can now access this SDI and get a route calculated as well as visualized in a 3D environment. In our own client, we have additional features like a flight along the route or highlighted decision points for an optimized result (figure 4).

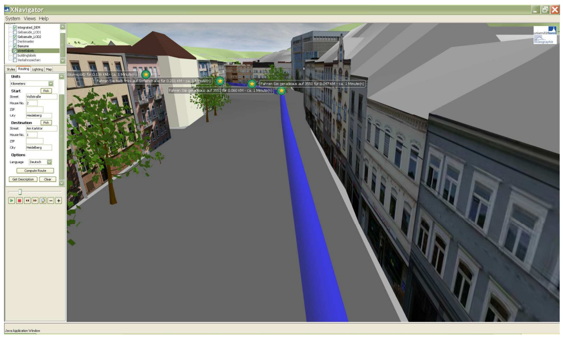

Figure 4: Visualizing a route in a 3D SDI environment

Upgraded wayfinding

It is very well researched, that the navigation experience can be enhanced significantly by including landmarks into the route instruction. We currently are developing another extension to the *OpenLS Route Service*, which will support the usage of fixed *Points of Interest* as landmarks as well as more dynamic approaches. For more effectiveness, the visibility as well as inherent properties of the objects shall be considered during the selection of suitable landmarks. These functionalities will be realized using the new *OGC Web Processing Service (WPS)*. We already have implemented a number of WPS processes within the project *www.OK-GIS.de* (Stollberg & Zipf 2007) and www.GDI-GRID.de (Lanig et al 2008).

3D visualization rules for navigation

Now we need to visualize the 3D scenes in an appropriate and interoperable manner. Typically, within GIS there is a clean division between the raw geodata and the visualization properties. This is an advantage because the same data can be used and displayed in multiple ways according to the specific needs. This division should also apply to 3D city models and mobile applications. In order to allow a clean cut between raw data and visualization, a separate open format for the visualization regulation needs to be defined. This way it is already usually done for 2D (web) maps through the *OGC Styled Layer Descriptor* (SLD) specification - or more precisely the newer *OGC Symbology Encoding* specification (SE). This offers many chances: Next to allowing a client application or end user to define the style of a map, more importantly it makes it possible to integrate diverse data sources into one WMS map and to style them consistently within that map. For the same reasons it would be very beneficial if this mechanism could also be applied to 3D data representing DEMs, 3D landscape and city models. Therefore we have developed (Neubauer & Zipf 2006) an extension to the current *OGC Symbology Encoding* specification, that is implemented into our W3DS (Neubauer et al. 2007). This can be used to define the appearance of the 3D scene directly from the client side, such as it is the case with 2D WMS.

In particular this allows further to use the *OGC Filter Encoding* functionalities for thematic filtering, to select 3D objects like buildings based on attribute values. The selected buildings than receive their specific visualization properties through the SE too.

It is also possible to include external 3D graphics (e.g.in form of VRML models) for point-objects. This allows to change the representation of objects on the fly. One example for that is that the 3D representation of landmarks can be changed dynamically. This can for example be used to provide different user groups with different visualizations or to adapt the visualization according to traffic modalities or other changes of the context.

An example of this are 3D focus maps, as shown in figure 5, an extension of the original 2D focus maps (Zipf & Richter 2002). When calculating routes or maps for navigation, it includes and distinguishes automatically relevant objects in order to assist the user to focus on the most significant parts on the map.

Figure 5: 3D focus map along an inner city route

Getting mobile

The combination of mobile clients and spatial data infrastructures depend on a means to direct to clients to the right data providing service depending on its location. This can be handled by a *Web Catalogue Service* where all the necessary data sources are listed and the client gets directed to the appropriate server.

Mobile navigation systems also need to synchronize the time and/or place a route instruction has to be uttered. To achieve this, we are currently planning to advance our Route Service towards a Navigation Service, so mobile navigation can be fully supported.

Efficient looks

When working with large scale, detailed datasets in combination with mobile applications, the data transfer to the client always constitutes a bottleneck. A large part of the data that needs to be transferred consists of textures for the 3D models, slowing down the performance decidedly - but displaying only mono-colored buildings is not satisfactory either. In order to solve this dilemma, our partners at the University of Technology Stuttgart are developing a smart algorithm to decompose building textures into essential parts. Then these parts are transferred to the client along with a so called *pulse function,* determining how they are to be assembled so as to form a realistic although synthetic texture (Coors & Zipf 2007).

Personalized and context aware LBS

A further set of new specifications (or drafts) we are working with deal with the integration of sensor data: the so called *Sensor Web*. Dynamic data about a lot of information on the environment (weather, floodings, etc.) or the traffic situation (traffic jams, accidents, construction works etc.) or even surveillance cameras can be sensed and distributed in near real time now. The integration of those extremely heterogeneous data sources through open standards is becoming more pressing. A first example we are realizing currently, is access to the information broadcasted through the European *Traffic Message Channel* (TMC). At present, this is integrated through the use of *OGC Web Processing Services* and some of the *Sensor Web* standards, such as the *Sensor Observation Service (SOS)* into our *OpenLS Route Service*, and then can be used also with *OpenRouteSerivce.org* or within *MoNa3D.*

This is of particular importance when we take the promise of LBS – to offer the right information to the user in the right time and the right way seriously. The variety of new sensor data will allow to develop adaptive services that offer personalized and situation aware information. This has been proposed for a few years in particular in the area of mobile maps (e.g. for tourism, Zipf 2002), but now we see the more and more dynamic data sources becoming available that allow to realize this in a wider context to the point of Ubiquitous Computing (UbiComp). A term that may be defined as: *Pervasive services based on UbiComp technology and devices, supporting context-dependent (i.e. adaptive) interaction, realized by information and functions of geographic information services based on interoperable SDI* (Reuter & Zipf 2008).

It has been pointed out earlier, that the adaptivity of GI services to context can be seen as one of the next steps for GIScience research in order to achieve more intuitively usable GI systems (Zipf 1998). A few ideas of which adaptive services might be suitable within the context of GI services:

- adaptation of the visual presentation of the contents offered – both textual and graphical (pictures, maps, video, VR models);
- adaptation of route planning (by individual weighting and restrictions);
- adaptation of queries (combined location- and interest-based tips;
- adaptation of the offered contents (e.g. concerning details, topic).

Conclusion

So we could show that today's considerable suite of OGC specifications (or draft specifications) is quite rich in order to develop interesting LBS or mobile and web-based GI applications in general. Of course there are still open issues, in particular when it comes to more fine grained visualization rules for 3d maps as well as thematic mapping, where the current SLD/SE approach is too limited and needs extensions (Dietze & Zipf 2007). While processing and analysis of spatial data can now be integrated into a service chain of OGC services through the *Web Processing Service* (WPS) specification in general, there is still a lot of research about how to deal with WPS functionalities in detail (see Stollberg & Zipf 2007,2008, Goebel & Zipf 2008).

These service chains can be also realized in the area of navigation and 3D-GIS (Zipf et al. 2007), but earlier we have identified some technical challenges for dynamic web service orchestration based on as the Business Process Execution Language (BPEL) (Weiser & Zipf 2007) in a different, but comparable application domain. These problems should disappear soon, as technologies mature and OGC services will support further industry-standards such as WSDL (Web Service Description Language).

It is our belief and motivation, that in combination the introduced technologies can lead to more pervasive GI services and so can contribute to the development of the next generation of mobile navigation systems. Maybe they even show the way to something for which the term Ubiquitous Geographic Information = UbiGIS could be applicable.

Some of these ideas are yet to be evaluated and empirically proofed, an undertaking for which we preparing tests and empirical studies for.

Literature: References can be found at http://www.geographie.uni-bonn.de/karto/

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