Journal of Location Based Services
Vol. 2, No. 2, June 2008, 153–174

Extending the OGC OpenLS Route Service to 3D for an interoperable realisation of 3D focus maps with landmarks

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(*Received 23 February 2008; final version received 18 July 2008; accepted 11 August 2008*)

Landmarks and focus maps can play an important role by supporting users in route finding and navigation. This article shows one possible solution for generating focus-based maps with landmarks by only using OGC® web service standards. The aim is to increase technical interoperability of implementation of location-based services or navigation applications. The techniques for choosing specific landmarks and generating the focus maps are shortly presented and their functionality is explained. For this we explain the concepts of both landmarks and focus maps. Also the relevant technologies from *3D spatial data infrastructures*, (3D-) symbol encoding (SE) for representing visualisation rules in 2D and 3D and the OGC *OpenLS* specifications are introduced briefly. The *OpenLS core services* implemented by ourselves and the first applications of these are discussed. The integration of the landmarks to the route instructions of the OpenLS *Route Service* happens during the route calculating algorithm without adding extra attributes or new elements to the standardised service interface. The generation of the focus-based maps is realised in similar ways for 2D and 3D using the (extended) SE. In 2D the realisation is based on our implementation of an OpenLS Presentation Service. In 3D our *Web3D Service* has been extended accordingly. The article ends with an outlook on ideas for future deployment and research.

Keywords: OpenLS; 3D focus maps; landmarks; OGC Web Services; navigation; interoperability; 3D spatial data infrastructures

1. Introduction

Developing location-based services (LBS) still poses a long list of challenges and research issues to the GIScience community. Raper *et al.* (2007) have conducted a comprehensive survey about the related potentials and key issues. Among others they identified both wayfinding in car/pedestrian navigation and map-based *versus* virtual interfaces to LBS as urgent research topics. The work presented here deals with both aspects, as we search for possibilities to develop user-aware 3D interfaces for navigation systems. Two important topics have been identified among others as being relevant when assisting a user of a navigation system with mobile maps from a cognitive point of view:

(a) Focusing on relevant information in the area the user is currently interested in – e.g. through the concept of 'Focus Maps' (Zipf and Richter 2002) and
(b) adding landmarks as key elements of wayfinding support (e.g. Golledge 1996).

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ISSN 1748–9725 print/ISSN 1748–9733 online

DOI: 10.1080/17489720802400413
http://www.informaworld.com

Further aspects of presenting route instructions are present e.g. Kray *et al.* (2003). In addition to that, it is desirable from a technical point of view to realise such systems based on open standards, e.g. by the *Open Geospatial Consortium* (OGC) on top of *spatial data infrastructures* (SDI) (Zipf 2004). This helps to increase interoperability of such systems within a heterogeneous world of mobile devices and web services. In the context of mobile LBS, the *Open Location Services* (OpenLS) initiative of the OGC is developing open specifications for standardising these.

The concept of focus maps (Zipf and Richter 2002) shortly states that some regions on the maps are usually of higher interest to the user and should, therefore, be presented in a more dominant way as the reminder of the map – especially in the case of maps on mobile devices with limited displays. A range of stylistic means are available in cartography to realise that, from different degrees of generalisation to faded usage of colours and size of labels in different 'focus regions' – e.g. buffers around the 'areas of interest'.

Therefore the following question arises: How can we realise focus-based maps in combination with landmarks using OpenLS Services? The OpenLS Service Framework (OpenLS 2005) offers several core services, among them – the OpenLS Route Service and the OpenLS Presentation Service. The realisation should re-use existing *OGC Web Services* (OWS) whenever possible, in order to minimise duplication of work. So the aim is to implement a *service-oriented architecture* (SOA) of well-known standardised components like *Web Map Service* (WMS) (OGC 2002), *Web Feature Service* (WFS) (OGC 2004a) and the suite of OpenLS Core Services such as the OpenLS Route Service, the OpenLS Presentation Service and the OpenLS Location Utility Service (Geocoder/Reverse Geocoder). These OpenLS services have been implemented within our projects (Neis 2006, Neis *et al.* 2007). In this article, we present extended versions to our current implementations of these OpenLS services.

As these are using a range of existing OGC standards we introduce them shortly:

- *GML – OGC/ISO Geography Markup Language* – An XML schema to express geographical features. GML serves mostly as an open interchange format for geographic information on the Internet.
- *WMS – OGC/ISO Web Map Service* – A service interface for requesting and interacting with 2D maps on the Internet (OGC 2002). 3D scene graphs can be requested through the Web 3D Service (W3DS) interface as described later in the article.
- *WFS – OGC/ISO Web Feature Service* – (OGC 2004a) A spatial database accessible through the Internet providing thematic and spatial search functionalities for spatial data using the OGC Filter Encoding language (OGC 2004b). The data is exchanged using the GML format (OGC 2007).
- *OGC Filter Encoding* – An XML schema grammar for defining filtering options for spatial data – including the possibility to use thematic and spatial properties for selecting spatial features (OGC 2004). It is used both in requests to the WFS as also within the OGC Styled Layer Descriptor/Symbology Encodings.
- *OGC Styled Layer Descriptor/Symbology Encoding* – XML schemas for representing simple 2D maps through defining the visual appearance of individual map layers using a range of renderer, e.g. for Markers, Text, Lines or Polygons through attributes like colours, line-size, etc. (Müller 2007). It also includes filter rules for selecting geographic features using the Filter Encoding specification and applying visualisation rules to the selected features. (OGC 2002, 2005)

2. 3D Spatial data infrastructure

The W3DS is an OGC discussion paper describing a service interface for presenting 3D scenes. We have implemented and extended it to also support the *Style Layer Descriptor* (SLD) or more precisely the newer *OGC Symbol Encoding* (SE) specification. This is well known for WMS in order to define the style of a map. This specification has been extended into the third dimension as a profile. We call this new profile 'SLD-3D'. It is used to define in a declarative way the visual appearance of the geometries of a 3D scene. The first realisation is presented in Neubauer and Zipf (2007). It uses and supports the same concepts as the well-known SE/SLD. It seems possible to generate focus-based 3D scenes in a similar way as focus-based maps. The general idea to define route-based focus maps has already been presented by Schilling and Zipf (2003). At that time no standards have been used, as there were not enough powerful standards available. But nowadays we need more interoperable solutions.

We aim at evaluating the use of relevant open standards – in particular those of the OGC – with respect to mobile navigation. This may lead to suggestions for modifications or extensions, such as in the case of the 3D-Symbology Encoding, or best practices on how to set up service chains of such services in order to deliver the desired result. Such a combination of standardised services managing, processing and delivering 3D spatial data can be considered as first steps towards a 3D-SDI. First examples of 3D-GI-applications based on such SOAs have been presented (Neis *et al.* 2006, Schilling *et al.* 2007, Basanow *et al.* 2007). An example is presented in Figure 1, showing the current GDI-3D (GeoSpatial Data Infrastructure 3D) for Heidelberg. Future work will not only focus on technical aspects regarding the appropriateness of the used standards, but also questions on how to interact with commercial and proprietary solutions.

We can use the complete service chain of the *Route Service with Focus Maps and Landmarks* and present the result not only as a 2D map but also as a 3D scene. We agree here with Zlatanova and Verbree (2005) that LBS needs extensions into 3D and are actively working on these. Therefore, a W3DS and a Java3D-based client have been

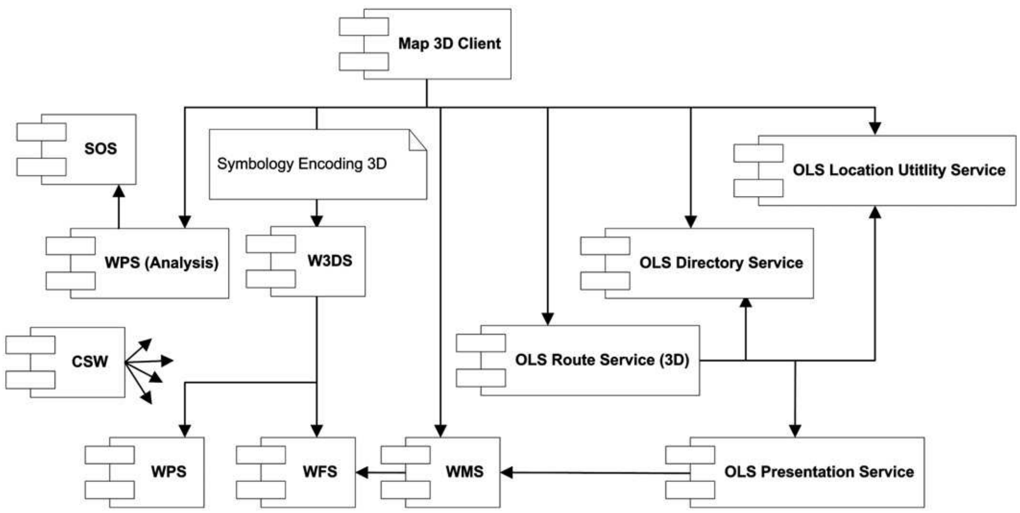

Figure 1. OGC Services in the Heidelberg 3D-SDI.

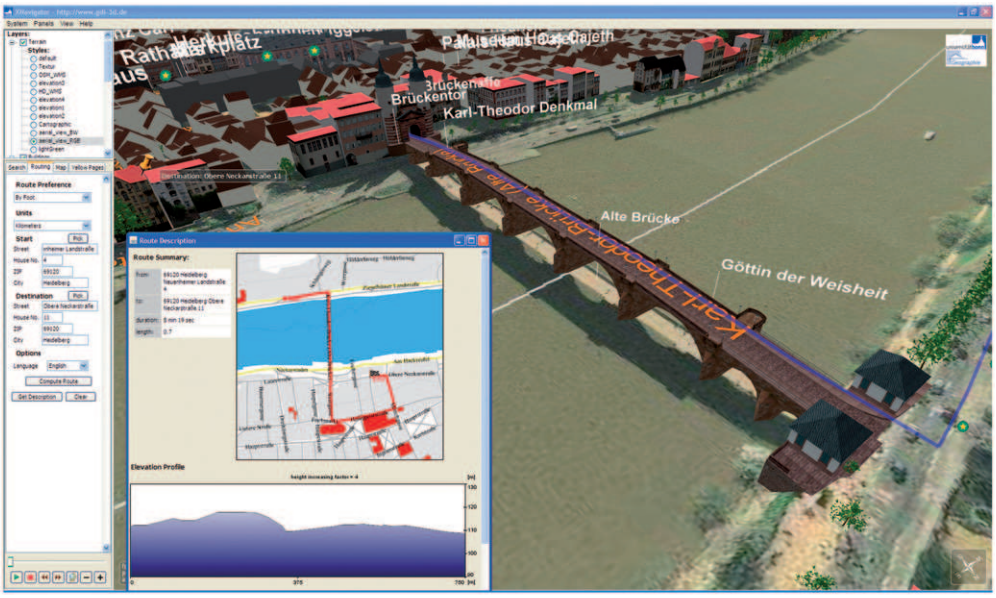

Figure 2. Representation of a requested route and within the respective 3D city model along with route instructions from OpenLS Route Service realised with our 3DWS from www.heidelberg-3d.de.

implemented within a project on 3D-SDI (www.gdi-3d.de). The client merges the requested route geometry to the matching 3D scene delivered by the W3DS and provides additionally to visualisation of the routes geometry in 3D and navigation instructions also an animated route flight (Figure 2).

Some examples of already available functionalities of the services in GDI-3D can be tested using the available online system on www.heidelberg-3d.de. Also further pictures and video captures are available showing functionalities that are still under development.

3. OpenLS – the OpenGIS location services

For LBS the OGC has specified a range of services for supporting route planning, etc., which provide a base for realising interoperable navigation applications. Most of those OpenLS core services we have implemented already and combined with 3D city models (Neis *et al*. 2007, Neis and Zipf 2007, see Figure 1). But the result has not yet been optimised for a mobile device, which is one of the tasks within the MoNa3D project (Coors and Zipf 2007, Bauer *et al*. 2008). Some aspects of this will be discussed in the following chapters. The topic of how to include landmarks into such a SOA based on open standards is being discussed by Neis and Zipf (2007) with respect to mobile 2D maps. As explained later a similar approach utilising buffers can be used also in 3D.

OpenLS stands for *Open Location Services* or *OpenGIS Location Services*. Since 2000 this OGC initiative has been developing implementation specifications (interfaces and protocols) for standardising services that are relevant for LBS. The OpenLS service framework consists of five core services at the moment (OpenLS 2000). Just recently, in winter 2007/2008 a new version of the OpenLS specification (v.1.2) has been successfully adopted by the OGC:

- The *Directory Service* is a service that provides access to an online directory (e.g. Yellow Pages) to find the location of a specific or nearest place, product or service.
- The *Gateway Service* is a service that fetches the position of a known mobile terminal from the network; this interface is modelled after the *Mobile Location Protocol* (MLP) Standard Location Immediate Service.
- The *Location Utility Service* provides a Geocoder/Reverse Geocoder; the Geocoder transforms a description of a location, such as a place name, street address or postal code, into a normalised description of the location with a point geometry usually placed using Cartesian coordinates, often latitude and longitude.
- The *Presentation Service* portrays a map made up of a base map derived from any geospatial data and a set of *Abstract Data Types* (ADT) as overlays. The interface is different from the OGC WMS, though having a similar purpose.
- The *Route Service* determines travel routes and navigation information in different forms according to a range of parameters.

Recently a sixth service has been standardised by the OGC Location Services working group: the 'Tracking Service.' It is not considered a 'core' OpenLS service. We are currently in the process of implementing this, too. A further service – the 'Navigation Service' – has been in discussion since 2000, but has not yet reached a stable version. It is planned to add it in the new planned version 1.3 of the OpenLS Spec.

Four of the five core services mentioned (Location Utility Service, Presentation Service and Route Service and Directory Service) have already been implemented by us and have also been integrated into the online service www.OpenRouteService (Neis and Zipf 2008). OpenRouteService.org uses the collaboratively collected free spatial data from Open StreetMap (Coast 2007). This new type of dealing with spatial data has been coined 'Volunteered Geography' by Mike Goodchild (2007). The Tracking Service implementation will be finished in the near future. An OpenLS Gateway Service was not needed within our projects so far. Its realisation is also dependent on access to a mobile telephone location server.

Especially the *Route Service* (RS) has already been used within a number of our further projects. These include:

- OK-GIS: Open disaster management with free GIS solutions – www.ok-gis.de
- A Web-SDSS (Spatial Decision Support System) for automating of multi criteria model building for user specific and regional analysis of the residential market in Rhineland-Palatinate/Germany.
- GDI-3D: geoSpatial Data Infrastructure for 3D spatial data (3D-SDI) for the city of Heidelberg/Germany – www.heidelberg-3d.de
- Mobile Navigation 3D – www.MoNa3D.de
- Free OpenLS Route Service with Free OpenStreetMap Data – www.OpenRouteService.org

In addition, several services have already been developed as spin-offs of the OpenLS RS, which have been used in a number of domains and scenarios:

- *Emergency Route Service* (ERS) – The ERS is a special OpenLS Route Service, that considers automatically current areas to be avoided (e.g. flooded or blocked roads, landslides and poisoned areas) while calculating the requested route. The service acts as proxy to the original RS, so the interface has not been changed at all (Weiser *et al.* 2006).

- *Accessibility Analysis Service* (AAS) – This is a service that calculates a polygon around a certain start location given as parameter (e.g. city, point of interest and address). That polygon represents the area that contains the area that is reachable from the start location within a certain time or a defined distance. The calculation is based on a street network with each street leg having several different attributes (e.g. one-way track or speed limits) (Neis and Zipf 2007).
- *Route Service 3D* (RS3D) – The RS3D is a cascade of the OpenLS RS. It calculates the 2D route geometry in the specified way. But after that, it maps this route geometry onto a Digital Elevation Model (DEM) and calculates ground heights for the existing route points as well as new 3D-points to avoid intersections with the terrain. The response consists of all these new or altered 3D-route-points (Neis *et al.* 2007).
- *Route Service with Landmarks and Focus Maps* – This service is being introduced in this article shortly (cf Neis and Zipf 2007). It is an extended version of the original OpenLS RS. When calculating navigation or maps for the route it includes automatically relevant landmarks. Additionally the map is changed to a focus map in order to assist the user to focus on the most relevant objects on the map.
- *3D Route Service with Landmarks and 3D Focus Maps* – This is a further extension of the version just introduced. Similarly it includes landmarks and produces focus maps, but these landmarks are 3D landmarks in a 3D scene and the focus maps are 3D focus scenes delivered from an OGC W3DS instead of a WMS.

4. Landmarks

The significance of landmarks for human wayfinding has been recognised for a long time (Lynch 1960). A route instruction using landmarks is rated much higher by the recipient than the current standard using only distance information and road names (Lovelace *et al.* 1999, Tversky and Lee 1999, Michon and Denis 2001).

Landmarks are generally divided into two groups regarding their visibility. Those that are visible over great distances are called 'global landmarks'. Their position, seen from the user's point of view, changes only insignificantly upon minor movements what makes them suitable reference points for global orientation. On the other hand those landmarks that are only evident within close range are called 'local landmarks'. They act as means for supporting navigation decisions along the route and can be incorporated into the route instructions as an affirmative as well as to make the instructions more natural sounding. In the approach specified below, we primarily use local landmarks.

When used as a decision support along the route, local landmarks can be subdivided regarding their position in relation to the route. There are 'check points', landmarks on decision points where change of direction is required, and 'potential check point' at crossroads where only a confirmation to stay the course is given (Lovelace *et al.* 1999).

To adapt landmarks to individual situations and user requirements, metrics and evaluations are needed that rate the importance of the integrated objects (e.g. Klippel and

Winter 2005). Based on the results of the analysis, important landmarks can be visualised more prominent than less relevant information. This differentiation can be apparent by generalisation or different colouring of objects. Zipf (2002) emphasises the inclusion of situational parameters like personal preferences or general context parameters. Especially with the growing usage of mobile maps, route visualisations that adapt to individual and situational attributes will gain in importance. Some further examples building on those ideas include Baus *et al*. (2002), Klippel and Richter (2004), Sarjakoski and Nivala (2005), Swienty and Reichenbacher (2006), Schmid (2007).

One problem is that the complexity of creating 3D models of landmarks is higher than taking a snapshot of an object and copying it to a 2D map. This is especially true for realisations on mobile devices.

5. Route description with landmarks

Still, most commercial route planners and car navigation systems do not exploit the potential of landmarks completely, in fact until recently most of them did not provide landmark-based navigation support at all. Reasons include the problem of insufficient data on landmarks (coverage, etc.) as well as inadequate algorithms for selecting those from available data sets. This situation is improving (e.g. Elias 2006) and commercial companies start to build up dedicated databases on landmarks at the national or usual level. As the perspective view (pseudo 3D) in car navigation systems was a big commercial success these companies put further efforts towards support for the third dimension in those systems. Similar 3D-GIS are becoming more widespread in a range of domains (Coors and Zipf 2005). But due to unsolved problems on data availability, management and update, as well as of performance issues on mobile devices until now these mobile navigation prototypes usually only provide 2,5D terrain visualisations with individual landmarks in 3D. Only a few research prototypes actually provide real 3D city models on mobile devices (e.g. Coors and Schilling 2004, Fischer *et al*. 2006, Nurminen 2006a, b) or work on the topic of interoperable management (Schilling *et al*. 2006, Basanow *et al*. 2007) and their combination with standards-based route planning possibilities (Neis *et al*. 2007).

The next step is to find out more on how landmarks should be visualised on a mobile device in particular with respect to 3D, and how much realism is needed for that. There are some early publications about this available, but only with preliminary results.

6. Personalised 3D visualisations through styling rules for 3D maps

With the advent of LBS the topic of personalisation (Zipf 2002) or context awareness (Zipf 1998) became a topic within GIScience (see also Meng *et al*. 2004). In order to extend this to mobile 3D maps both research on cognitive aspects and information visualisation is needed on the one hand, and on the other hand also the technical possibilities to define the look of a 3D scene (3D map) in a declarative and interoperable way. Within this article we will mention the second issue only briefly. A possible approach is the definition of a specification that allows styling different objects and featuring classes within a 3D scene individually. This shall be based on rules that can be defined in a document which then is fed into the application (i.e. sent to a server within a request in case of an SOA). Some examples of not predefined styles that have been dynamically generated by the W3DS only through changing the configuration of the W3DS files are presented in Figure 3.

As shown in Figure 3, it is also possible to include external 3D graphics (e.g. in the form of VRML models) for point objects. This allows to change these on the fly – and, therefore, also 3D representations of landmarks – this can be used, e.g. for different user groups, traffic modalities or other changes of the context. This has been realised within a first prototype of our W3DS (Neubauer and Zipf 2007).

Future work now needs to focus on cognitive aspects of choosing the right landmark with the best visual representation in the given situation.

7. Route service with focus maps and landmarks

To generate focus-based maps including landmarks for the usage in routing, we created the *'Route Service with Focus Maps and Landmarks'*. It is an extended version of the conventional OpenLS RS. This means that it uses the identical interface for requests and responses – just like the specified OpenLS RS. The difference is the response: the route instructions and route maps are supplemented with landmarks for a more cognitive adequate representation of route instructions and filtered for producing focus-based route maps.

As shown with the base OpenLS RS, routing can be done by the 'Route Service with Focus Maps and Landmarks' with respect to many different criteria, e.g.: 'Fastest', 'Shortest' or 'By Foot'. For giving the points of destination and arrival or some user defined via points many options such as address, coordinates, points of interest or geometries are possible. With using addresses there is the ability of using structured or non-structured addresses. The geocoding of all forms of addresses is done by an external OpenLS Location Utility Service (Geocoder/Reverse Geocoder). To support the numerous spatial reference systems (for giving start-, end- or via- points) the Focus RS is connected to a special database containing all spatial reference systems with their specific parameters as specified by the *European Petroleum Survey Group* (EPSG). This makes it possible to transform all needed coordinates to one system needed for calculation (e.g. Gauß-Krüger or WGS-84).

There are four parameters within the route request that affect the route response in different ways. The following four categories can provide information about the requested route (OpenLS 2005).

(1) *Route summary* – The route summary gives some meta information about the requested route, e.g.: overall distance, overall needed time expected. In addition, one can demand a special distance unit (M for metres, Y for yards, KM for kilometres and FT for feet) by specifying it inside the route request.
(2) *Route geometry* – Using this parameter one can demand information about the routes geometry (line string containing all waypoints of the route). Here one can define a maximum of waypoints. This causes a generalisation if more waypoints have been calculated. The generalisation is done by the well-known Douglas–Peucker Algorithm.
(3) *Route instruction* – Route instructions are 'step by step' driving or walking instructions of the calculated route. This was realised in our application in a simple form for various languages (e.g. German, English, Italian, and Swedish). As important additional features of the new Focus RS, the relevant landmarks along the route are mentioned within the route instructions when it makes sense.

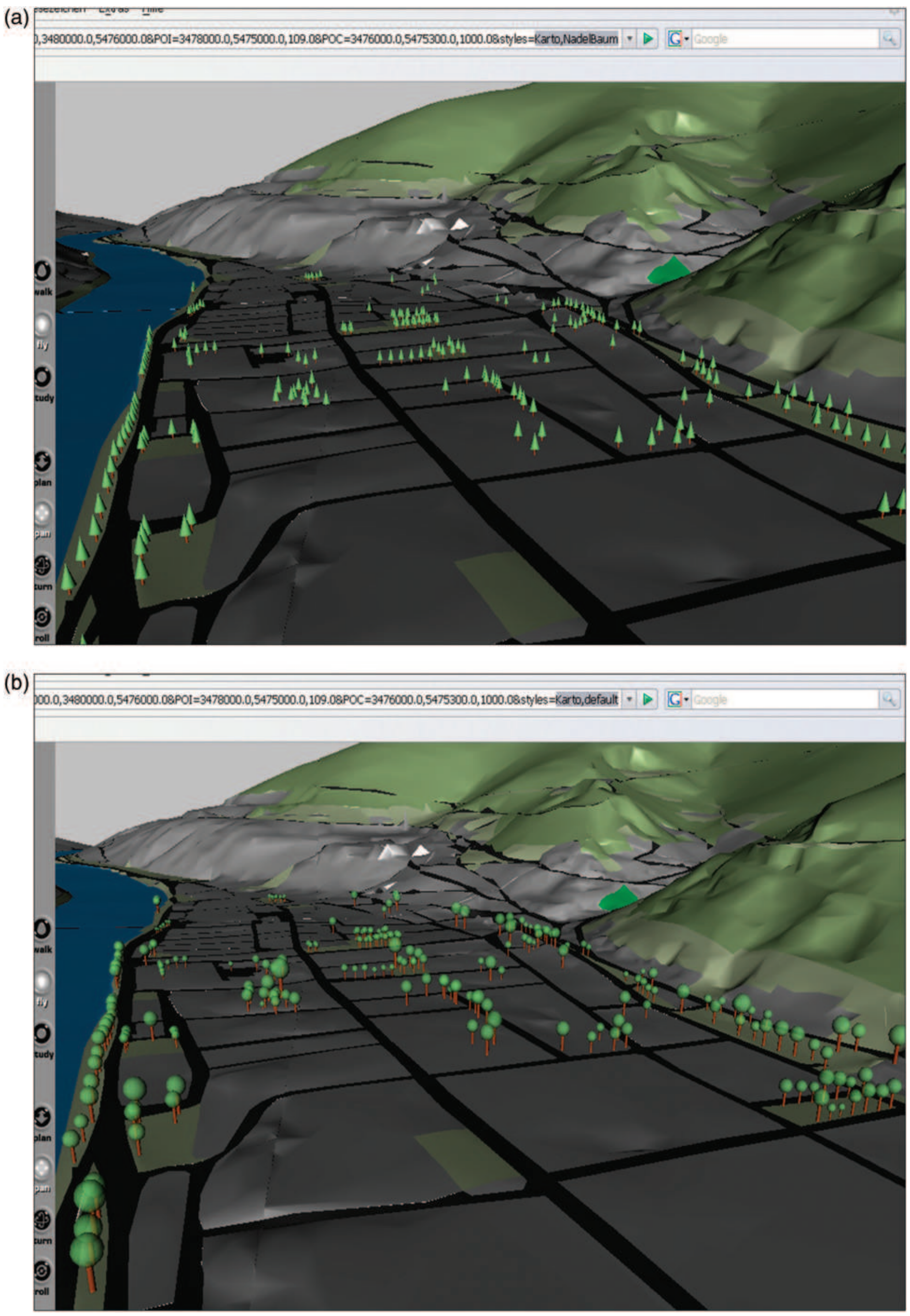

Figure 3. Examples of not pre-configured visualisations (different tree symbols).

(4) *Route maps* – These are maps, onto which the calculated route is displayed. Amongst other possibilities it is possible to request several route maps in the same *request*. For example an overview map as well as detailed maps of the start and destination points can be returned. Here the known landmarks are also included as special features of the Focus RS and the map is focused on the demanded route.

7.1. *Architecture of the RS with focus maps landmarks*

The implemented Focus RS is a Java servlet running on the Tomcat Server (for architecture, see Figure 4). It can be accessed exclusively through HTTP-POST and XML. The request and response are modelled as XML schema as specified through OpenLS. To generate 2D maps the Focus RS uses the OpenLS Presentation Service that has been implemented by us. This uses internally a WMS which supports the SLD version 1.1.

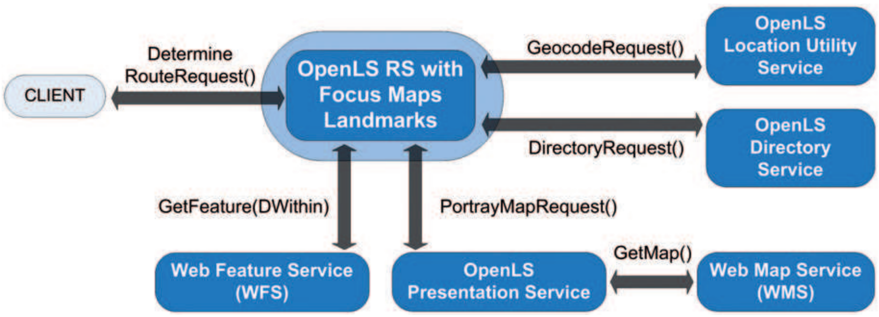

Figure 4. Architecture of the OpenLS RS with focus maps landmarks.

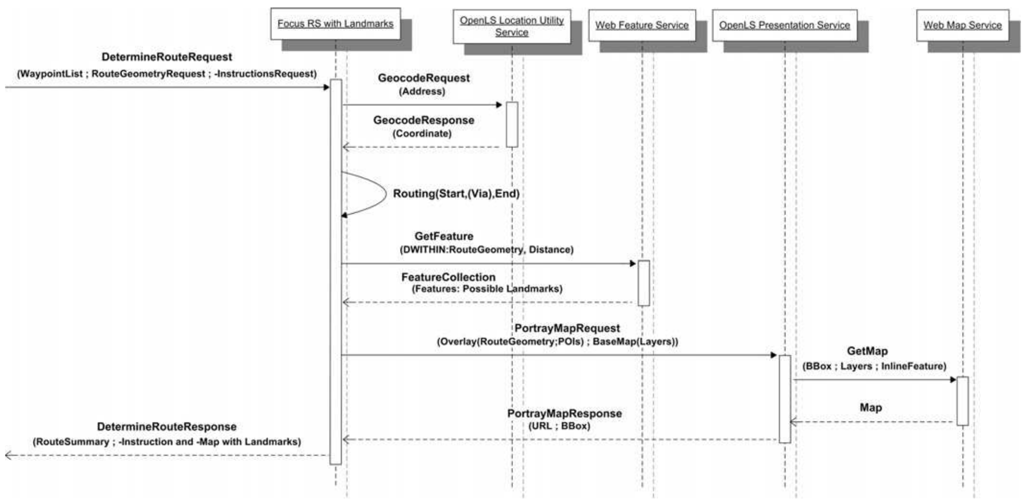

Figure 5. Sequence-diagram of the Focus RS with landmarks.

Through that it is possible to use advanced possibilities of SLD, such as *InlineFeatures*, which are used to transmit geometry in the form of GML along with the map request. Furthermore we use a WFS that needs to be able to provide all landmarks and map layers that shall be contained in the resulting map.

7.2. *Interaction between focus RS and other OpenGIS web service*

In an earlier version (Neis and Zipf 2007) of the Focus RS, the calculation of the routes was done by the individual separate OpenLS RS. Then the navigation instructions returned by these have been parsed by the Focus RS and the landmarks were added then through the Focus RS to the original response. But this indirection leads to loss of performance and the Focus RS cannot use internal information already calculated by the RS. Therefore, the new version of the Focus RS now is a direct extension of the original RS. This means that the landmarks are now calculated and added to the output directly when the navigation instructions are calculated in the first place. The whole interaction between the OGC services involved is depicted as UML sequence-diagram in Figure 5. The selection of the landmarks is still quite simple. In principle, we have to consider a range of properties of buildings in order to calculate if they are relevant landmarks. As we do not have that many attributes at the moment, we consider the geometry and the type of object. We assume that also in the future all relevant attributes for determining the landmarks are stored in a spatial database that can be accessed through WFS. Then we can use the OGC Filter encoding for calculating parameters for determining the currently most suitable landmarks. Only the calculations used in the OGC filters need to be adapted when further attributes will become available in the future. A spatial query is used to select those potential landmarks that are close to the calculated route using the WFS filter function DWithin.

The DWithin filter function is also used for generating the focus of the maps. The route is embedded in several buffers to determine the objects (e.g. buildings or streets) in the near distance to the route. The feature ID of those detected objects is stored and every geometry collection belonging to the same buffered area is styled in the same way. This is done via a *PortryMapRequest* and SLD to an OpenLS Presentation Service/SLD-WMS.

Figure 6 shows the DWithin buffer functionality. For detecting the necessary landmarks this is a first practical realisation that works, but not optimal solution. We focus in this article on usage of standard-based OWS, therefore, we mention only this part of the detection process in detail. Of course, better solutions for choosing landmarks would include a range of further parameters and also include the analysis of visibility of all landmarks.

Currently, we are working on an extension that also considers visibility of the objects. The visibility calculation will be realised as an individual service for geoprocessing, which would also allow using this in a preprocessing step. The relevant OGC standard for this is the new *Web Processing Service* (WPS). We have already realised a number of WPS processes already within the project www.OK-GIS.de (Stollberg and Zipf 2007) using the degree framework (Kiehle *et al*. 2006, 2007). On the other hand more dynamic information can be gathered through an OGC Sensor Web Service (e.g. SOS) or being calculated by the WPS. This would allow in particular the calculation of visibility based on dynamic attributes (e.g. weather conditions).

From such an approach even a context and user adapted selection of landmarks would be possible as proposed in the literature earlier a couple of times (e.g. Winter 2003,

Figure 6. DWithin filter.

Elias *et al.* 2005, Meng *et al.* 2004, 2008). Currently we assume here that all needed data has already been pre-processed and is then available within WFS.

The image above shows three geometric buffers of different size. The inner buffer is responsible for detection of the landmarks and focussing the map, while the other buffers support the focus algorithm. Of course a larger number of buffers could be used for a more fine-grained differentiation of the focus regions. This figure is only for explaining the principle.

7.3. *Focus route maps*

To receive the needed maps the Focus RS creates a *PortrayMapRequest* and sends it to the OpenLS Presentation Service. This request contains the position and character of the detected landmarks additionally to the route geometry. The ID's of the objects necessary for focusing the maps come along with that request as well. The OpenLS Presentation Service generates an SLD (SLD Version 1.1) document in which the route geometry and the useful landmarks for the calculated route are included in the SLD element *InlineFeature*. The SLD is sent to a WMS that generates the resulting map including the SLD *InlineFeature* and *UserStyle* (OGC 2005). Examples of resulting focus maps of our first implementation prototypes using only OGC standards for the realisation of the focus effect are shown in Figure 7 (right).

The left example shows a conventional route map while the right example is a first version of a Focus Map that has been generated by our new implementation as described above. These maps shall attract the user's attention to the spatial information relevant for the current task. Therefore the map has been divided into different zones. Those areas that are further apart of the *area of interest* (AOI) – in our case the route – are shown more generalised, with fewer labels and in lighter colours within our current first implementation. This has been realised by generating focus-buffer along the route calculated using the OGC Filter Encoding.

Figure 7. Map without focus (left) and focus map (right) as returned by our 'Focus RS with landmarks'.

Figure 8. Route map with landmarks.

7.4. *Route instructions with landmarks – first example*

Besides focusing the map to the route geometry the realised service mentions the selected landmarks also in the route instructions and presents them in the resulting map. The used landmarks are divided into two groups of being needed for route description or not. The map in Figure 8 contains two landmarks (a gas station and a stop-sign). The example of the respective route instructions only contains the part with the gas station in order to shorten the example.

The route instructions seem to be similar to those of a basic OpenLS RS. A difference occurs if the route leads past a detected landmark, then these particular landmarks are mentioned inside the instruction (see rows 13–18 in Listing 1). Richter and Klippel (2005) and Hansen *et al.* (2006) complete those route instructions of the OpenLS Navigation Service by giving more information about the descriptive landmark (e.g. coordinates and description), but through this they change the current version of OpenLS specification. In our approach, we tried not to need doing this. But we are aware that a real Navigation Service would be needed for the advanced features we are aiming at.

8. Integrating 3D landmarks in a 3D scene

After we have explained an OGC conformant realisation of adding landmarks to route instructions and realising focus maps in 2D, we now have to extend the case to 3D. This means that a 3D scene needs to be calculated by an OGC W3DS that includes landmarks on the one hand and extends the concept of focus maps towards the third dimension.

When we want to emphasise landmarks in a 2D map we can use appropriate signatures, e.g. more dominant colours. In 3D this is a little bit more complex.

```xml
.....
<xls:RouteInstructionsList xls:lang="en">
  <xls:RouteInstruction duration="PT0S" description="Action No. 1">
    <xls:Instruction>You start on Rheiner Landstrasse</xls:Instruction>
    <xls:distance value="0" uom="KM"/>
  </xls:RouteInstruction>
  <xls:RouteInstruction duration="PT25S" description="Action No. 2">
    <xls:Instruction>
      Drive straightforward on: Rheiner Landstrasse for 0.4 KM - approx ~1 minute(s)
    </xls:Instruction>
    <xls:distance value="0.4" uom="KM"/>
  </xls:RouteInstruction>
  <xls:RouteInstruction duration="PT49S" description="Action No. 3">
    <xls:Instruction>
       Drive right after the gas station on: Augustenburger Str. for 0.7 KM - approx ~1 minute(s)
    </xls:Instruction>
    <xls:distance value="0.7" uom="KM"/>
  </xls:RouteInstruction>
  ……
  <xls:RouteInstruction duration="PT0S" description="Action No. 6>
    <xls:Instruction>You arrived at destination</xls:Instruction>
    <xls:distance value="0" uom="KM"/>
  </xls:RouteInstruction>
</xls:RouteInstructionsList>
.....
```

Listing 1. Example route instruction with landmark.

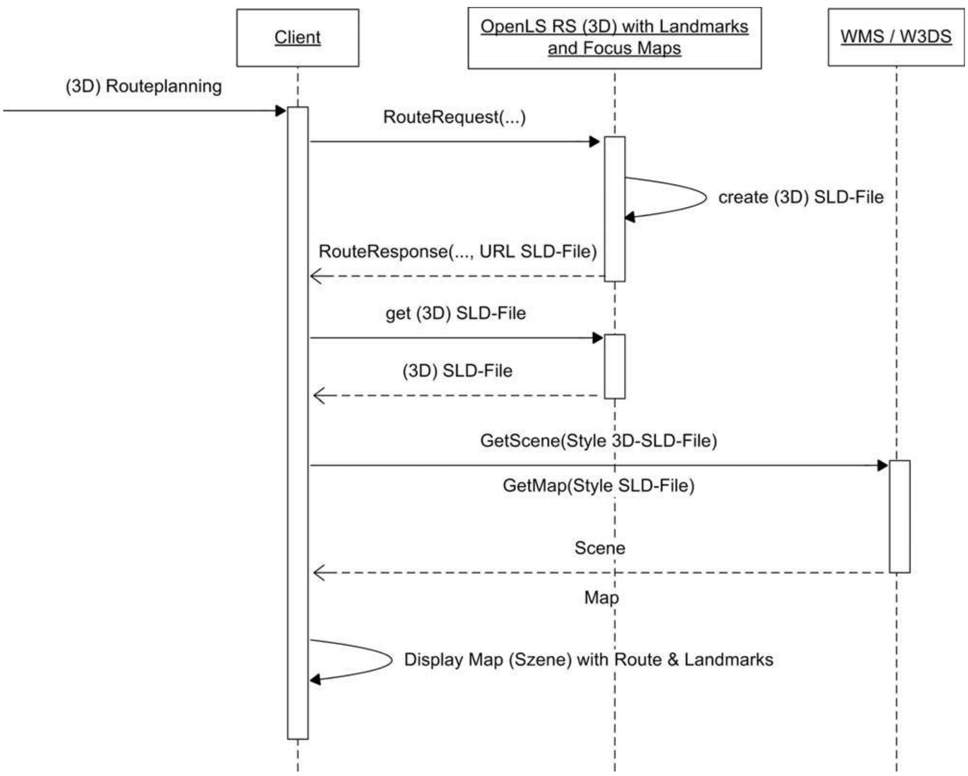

Figure 9. UML sequence diagram for (3D) SLD-files.

Figure 10. 3D Focus map: 3D scene with focus on area around the route realised with 3D-SLD enabled 3DWS.

If, for example, within a 3D city model textures are used for facades it is not wise just to change the colour of the building material.

When navigating through a 3D scene it is desirable to recognise the next landmarks already from the distance. A possible solution is to use 3D signature, such as arrows or labels on top of the landmark. A range of possibilities exist here and, for example, Glander *et al.* 2007 present a spring algorithm for positioning labels automatically on top of 3D buildings. But this approach can only be used on the client side, while we are here considering the OGC way where the resulting scene is generated by a server. We are still experimenting with several ways on how landmarks can be recognised more easily. We will conduct an empirical study with ~200 students to evaluate several approaches soon.

Such a form of visualisation can be used to highlight important objects which are already loaded in the scene. The viewer needs to know which objects should be identified as landmarks. Technically this can be realised by our OpenLS RS 3D with landmarks through providing a file to the client. This file contains the complete W3DS *GetScence* request along with the relevant *3D* SE file. Within the latter the route geometry is included as GML. Further the IDs of the landmarks are used within the *3D SE* file to select the relevant objects though the well-known OGC Filter encoding mechanism. This file can be used to select the relevant landmarks within the scene. The focusing of the 3D scene on relevant areas around the route can be realised with similar mechanisms using also the OGC *Filter Encoding* within the *3D* SE file. The resulting UML sequence diagram of OGC services is shown in Figure 9.

When using such a *3D SE* file for focusing on buildings along the route and adding landmarks from a W3DS client the result currently looks like that shown in Figure 10.

As just explained for the 3D case, the same ideas can also be applied in 2D. The OpenLS RS with landmarks and focus maps then just generates 3D *GetMap* requests with corresponding SE files. These can be used by clients or intermediate services in order to

```
.....
 <xls:RouteMapRequest>
          <xls:Output format="SLD"></xls:Output>
 </xls:RouteMapRequest>
.....
```

Listing 2. Example route request to get a SLD-file.

```
1  .....
2    <xls:RouteMap>
3       <xls:Content format="SLD" height="400" width="400">
4          <xls:URL>http://www.MyService.com/openls-rs/routes/1198839104650.sld</xls:URL>
5       </xls:Content>
6       <xls:BBoxContext>
7          <gml:pos>8.001 50.002</gml:pos>
8          <gml:pos>8.100 50.100</gml:pos>
9       </xls:BBoxContext>
10 .....
```

Listing 3. Example route response for a SLD-file.

adapt the requests even further – if needed. The following example shows an XML-snippet from a *RouteRequest* requesting an SLD-file as a result. The second example shows the answer for the Route Service: within the element URL (see Listing 3, Row 4) the address can be found where the generated SLD-file can be found.

9. Summary and future work

We have presented a proposal and prototype implementation of an extension of an existing route planning service by focus maps and landmarks both on the map and within the route instructions. This has been realised through the use of OGC services solely. We did not change the interfaces of the services in order to achieve this. Instead we connected several OWS and OpenLS services in a defined manner. This interaction between the services can be regarded as a service chain of web services which is an important aspect of SOAs. Currently research is conducted regarding how such service chains can be defined and orchestrated (as it is called) in the most flexible way (e.g. Einspänner *et al.* 2003, Stollberg and Zipf 2007, Weiser and Zipf 2007).

As navigation support within future ubiquitous environments (www.ubigis.org) needs to combine support for indoor and outdoor environments some first empirical studies regarding landmark based 3D indoor navigation are presented by Mohan and Zipf (2007).

One task is to extend the algorithm further to implement an advanced filter for the inclusion of landmarks or buffers originating from landmark facades intersect with the route geometry, while the buffer size is dynamically defined by the landmarks relevance. Further investigations regard the question: what parameters can be used for adapting and selecting landmarks based on the data available in the MoNa3D project, such as 3D city models and data from the project partner TeleAtlas, extending work, e.g. by Elias (2006) who focused on ALK (2D building) data. While some proposals exist on how formulas for context-aware landmark selection can look like (e.g. Raubal and Winter 2002, Zipf 2002), etc., practical implementations are always limited through the number of actually available attributes.

Figure 11. Result of the OpenLS route service applied in www.OpenRouteService.org.

The algorithm for creating the focus maps also has to be enhanced in the way that features or buildings, which are in a higher distance to the route, will be generalised to a higher degree in order to support focusing the map content. As dynamic generalisation is still too calculation intense, a possible approach might be the use of pre-calculated layers for different scales, that then can be combined. This shall minimise the possible loss of performance. Typical approaches include the usage of multi-resolution databases for storing the scale-dependent data set (Jones and Ware 2005), from which the individual map features can be selected.

Our 'normal' implementation of the OpenLS Route Service will be made available soon as open source. It shall be available at *www.FreeOpenLS.org*. The further OpenLS services shall also be added in the future, but details on this have not yet been decided. So far we have successfully tested our service based on a modified version of the geotools Dijkstra library with *OpenStreetMap* (OSM) data. OSM provides free editable and usable street data (Nelson *et al.* 2006, Coast 2007), but for several reasons this data is not provided through a standardised specification, but through a specialised API and proprietary XML schema. We think that the data provided by OSM is too important to be left out in the current trend of setting up SDIs based on open OGC standards realised as web services. Therefore, we also loaded parts in OGC standards based services, like WFS, WMS and most important our OpenLS RS and make them available as such.

Currently, we are improving the website and the performance of the service for larger number of users and higher volumes of data. The amount of data provided by OSM is already huge and is growing fast. As a first example we selected the data for Germany and we soon got over 2 million street segments that need to be transformed into a topological graph structure that is read and processed by our service. After preparing the data this results in about 2 million topological street segments for Germany alone. But when the data set covers several countries at once the response time increases to several seconds. Therefore we need to use a more sophisticated approach. Of course there are a range of other route planning algorithms and libraries. We will test those and then we decide which one will be used in future realisations of the route service in order to speed up response times.

As the OpenLS Route Service with landmarks and focus maps generates an SLD for 2D maps and a 3D-SLD file for W3DS scenes and returns to the client, our OpenLS route service can now also generate and return a *Keyhole Markup Language* (KML) file for Google Earth or Google Maps. This means, that the result of the route planning can be visualised in Google Earth or other applications that can read KML files (Figure 11). Further, a version of the OpenLSRoute Service has been integrated into the web-based www.OpenRouteService.org, which uses OpenStreetMap data for routing.

Acknowledgements

This work has been supported by the Germany Ministry of Education and Research (BMBF) within the project MoNa3D and through the Klaus Tschira Foundation Heidelberg (KTF) project GDI-3D Heidelberg. We thank all of our project partners and co-workers for their valuable support and input and the data providers for their contributions (Vermessungsamt Heidelberg, European Media Laboratory EML Heidelberg).

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