Blended Maps and Layered Semantics for a Tourist Mobile Guide

Kris Luyten, Karin Coninx, Geert Houben and Frederik Winters

Limburgs Universitair Centrum
Expertise Centre for Digital Media
Universitaire Campus
B-3590 Diepenbeek - Belgium
{kris.luyten,karin.coninx,geert.houben,frederik.winters}@luc.ac.be

Abstract

Nowadays, mobile applications are becoming more and more widespread, location-based services gain interest from users as well as service providers. In contrast with classical computing applications, location-aware services can contribute significantly to a richer user experience. Through the use of location-aware services the physical world can be enhanced by elements that are stored in a virtual world. Both worlds are aligned with each other by relating information artefacts from the virtual world with locations and areas in the physical world. We created a framework, ImogI, to support location-aware services centered on the principle of electronic mobile guides. Depending on the physical position of the user and the available connectivity, services can be accessed through a mobile device such as a PDA. Each service is presented as a semantic layer on top of the mobile guide and layers can be related with each other. This results in a generic approach to create location-aware mobile services that can take advantage of the underlying mobile guide. Furthermore we extend the map-based interface with a new technique, blended maps, supporting different inter-related views on the same area. These views can be presented in a different scale, either a constant or a variable scale.

1 Introduction

Mobile Tourist Guides are becoming increasingly widespread and a lot of effort is spent on re-implementing the same basic services over and over again. A set of *generic* functionalities can be identified that is implemented by most mobile guides, such as map visualization and Global Positioning System (GPS) tracking. A set of *specific* functionalities that is only applicable for a certain area or goal can also be identified. In this paper we describe a solution to create a reusable mobile guide component, *ImogI*: an interactive mobile guide (Luyten and Coninx, 2004), that takes into account the specific requirements that can be found for most electronic mobile guide implementations. This reusable mobile guide component provides the set of generic functionalities as a basis to build custom mobile guides. This solution provides a way for domain experts to define a mobile guide according to their domain knowledge: the separation between generic and domain-specific functionality results in an *extensible* framework. Customizations and extensions are accomplished by *semantic layers* that are defined on top of the generic mobile guide component.

Involvement of domain experts is often left out of the design of existing mobile guides: the different participating roles are usually limited to the end-user and the guide developer. The domain expert clearly plays an important role to create a suitable mobile guide and the goal is to offer better support for this particular role. For the remainder of this paper we will refer to the domain expert as the “guide designer” and the guide developer as the “software developer” to emphasize the difference between both roles. As a practical case we will show how a mobile photo blogging application can be created with our system as a new layer that defines the semantics and presentation for this application domain.

The remainder of this paper is structured as follows: section 2 provides an overview of related work. Next, section 3 gives a short overview of our mobile guide implementation, ImogI. Sections 4 and 5 each highlight an important aspect of this mobile guide: the possibility to combine different custom maps and a way to add new (location-aware) services on top of the reusable mobile guide component. Section 6 provides the reader with an example case study that has been implemented as a separate layer. Finally, section 7 discusses the future work, summarizes this paper and gives the conclusion.

2 Related Work

Since the PDA has become powerful enough to serve as a mobile guide, there was a real boom in the research *and* development of these kinds of applications. Kray and Baus give an overview of existing mobile guides (Kray and Baus, 2003); they compare mobile guides on 5 aspects: basic features, situational factors, adaptation capabilities, user interaction and architecture. Only few mobile guides also take *context* into account, with context being location, user, environment... The GUIDE system from Cheverst et al. (Cheverst et al., 2000) is such a system that offers context-aware content: the provided information is linked to the location of the user. (Cheverst et al., 2000) also confirmed the need to use a map as a basic representation for a mobile guide.

There is still an important threshold for introducing electronic mobile guides in a tourist environment. Even more than desktop applications they require extensive user testing, which turns out to be a real challenge (Börntrager and Cheverst, 2003). An electronic mobile guide is very obtrusive: the success and benefits depend on its ease of use, the users and the kind of tours it tries to replace or enhance. One such example is provided by Goodman et al. (Goodman, Dickinson and Syme, 2004): the success rate of introducing new technologies for common (mobile) tasks is highly dependent on the target groups. This dependency increases when the technology is not a necessity to execute the tasks.

Only little has been published about a common structure for mobile guides. Since most mobile guides share common goals (like guidance and information transfer) a classification can be made of the approaches that are used to create a mobile guide. For example, Zipf and von Hunolstein introduce some concepts that support the creation of a task-oriented mobile guide (Zipf and von Hunolstein, 2003). In contrast with their task-oriented approach, our approach is service-oriented: a service tries to accomplish an optimal combination of task-oriented visualisation and task-oriented functionality. Both functionality and visualization for a *particular domain* are combined in a *separate layer* in our approach. We will show how each layer corresponds to a certain ontology (Noy and McGuinness), the ontology being a domain definition for the data visualized and processed by a layer.

An ethnographic study of city tourists in combination with mobile technology has been carried out by Brown and Chalmers (Brown and Chalmers, 2003). Two important new concepts were introduced as a result of their study: pre- and post-visiting. The former presents the activities related to the visit before the tourist visits a place using the mobile guide (e.g. planning a visit). The latter describes the activities that are executed after the visit. The same type of concepts can be introduced for the layers used in our approach: a layer can require *pre-visiting information* and/or *generate post-visiting information*. Pre-visiting information is available before a visit takes place. Post-visiting information is the information created as a result of this visit.

3 ImogI

The functionality provided by the core ImogI component can be roughly divided into three modules: *location tracking*, *map visualization* and *map interaction*. Location tracking makes use of GPS coordinates that are read from a GPS receiver. The map and the position of the user are visualized by a rendering module, which supports bitmap graphics as well as vector graphics. Map interaction is provided by a user interface component which contains functionalities like panning, zooming and “click and fly” (by clicking on an icon the camera flies to that location).

Most mobile guides use tourist maps based on vector graphics. These maps contain meta-data and are much smaller to store than maps based on raster data (bitmaps). In our approach we explicitly made the choice to use raster data maps. This allows the guide designer to use his own hand-drawn maps without applying conversion to vector graphics data. Most tourist brochures and guidance plans use printed maps, so it is easy to capture them and use them in the mobile guide straightaway. Figure 1 shows a screenshot of ImogI while it is being used. ImogI has been developed using the Compact .NET Framework for PocketPC and can be used on any device supporting this framework.

In this paper two different concepts are described: *blended maps* (as a part of the core functionality "map visualization") in section 4 and *context-driven semantic layers* (as a way to extend the mobile guide) in section 5.

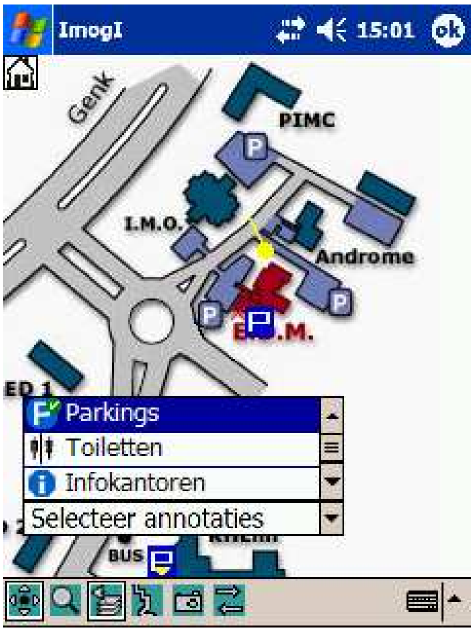

Figure 1 Screenshot of our electronic mobile guide.

4 Blended Maps

Blended maps indicate there is more than one map that can be used in the guide and there is a relation between the different maps. One map can have a different graphical presentation for the same area than the other maps. *Variable scale* maps are very important for tourist mobile guides: they emphasize points of interest and this type of map is already available in most tourist settings. They do not correspond exactly to the reality of the physical world because the scale is not constant for the whole map. Because hand-drawn artistic maps allow emphasizing tourist points of interest, they are more attractive and recognizable for the user (being a visitor). Moreover, they can be found in many tourist brochures and guidance plans. Interesting points in the environment are often drawn bigger on the map so they have another scale than their surroundings.

Physically correct maps will be called *constant scale* maps (e.g. aerial picture of an area). By allowing inter-map relations, variable scale maps can be easily supported. Inter-map relations identify how the same areas on different maps are related to each other: e.g. how the scale for the same area varies between both maps (Harrie, Sarjakoski and Lehto, 2002). We show a simple but effective synchronization algorithm that can be used to synchronize an arbitrary number of maps that all show the same area in another way.

If the correct physical position of the user has to be visualized on the hand-drawn map, we need a mapping algorithm that maps the real coordinates of the user onto the custom map. This mapping includes the reflection of the GPS coordinates (real world representation) on virtual map coordinates (virtual world). For the following example we will use two maps: a topographic map (real, correct world) and a corresponding hand-drawn map (map of the guide designer).

We created a desktop tool by which the guide designer can indicate corresponding position points on both maps. These points are used in our algorithm to calculate the correct user position on the virtual map. Figure 2 shows a screenshot of the tool. Based on the corresponding points of a variable and constant scale map a reasonably exact position of the user can be calculated on the variable scale map (by approximation). The algorithm implemented for our mobile guide can be used for the synchronization of an arbitrary number of maps with a different visualization of a certain area and with different scales. The algorithm is given in pseudo-code:

```
Point mapPosition(Position gpsPos, List virtualPoints, List realPoints)
{
     Point pos = gpsToMapCoordinates(gpsPos);
     List closeRealPoints = getClosestPoints(realPoints, pos);
     List closeVirtualPoints = getClosestPoints(virtualPoints, pos);

     List translationList = closeVirtualPoints - closeRealPoints;
     List distanceList = distance(closeRealPoints, pos);

     float shortestDistance = getSmallestValue(distanceList);
     List weightList = weightList(distanceList, shortestDistance);

     Point totalTrans, totalWeight;
     foreach (element of translationList)
     {
        totalTrans += translationList[i] * weightList[i];
        totalWeight += weightList[i];
     }

     return (pos + (totalTrans / totWeight));
}
```

The input of our algorithm is the GPS coordinate pair of the position of the user, and the lists of corresponding points marked by the guide designer on the constant scale map (CSM) as well as on the variable scale map (VSM). The first step in the algorithm is the “translation” of the GPS coordinates into map coordinates (this is straightforward if the GPS coordinates of the corners of the map are known). After this conversion, some new lists are created: `closeRealPoints` are the points on the CSM within a certain radius around the user position, `closeVirtualPoints` are the same type of points on the VSM. `translationList` contains the translations between each corresponding coordinate pair of the CSM and VSM. The distances between the position of the user and the marked points of the CSM are stored in `distanceList`.

From the `distanceList` the smallest value is determined and used to assign weights to every list value. In the last step the mentioned weights are multiplied with the calculated translations (`translationList`). By adding the results to the original GPS position, we get the corresponding correct position on the variable scale map.

This relatively simple algorithm suffices for a good approximation of the position of the user on the variable scale map. In contrast with (Harrie, Sajakoski and Lehto, 2002), where more complex parameterized map distortions can be modeled, our approach only uses the indicated corresponding points as input. Since this information is limited to the points that were indicated by the guide designer, there is no underlying grid structure that is suitable to calculate an exact transformation from a coordinate on the real map to a coordinate on the hand-drawn map.

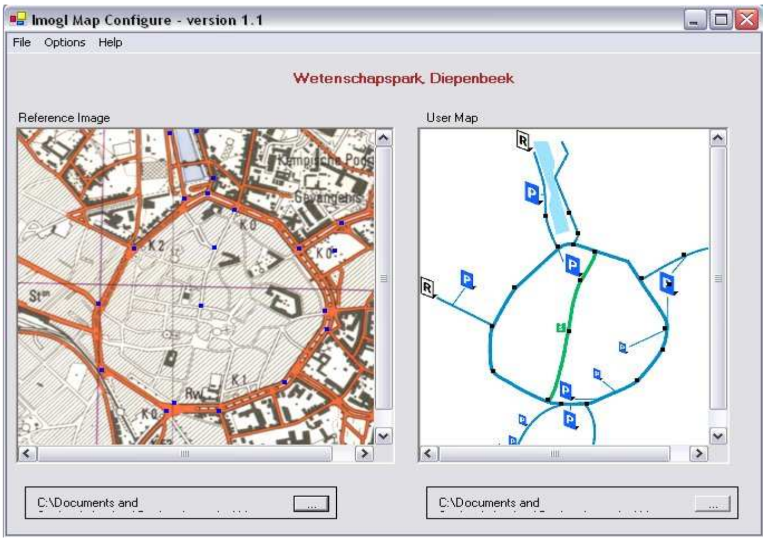

Figure 2 Two maps of different and/or variable scales can be related with each other by indicating identical points on both maps.

5 Layered Semantics

The visualization of the map with the position of the user is considered as the basic functionality on which other services can be provided. ImogI offers the possibility to create separate autonomous services that make use of the basic functionality. A service can render data on the display (on top of the map or in a separate dialog) and the user can interact with this data. As such, a *semantic layer* is responsible for the visualization of a service and for the interaction with this service. Semantic location-based layers can be considered as a specialization of annotations on electronic documents (Fogli et al., 2004).

Figure 3 shows the three maps that are interrelated (section 4 shows an example with two maps) with on top of these maps three different layers that provide an iconic presentation of their data. One layer shows parking icons on the map and the user can interact with these icons to retrieve the number of free spaces on each parking. The second layer shows icons that provide general information about a place. The third and final layer shows pictures that have been taken with the mobile guide on a particular location. Each layer visualizes some domain-specific information, but also provides domain-specific functionality. As will be shown in section 6 the functionality that is required to

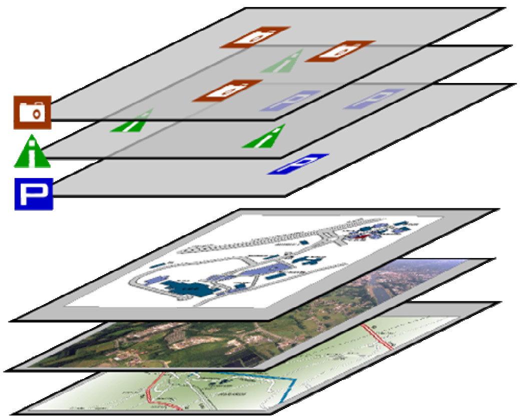

Figure 3 Three layers on top of three maps.

execute a domain-specific service can be embedded in the program code for a layer.

The advantage of this approach is the possibility to provide a separate tool for each layer. Since each layer is defined by a separate ontology a “layer tool” reflects this ontology in the type of data that can be manipulated by the tool. The generation of a dialog-based interface from a (formal) domain description of a dialog is discussed in (Eriksson, Puerta and Musen, 1994). In this work the authors show how a domain ontology acts as a specification for a target tool.

Figure 4 shows a tool that allows creating data for the “Company info layer” (layer 2 in figure 3), so this information can be shown when the user interacts with an icon indicating there is some company info related with a particular location. The “Company info layer” is a typical example of a layer that requires pre-visiting information but does not generate any post-visiting information. It is informative but does not capture related data during the visit like whether one of the companies was actually visited by the user.

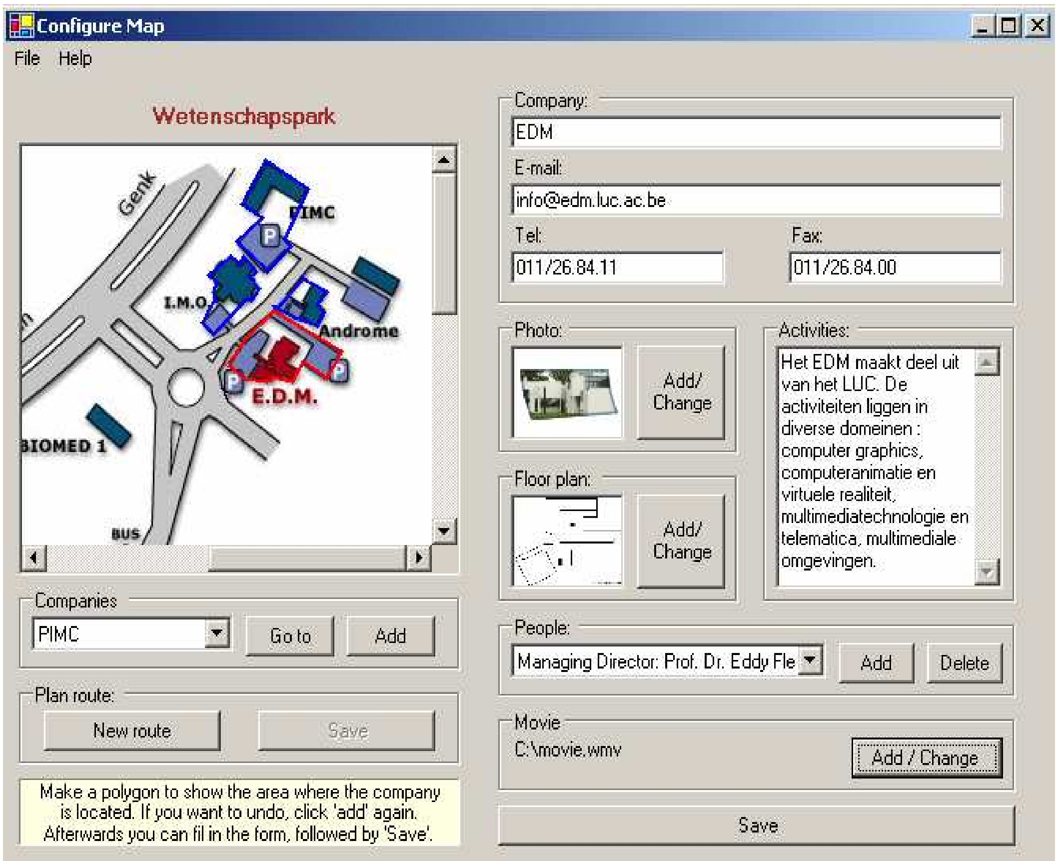

Figure 4 A simple tool for the creation of data for the "Company information layer" to add information to a company on the map. The input fields can be mapped onto the ontology for "Company information".

At this stage ImogI offers a separation of different domains and services in separate layers. The information entities provided by the different layers often have relations that could be sufficiently important to visualize in the user interface. We propose the use of a common formalism to specify these relationships: since each layer is in accordance with a certain ontology, inter-layer relations can be expressed by means of another semantic web technology like the Resource Description Framework language (RDF, 2004) and the Web Ontology Language (OWL, 2004). In our current implementation this is not supported yet: more research is required to determine how and which semantic relations between layers should be visualized for the user.

6 Case Study: A Mobile Photo-Blogging Layer

As a proof of concept we created a mobile photo-blogging application that takes advantage of the integrated hardware available in modern PDAs (GPS, camera, wifi-enabled) and networking opportunities provided by the surroundings (WLAN). This layer is a service upon the ImogI framework and takes advantage of the capabilities offered by this framework such as GPS and visualization capabilities. The photo-blogging application enables the user to take pictures of the environment on several places. In figure 3, the top layer is the mobile photo-blogging layer: for each photo that is taken an icon is added on the map that indicates a photo is associated with that particular location. The blogging layer is a typical example of a layer that does not require any pre-visiting information, but does generate post-visiting information. The post-visiting information is used to automatically update a web-based photo-blog, where the different photos can be browsed and queried. Figure 5 shows the website that presents the post-visiting information: notice the captured meta-data enables us to automatically show the route of the visitor and to allocate the photos to different locations on this route.

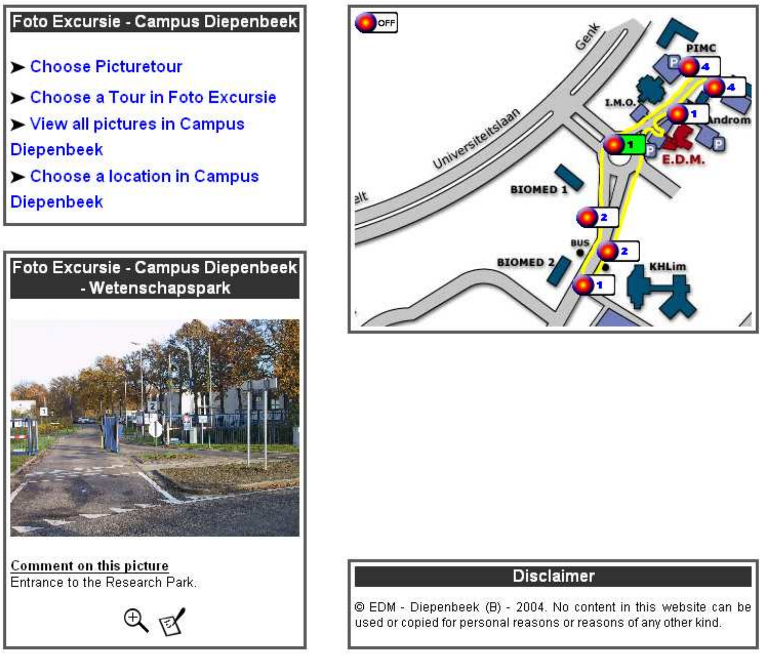

Figure 5 Mobile Photo Blogging: post-visiting information made accessible on the web.

Besides a real-time visualization of the data that is acquired during a visit, the functionality embedded in this layer automatically captures the meta-data and stores it with the related information entities that were captured. The information that can be extracted from sensor readings and related information includes which known artefacts are nearby the current position, orientation of the user, GPS coordinates and time. This meta-data can be used afterwards to create a richer user experience by visualizing this information in an appropriate way. A similar application can be found in (Davis et al., 2004), where part of the meta-data is inferred and/or corrected by leveraging the spatio-temporal context and social community of media creation. Travelblog (Brown and Chalmers, 2003) is another similar example: it is a system to build web based travelogues describing their travels with pictures, videos and text captured by a mobile phone. To the author's knowledge Travelblog does not provide automatic meta-data capturing.

7 Future Work and Conclusions

In this paper we presented an electronic mobile guide that is divided in two different parts: a core component providing functionality that is common for most mobile guides and a component supporting domain-specific layers that make use of the services offered by the core component. Each layer contains domain-specific functionality and domain-specific visualization and is based on an ontology describing the concepts and relations from the targeted domain. Relations between ontologies indicate relations between different layers of the mobile guide. We found this approach allows software developers to customize an electronic mobile guide with new services, taking into account domain-specific knowledge.

Although the system presented here is fully operational, there is no automatic conversion of an ontology into a layer and of inter-ontology relations (e.g. owl:sameAs (OWL, 2004)) into inter-layer relations. Tools are necessary to support the creation of semantic layers conform to the ontology definitions that go with these layers.

8 Acknowledgements

Part of the research at EDM is funded by EFRO (European Fund for Regional Development), the Flemish Government and the Flemish Interdisciplinary institute for Broadband technology (IBBT).

References

C. Bornträger and K. Cheverst, Social and Technical Pitfalls Desiging a Tourist Guide System, In *HCI In Mobile Guides*, pages 1-5. In conjunction with *Fifth International Symposium on Human computer Interaction with Mobile Devices and Services*, 2003, Udine, Italy

B. Brown and M. Chalmers (2003) Tourism and mobile technology, In: Kari Kuutti, Eija Helena Karsten (eds.) P*roceedings of the Eighth European Conference on Computer Supported Cooperative Work*, Helsinki, Finland, 14-18 September 2003., Kluwer Academic Press

K. Cheverst, N. Davies, K. Mitchell, A. Friday, C. Efstratiou, Developing a Context-aware Electronic Tourist Guide: Some Issues and Experiences, *CHI '00: Proceedings of the SIGCHI conference on Human factors in computing systems*, 2000, pages 17-24, The Hague, The Netherlands, ACM Press

M. Davis, S. King, N. Good, and R. Sarvas. "From Context to Content: Leveraging Context to Infer Media Metadata." In: *Proceedings of 12th Annual ACM International Conference on Multimedia (MM 2004)*, ACM Press, 188-195, 2004

H. Eriksson, A. R. Puerta and M. A. Musen, Generation of Knowledge-Acquisition Tools from Domain Ontologies. *International Journal of Human-Computer Studies* 41:425-453, 1994.

D. Fogli, G. Fresta, A. Marcante, P. Mussio, IM2L: A User Interface Description Language Supporting Electronic Annotation, In *Developing User Interfaces with XML: Advances on User Interface Description Languages*, Eds. Luyten K., Abrams M., Limbourg Q., Vanderdonckt J., May 2004, Gallipoli, Italy

N. Fridman Noy and D. L. McGuinness, *Ontology* Development 101: A Guide to Creating Your First Ontology, *Stanford Knowledge Systems Laboratory Technical Report* KSL-01-05 and Stanford Medical Informatics Technical Report SMI-2001-0880, March 2001.

J. Goodman, A. Dickinson, and A. Syme, Gathering requirements for mobile devices using focus groups with older people, In S. Keates, J. Clarkson, P. Langdon, and P. Robinson, editors, *Designing a More Inclusive World, Proceedings of the 2nd Cambridge Workshop on Universal Access and Assistive Technology (CWUAAT)*, pages 81-90, Cambridge, UK, Mar 2004, Springer

L. Harrie, L. T. Sarjakoski and L. Lehto, A variable-scale map for small-display cartography. *Symposium on GeoSpatial Theory, Processing and Applications*, July 2002, Ottawa, Canada

L. Harrie, L. T. Sarajakoski and L. Lehto, A Mapping Function for Variable-Scale Maps in Small Display Cartography, In: *Journal of Geospatial Engineering*, vol. 4, no. 2, pages 111-123, December 2002.

C. Kray, and J. Baus, A survey of mobile guides, In *HCI In Mobile Guides*, pages 1-5. In conjunction with *Fifth International Symposium on Human computer Interaction with Mobile Devices and Services*, 2003, Udine, Italy

K. Luyten and K. Coninx, ImogI: Take Control over a Context-Aware Electronic Mobile Guide for Museums, *Workshop on HCI in Mobile Guides*, September 13, 2004, Glasgow, Scotland

OWL, OWL Web Ontology Language Overview, *W3C Recommendatiom*, Deborah L. McGuinness and Frank van Harmelen eds., http://www.w3.org/TR/owl-features/, 10 Feb 2004

RDF, RDF/XML Syntax Specification (Revised), Dave Becket and Brian McBride eds., *W3C Recommendation*, http://www.w3.org/TR/rdf-syntax-grammar/, 10 February 2004

A. Zipf and S. von Hunolstein: Task oriented map-based mobile tourist guides, In *HCI In Mobile Guides*, pages 1-5. In conjunction with *Fifth International Symposium on Human computer Interaction with Mobile Devices and Services*, 2003, Udine, Italy