INFO-1052 UDK: 681.3:008

Primljeno/Received: 2008-03-17 Pregledni rad / Author Review

MOBILE LOCATION BASED SERVICE FOR LOCATION AND PRESENTATION OF CULTURAL HERITAGE OBJECTS AND WEB 2.0 TECHNOLOGIES

MOBILNI LOKACIJSKI SERVIS ZA POZICIONIRANJE I PREZENTIRANJE OBJEKATA KULTURNE BAŠTINE I WEB 2.0 TEHNOLOGIJE

Tihomir Orehovački, Zlatko Stapić, Goran Bubaš

Faculty of Organization and Informatics, University of Zagreb, Varaždin, Croatia

Fakultet organizacije i informatike, Sveučilište u Zagrebu, Varaždin, Hrvatska

Abstract

The development of mobile technologies over the last few years has enabled their usage in all the domains of everyday life. One of the components that is becoming a common part of advanced mobile devices (e.g. mobile phones and personal digital assistance devices) is the GPS transceiver, the most common usage of which is determining the geographical location and helping navigating a certain area. In this paper we present the concept of a system for locating and presenting information about objects belonging to cultural heritage relying on mobile technologies and GPS. This kind of system can be used for educational purposes, promotion and enrichment of cultural heritage and the local community's tourist offer. Unlike other similar systems, this mobile location service has characteristics of Web 2.0 technologies usage in all its user-interaction components.

Sažetak

Razvoj mobilnih tehnologija u posljednjih nekoliko godina omogućio je njihovu uporabu u svim područjima svakodnevnoga života. Jedna od komponenti koje sve više postaju sastavni dio naprednijih mobilnih uređaja (npr. mobilnih telefona i osobnih digitalnih pomoćnika) jest GPS prijemnik, a njegova je najčešća uporaba u uređajima za određivanje geografske lokacije i pomoć u navigaciji određenim područjem. U ovom radu predstavili smo koncept sustava za lociranje i prezentiranje informacija o objektima koji pripadaju kulturnoj baštini, a oslanja se na mobilne tehnologije i GPS. Takvi se sustavi mogu koristiti za potrebe obrazovanja, promocije kulturne baštine i obogaćivanje turističke usluge lokalne zajednice. Za razliku od drugih sličnih sustava, ovaj mobilni lokacijski servis ima karakteristiku korištenja Web 2.0 tehnologija u svim komponentama koje su u interakciji s korisnikom, što je njegova velika prednost.

1. Introduction

The technological advancement in the area of mobile and wireless communications has opened a new perspective for tourism. Before the Internet era, one's departure on a journey or a vacation that was not organized by a tourist agency would require a preparation that included purchasing of travel tickets, booking the accommodation, and collecting a supply of brochures, catalogs and guides, which would normally be performed at several different locations. Today, new information and communication technologies (ICT) enable flexible online or mobile support for tourists, including easier and faster access to information. As an important component of the modern mobile telecommunications infrastructure, Location Based Services (LBS) can supply users with the necessary information depending on where users are located. LBSs can be viewed as a combination of several new forms of ICT which include a mobile telecommunication system, technology for positioning (GPS), Geographic Information System (GIS), and a database with spatial data /**1**/. Apart from the above-mentioned technology,

LBSs commonly consist of a service provider and a content provider. Initially, the mobile phone technologies enabled the transmission of voice data and short textual messages but further development of mobile technologies has resulted in the possibility to transmit multimedia objects (with the Multimedia Messaging Service – MMS), as well as in the potential of mobile wireless access to the Internet (wherein using GPRS has evolved to using EDGE/UMTS/HSDPA networks). This advancement has increased the potential of application areas of mobile devices. Modern mobile communication systems are made up of mobile devices and wireless communication networks. A mobile device, usually in the form of a mobile phone or a *personal digital assistant* (PDA), allows the user to send requests and receive the requested information and services through wireless communication networks. The main input data for LBS during the request processing is the exact position of the user who has requested a particular service. There are three most common types of location technologies for mobile devices: (a) network based technologies, (b) handset based technologies and (c) hybrid technologies /**2**/. Today, the majority of mobile devices for positioning use a *Global Positioning System* (GPS) receiver, primarily because of its accuracy and reasonable price. Apart from the GPS positioning, the approximate location of a mobile device can also be identified with the information about the mobile network cell in which the user is located, which, for example, is the case with the *Cell of Origin* (COO) technology, or with the *Angle of Arrival* (AOA) positioning technology based on the measurement of the angle of signal from a mobile device to at least two transmitters. Other location systems are *Time Distance of Arrival* (TDOA), *Enhanced Cell ID* (E-CID), *Enhanced Observed Time Difference* (E-OTD) or *Assisted Global Positioning System* (A-GPS) technologies. Each of them has its own advantages and disadvantages /**3**/. The fundamental element of LBSs is considered to be a *Geographical Information System* (GIS) used for the management, processing and delivery of spatial information that is stored in the appropriate database. Using GIS entails that the service provider, during the processing of a user request, performs a database search, locates certain objects of interest, calculates the shortest path and defines ways to navigate to the desired location, etc. However, sometimes location service providers do not manage all the information resources that users may be able to request. Instead, it is stored in databases of specialized content providers (cartographic agencies, transport companies, yellow pages, etc.). Close cooperation between them is common, allowing for the design of new types of LBS (e.g., notification about a free space in parking lots in urban areas, distribution of location specific marketing information, providing information about tourist services and offers, etc.). The late 90's witnessed an increased use of mobile phones, with a large number of manufacturers of wireless mobile technology and mapping software entering the LBS market /**4**/. Except for travel, LBSs are also convenient for their implementation in the area of tourism and a number of projects and studies have confirmed their potential in this field. One of such projects is CRUMPET (*Creation of User-friendly Mobile Services Personalized for Tourism*), funded by EU, the primary purpose of which was to develop a multi-agent system that will implement and evaluate personalized travel services /**5**/. Other projects related to LBSs that provide support to tourists are *Cyberguide* /**6**/, which provided information about the sights available in a certain city, *Guide* /**7**/, as an individualized intelligent electronic tourist guide, *PinPoint Tourist Guide* /**8**/, a contextually-oriented client-server service, *Hippie* /**9**/, which had the capability of learning and memorizing users' interests, and *M-views* /**10**/, in which the narrative aspect of LBSs was emphasized. This paper will outline the architecture of a mobile location system for the positioning of cultural heritage with an explanation of its features as well as present possible scenarios for its use. In addition, an explanation is provided of how to integrate the popular Web 2.0 technologies into LBSs for object positioning.

2. Location based services and presentation of cultural heritage

For successful presentation of cultural heritage information it is necessary to focus on different types of devices (those in general use, such as desktop and notebook computers connected to the Internet, as well as the specialized equipment that is used only in museum rooms or at archaeological sites). The most recent technologies for the presentation of cultural heritage are based on devices such as mobile phones and personal digital assistants, which provide an additional channel for communication with the tourists and various other users of such information. In addition, computer technologies are becoming more and more present in the human environment. Computer systems are being networked in order to monitor the situation in the human environment and assess the situation and the context in which the user of information is placed as well as to adapt its work and information that is being provided to the specific needs of users /**11**/. Among other things, new technologies allow for the tracking of visitors' interest in certain exhibits in a

museum (for instance, by visual tracking of visitors, their movement in the museum and sight direction) and the presentation of personalized audiovisual information on exhibits in accordance with the visitors' supposed interests. Other solutions allow for the creation of a personalized route for a tour of exhibits which closely correspond to the interests previously specified by the visitor. The third type of solutions enables the LBS to send multimedia content to users' mobile devices in accordance with their location in the region relative to the objects of cultural heritage (i.e., the information and other multimedia content concerning the heritage objects closest to the user/tourist can be automatically sent to their mobile device based on his/her position). Intelligent travel guides are especially suitable for combining technologies of mobile devices and LBS in one of the following three levels of technology integration /**12**/: (a) electronic folders, (b) location sensitive electronic folders, and (c) location sensitive intelligent electronic folders. For example, location sensitive intelligent electronic folders predict which objects the visitor will visit next and then pre-load the media content related to these objects (through a relatively slow mobile connection) that would be of interest to the visitor. Furthermore, such systems can analyze the physical behavior of visitors and their previous choice of information to download on a mobile device in order to create personalized services and individualized recommendations regarding the tourist attraction or heritage object of their interest. Finally, the information collected from current visitors using an intelligent location service, such as that concerning their interests and recommendations in relation to certain objects, as well the analysis of the type of multimedia content that the visitors have collected and decided to share with others (e.g., their photographs of a specific location) could be used to guide and inform future visitors. Needless to say, this last type of technology may involve the potentially interesting sites and objects of interest that are not yet included in the official tourist maps and brochures. Some possibilities of the application of LBSs in systems for the promotion of cultural heritage include the learning of history through historical battle simulations in a concrete spatial environment as well as the use of virtual worlds in multiplayer games /**13**/. Other investigated potentials of LBSs are associated with the use of applications that are sensitive to the context/situation /**14**/ in which a visitor of a museum or an archaeological area is placed. These applications can display more or less detailed personalized information related to the position of the visitor in the museum on the user's mobile device (e.g., a specific exhibition hall with artifacts and/or a picture on the hall wall the visitor is directed towards) or his/her position at the archaeological site (e.g., a 3D simulation of an ancient building, which shows what it used to look like from the location where a visitor is positioned). Such 3D simulations can be supplemented with intelligent guides that help the visitors during their movement through archaeological sites and/or with devices for displaying visual and audio content that the visitors place on their head (the so-called *head-mounted displays*). In this way visitors can observe both the present appearance of a site (e.g., the running track of the ancient stadium in Olympia, Greece) via a transparent display and the simulation of the movement of ancient inhabitants (e.g., the athletes who ran along the ancient Olympic track) in this area /**15**/. The described superimposed images can be created very precisely so that, except for a GPS device, a separate system is also used for determining the orientation of visitors with a compass and a video recorder. This allows the system to capture and recognize the object toward which the visitor has focused his/her eyes (e.g., a visitor is using video cameras on a device which resembles binoculars, which allows the visitor to observe a specific object and display the superimposed virtual images of how this object used to look in ancient times) /**16**/. By using edge detection of the actual objects (historical buildings, large monuments) that are being recorded by a video camera it is possible to determine the visitor's point of view and present a virtual image with the appropriate size and orientation over a particular real object /**17**/. Among especially interesting features of this system is the interaction between visitors of certain historical sites (or tourist routes in a city) in which they can create and share their content about specific heritage (and other interesting) objects online with their mobile devices, e.g., by photographing the object and its surroundings and providing comments, with a possibility of exchanging their experience with other visitors /**18**/ in an online forum, wiki or a blog. Also, it is technically possible to support group visits to certain locations taking into account the fact that individual visitors belong to a particular group and the type of their relationship with other group members. In addition, it is possible to combine the interaction between group members over mobile devices with the information about the geographical position of each group member /**19**/. When it comes to archeological sites, museums and historical subjects, the previously described technology can combine the LBS technology with mobile learning (mLearning) /**20**/. When heritage and tourist information is supplemented with e-learning technology and content, both traditional

forms of computer-aided instruction and newer forms of constructivist teaching in mobile learning can be applied, and the pedagogical techniques in form of learning games can be well combined with the techniques related to narration or other types of using historical stories /**21**/. Finally, there is a growing interest in the possibilities of combining LBSs and mobile learning with the so-called social software and Web 2.0 technologies /**22**/.

3. System for locating objects of cultural heritage

The main idea of mobile location services for the positioning of cultural heritage objects is to enable the user easy navigation during their visits to a particular heritage location, city or country. With the previous goal in mind, and assuming the availability and a wide range of possibilities to use information and communication technology, it is still necessary that the visitor to a heritage site owns a personal digital assistant (PDA) or a SmartPhone of the new generation which is equipped with a GPS receiver and a reliable connection to the Internet. Although we have previously listed several technologies for geospatial positioning, for our model we will consider the use of the GPS technology. Namely, from the perspective of application architecture there are not many significant differences between them, except for the precision of location information. An application which would be executed on the portable device would determine the position of the user and show the user the map of the city in which he/she is placed through communication with the web service, also offering details of the specific objects of cultural heritage located nearby. Although the idea of displaying *Points of Interests* is not new, the proposed system would differ from the existing ones in using certain Web 2.0 technologies, both through a mobile application and a standard web page. In other words, the main feature of our concept is the use of various web services which enable the user to browse advanced multimedia content in addition to the usual downloading of web pages with text and pictures. These web services also give the user the opportunity to place their own content (public or private, such as photographs, videos or text) online in the system. A special module in such a system would be informing the user about an object of cultural heritage in his/her immediate vicinity, which, according to user preferences, may be of the user's specific interest. On the other hand, when planning a tourist trip, the user could also access a standard web page with heritage information, which would be an integral element of the system, and enable the user to find information about cultural heritage objects of specific interest in a selected location or region. Such a system could be administered with the use of a standard web browser and the developed web application.

4. System architecture

There are several different technologies which could and also must be used when developing the system described in the previous chapter. To ensure proper selection of the appropriate mobile and other information and communication technologies

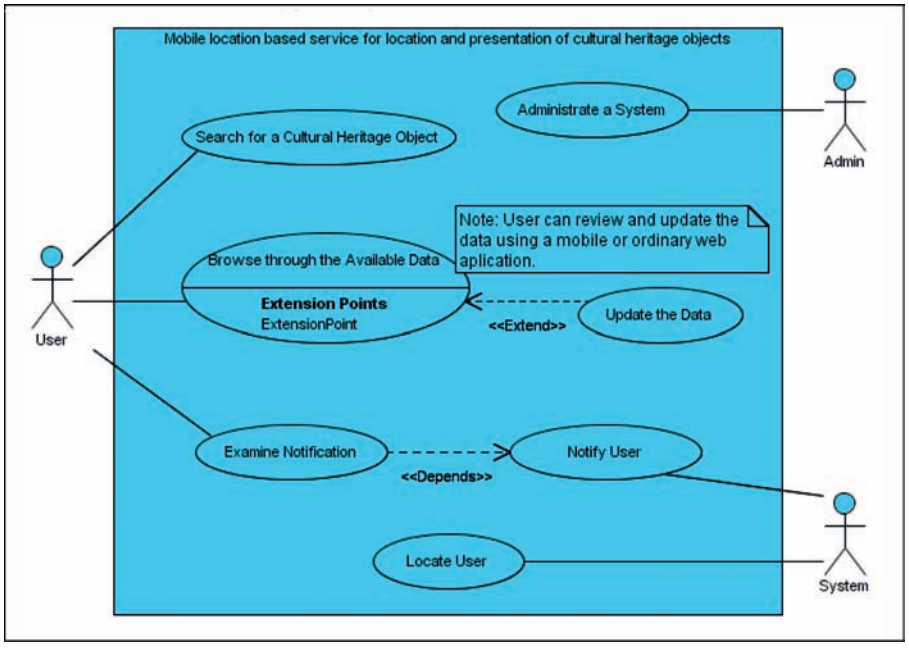

Figure 1. UML Use Case Diagram

it is necessary to implement the basic steps of the methodology of software products development during the development of such a system. Regardless of whether we choose a specific agile methodology (e.g., XP, RAD, DSDM) or a standard one (e.g., RUP, MSF, OOA), the first step in its implementation will be the definition of user requirements. At the same stage of software product development, after a set of user requirements is defined, we proceed to their specification. User requests are typically specified through the development of *use case diagrams* with the creation of detailed individual cases of use (*use case specifications*) and preparation of the document containing additional requirements (*supplementary specifications*) /**23**/. Figure 1 shows a UML (*Unified Modeling Language*) use case diagram of location services for the positioning of cultural heritage objects.

The result of our attempt to make the system easy to use and convenient for maintenance and updating of the data can be seen in the diagram in Fig. 1, which is based on the interaction between three actors. The defined actors are the user, the system, and the administrator. The *user*, as the first actor, searches for information on cultural heritage which is located in the vicinity of the place in which he/she currently resides by using a mobile SmartPhone or Pocket PC device. The *system*, which is the second actor, determines the GPS location of the user and forwards the information on cultural heritage to the user application. Apart from viewing data on the cultural heritage of the location (archaeological site, city, etc.) with a mobile device, the user also has the possibility to update the existing data with private or public documents, such as captured photographs, videos or texts to supplement the description of the visited cultural heritage objects. Naturally, users would also be able to access the same information online by using a standard web browser (not only with a mobile device with a GPS). However, in that case they would be deprived of the benefits arising from the knowledge of their location in relation to the location of the heritage objects or other points of interest. On the other hand, with a standard browser access they would have the possibility of accepting and viewing a more diverse and larger set of content concerning cultural heritage, such as high resolution video recordings, detailed image galleries and texts of greater length. It must be noted that the third actor is the *administrator* who would be in charge of administrating the content of the database which is delivered to the user by means of the above mentioned applications. The second and third phase in the development of software products are the analysis and design phases. The result of these phases is a set of different, mutually connected, static and dynamic diagrams that describe the detailed architecture of software products, collaboration and communication between participants and components, as well as other important aspects of a software product that programmers must be familiar with in order to develop software. Depending on the methodology, these two phases can be completely separated from the implementation phase (for example, by a standard methodology), or may be interwoven with the implementation phase (for

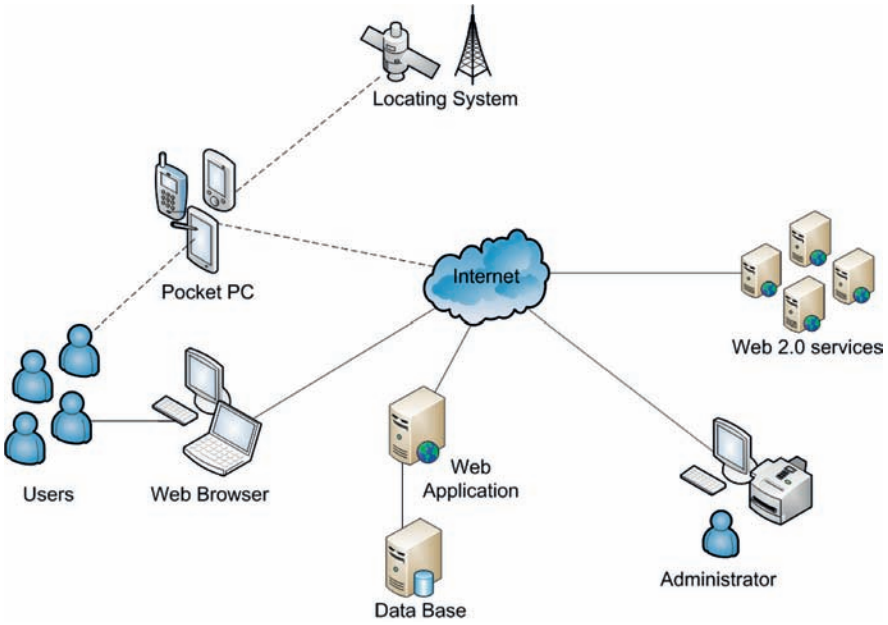

Figure 2. System architecture

example, by agile methodologies), where the system and documentation are developed in parallel and incrementally. However, the system architecture (in Figure 2) which is developed must be clearly specified, unambiguous and well established before implementation begins.

The complex system thus conceptualized consists of several subsystems that could be implemented using different information technologies and connected by means of various communication technologies. The application could be executed on mobile devices and implemented in the *.NET Compact Framework*, using MS SQL Server 2008 (or alternatively MySQL) as databases, with the web application created by using both PHP or ASP and Web 2.0 technologies. These components could be connected by using various communication technologies, such as GPRS, EDGE, UMTS, HSPDA /**24**/. The final technology would consist of a GPS receiver or another location service for the positioning of users and web services for the retrieval of cultural heritage information.

5. Web 2.0 technologies in location systems

Four years ago, O'Reilly /**25**/ presented a concept of a new generation of web applications. In his concept the dominant publishing form of web applications is replaced with dynamic, interactive and flexible web services. Users are no longer passive recipients of information, but actively participate in the creation, update, change, and transmission of new online content and knowledge. The basic properties of the new paradigms of the web are constant connection, collaboration, and exchange of resources between users.

In the application that we have conceptualized, which would run on mobile devices, the Web 2.0 technologies would perform the function of the content provider. It must be noted that in some cases service providers do not own and store absolutely every type of information that users can search for, which is why service providers are often connected with specialized content providers. Flickr, as a well known web photo album, could be used as a source of photographs on cultural heritage, which the user can view on his/her handheld device. Besides the standard database of photographs, the user could have the opportunity to take photographs of cultural heritage objects which he/she visits, upload them on Flickr and thus increase the quality and number of photographs that the mobile location service will provide to future users. Furthermore, users could be given the possibility to view a short video that would present to them the located cultural heritage object. Videos could be made available with the use of the podcasting tool Libsyn and stored at the YouTube website, the most popular provider of video content. A wiki system could be used as the main source of textual information on heritage objects, enabling users to place new information or update the existing information provided by other users. In addition, they could give personal impressions and other facts they consider important and interesting that have not been previously posted in the wiki. When it comes to navigation and positioning, the popular GIS Google Maps could be used, although for the non-exposed cities and regions (or higher resolution maps) a special cartographic module should be developed. The web applications could be developed using the Ajax (Asynchronous JavaScript and XML) technology.

5.1. Using the system: conceptual scenarios

In this section several conceptual scenarios will be explained. Potential uses of the system for positioning of cultural heritage objects will be illustrated by means of these scenarios in order to display its characteristics and practical value more clearly.

Scenario #1

John Brown arrives to the town of Križevci, Croatia, on business. John decides to fill the time between two meetings by going on a tour of the town's cultural heritage. However, he is not familiar with the town's landmarks, so he decides to use his PDA on which he activates the module for cultural heritage positioning. The system shows him the map of the town where all the sights are displayed, as well as John's location and distance to all cultural monuments. John notices that there is a Greek-Catholic cathedral in his vicinity. By clicking on the icon that represents the cathedral, John can choose to preview images of the cathedral, watch a short video or get further information on the history of the cathedral in textual form. After a short video preview, John decides to visit the cathedral. He also visits some other points of interest in near vicinity and marks those he would like to learn more about later in the LBS application of his PDA. After the second meeting John goes to the hotel where he opens a set of brief mobile learning courses on the Greek-Catholic cathedral and other selected points of interest which include educational texts, multimedia material and quizzes as well as comments made by other visitors.

Scenario #2

Mary Smith decides to visit the baroque town of Varaždin, Croatia, and get familiar with some of its cultural heritage. Mary has a PDA device that

has a personal page for the positioning of cultural heritage objects. From all the cultural heritage objects available, Mary is most fascinated by castles. During sightseeing, the module for cultural heritage positioning provides an audio signal notifying the user that the requested information has been downloaded to her mobile device. A click on the module icon informs Mary that she is located near the Old Town castle and gives her the information about the distance from the castle, the possibility of reviewing the notes about the castle, pictures and videos as well as the navigation to the castle. Mary decides to follow the navigation guidelines, and successfully arrives at the castle. She takes some photos from the angles she finds interesting and attaches her comments to them. On her PDA device she looks up the photographs and comments provided by other visitors for several points of interest at the castle. While she rests in the park with a view of the castle she uploads her selected photographs and makes them available to future visitors of the castle together with her impressions. In addition, in the online forum she briefly comments the collection of historic artifacts at the castle museum. Her activity with the LBSs is stored in a special account and she can later review both her tour of the castle and the museum, as well as her contributions as the provider of multimedia content and text. From the examples above we can conclude that the basic characteristics of the system for positioning of cultural heritage objects are the following:

- GPS coordinates are connected with the data from a GIS for a particular city or region,
- the user has the possibility of system personalization,
- the behavior of the system is defined by the context and scenario and can be proactive, if the user wants to it be so,
- the specific interests of users and their location serve as the basis for selecting and proposing services,
- the system provides location services such as navigation.

7. Conclusion

A mobile location service for locating and presentation of cultural heritage elements should differ from the existing web-based systems by many of its elements. First of all, the system should give users the possibility of personalization and customization based on their needs and interests. Furthermore, the behavior of the system should be defined by the context and scenarios and could be proactive if the user wants it to be so. On the other hand, integrated Web 2.0 technologies would allow users to supplement the existing content with their own photographs, videos or impressions, which should result in a better efficiency of interaction with users and thus increase the quality of service.

References

/1/ Brimicombe A. J., GIS: Where are the frontiers now? Proceedings of GIS 2002, Bahrain, 2002.

/2/ Unhalker, B., Handbook of Research in Mobile Business: Technical, Methodological and Social Perspectives, Ideal Group Reference, Vol. 1, 2006.

/3/ Ibidem

/4/ Dao, D., Rizos, C., Wang, J., Location-based services: technical and business issues, GPS Solutions, Springer Berlin / Heidelberg, Vol. 6, No. 3, pp. 169–178, 2002.

/5/ Poslad, S., Laamanen, H., Malaka, R., Nick, A., Buckle, P., Zipf, A., CRUMPET: Creation of user-friendly mobile services personalised for tourism, Proceedings of 2nd International Conference on 3G Mobile Communication Technologies, IEEE, London, UK, 2001.

/6/ Abowd, G. D., Atkeson, C. G., Hong, J., Long, L., Kooper, R., Pinkerton, M., Cyberguide: a Mobile Context-Aware Tour Guide, Wireless Networks, Vol. 3, No. 5, pp. 421-433, 1997.

/7/Cheverst, K., Davies, N., Mitchell, K., Friday, A., Efstratiou, C., Developing a Context-Aware Electronic Tourist Guide: Some Issues and Experiences, Proceedings of the SIGCHI conference on Human factors in computing systems, ACM, The Hague, Netherlands, 2000.

/8/ Roth, J., Context-aware Web Applications Using the PinPoint Infrastructure, IADIS International Conference WWW/Internet, IADIS Press, Lisbon, Portugal, 2002.

/9/Oppermann, R., Specht, M., Jaceniak, I., Hippie: A Nomadic Information System, Lecture Notes in Computer Science, Springer Berlin / Heidelberg, Vol. 1707, pp. 330–333, 1999.

/10/ Crow, D., Pan, P., Kam, L., Davenport, G., M-views: A System for Location-Based Storytelling, Proceedings of ACM Ubiquitous Computing Conference – UbiComp'03, Seattle, WA, 2003.

/11/ Ryan, N., Salmon Cinotti, T., Raffa, G., Smart Environments and their Applications to Cultural Heritage, Proceedings of ACM Ubiquitous Computing Conference – UbiComp'05, Tokyo, Japan, 2005.

/12/ Sklenar, L., Uttig, I., Growing a Tourist Guide, Smart Environments and Their Applications to Cultural Heritage, Proceedings of ACM Ubiquitous Computing Conference – UbiComp'05, Tokyo, Japan, 2005.

/13/ Prasolova-Førland, E., Wyeld, T.G., Divitini, M., Lindås, A., Battle of Stiklestad: Supporting Virtual Heritage with 3D Collaborative Virtual Environments and Mobile Devices in Educational Settings, International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies, IARIA, Papeete, French Polynesia, 2007.

/14/ Roffia, L., Raffa, G., Pettinari, M., Gaviani, G., Context Awareness in Mobile Cultural Heritage Applications, Smart Environments and Their Applications to Cultural Heritage, Proceedings of ACM Ubiquitous Computing Conference – UbiComp'05, Tokyo, Japan, 2005.

/15/ Vlahakis, V., Karigiannis, J., Tsotros, M., Gounaris, M., Almeida, L., Stricker, D., Gleue, T., Christou, I.T., Carlucci, R., Ioannidis, N., ARCHEOGUIDE: First Results of an Augmented Reality, Mobile Computing System in Cultural Heritage Sites, Proceedings of the 2001 conference on Virtual reality, archeology, and cultural heritage, ACM, Glyfada, Greece, 2001.

/16/ Vlahakis, V., Pliakas, T., Demiris, A., Ioannidis, N., Design and Application of an Augmented Reality System for Continuous, Context-Sensitive Guided Tours of Indoor and Outdoor Cultural Sites and Museums, 4th International Symposium on Virtual Reality, Archaeology and Intelligent Cultural Heritage, Brighton, United Kingdom, 2003.

/17/ Kretschmer, U., Using Mobile Systems to Transmit Location Based Information, Proceedings of the ISPRS Commission III Symposium, Graz, Austria, 2002.

/18/ Arrigo, M., Di Giuseppe, O., Fulantelli, G., Gentile, M., Novara, G., Seta, L., Taibi, D., A Collaborative mLearning Environment, Conference Proceedings mLearn 2007, Melbourne, Australia, 2007.

/19/ Stock, O., Rocchi, C., Zancanaro, M., Kuflik, T., Discussing Groups in a Mobile Technology Environment, Proceedings of the Virtuality Continuum Revisited (CHI 2005 Workshop), Portland, USA, 2005.

/20/ Costabile, M.F., De Angeli, A., Lanzilotti, R., Ardito, C., Buono, P., Pederson, T., Explore! Possibilities and Challenges of Mobile Learning, Proceeding of the twenty-sixth annual SIGCHI conference on Human factors in computing systems, ACM, Florence, Italy, 2008.

/21/ Raessens, J., Playing History. Reflections on Mobile and Location-Based Learning, Didactics of Microlearning. Concepts, Discourses, and Examples, Münster: Waxmann Verlag, 2007, pp. 141-160.

/22/ Taibi, D., Gentile, M., Arrigo, M., Seta, L., Di Giuseppe, O., Novara, G., Fulantelli, G., Social Tagging in a Mobile Learning Environment, Ninth IEEE International Symposium on Multimedia, 2007.

/23/ Avison, D., Fitzgerald, G., Information Systems Development: Methodologies, Techniques and Tools, Mc Graw Hill Education, 4th edition, Berkshire, 2006.

/24/ Sauter, M., Communication Systems for the Mobile Information Society, John Wiley and Sons Ltd., Chichester, 2006.

/25/ O'Reilly, T., What Is Web 2.0 – Design Patterns and Business Models for the Next Generation of Software, 2005, accessed: 28th April 2008, URL: http://www.oreillynet.com/pub/a/oreilly/tim/news/2005/09/30/what-is-web-20.html