Evaluation of Mobile Tourist Guides

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Abstract. Mobile guides have been in the spot light for the past decade or so they are becoming excessively available to tourists visiting places around the world. Most of which are to be used via a network connection on a browser based device and others as such as proprietary mobile applications, installed on-device. As such, some guides are used as navigational assistants in large cities solely for exploratory services and others can be used indoors as museum guides. This paper researches past and present mobile guide applications using a detailed set of evaluation criteria to extract design principles which can be used by an application-designer or an application-developer.

Keywords: mobile tourism, map guides, guide architecture, evaluation

1. Introduction

The convergence of information technology, the internet and telecommunications have generated radical changes to tourism industry. In parallel, mobile phones are transcending from a traditional voice communication devices to instruments facilitating an interaction of the three major sectors noted above [1]. The mobile phone sector increasingly supports personal navigational systems and the usage of the mobile web platform [2]. However, by nature, mobile phones will always have differences in comparison to the desktop computer; let it be screen size, input methods, or just capabilities. Given current technology constraints of the mobile web platform on mobile devices, a number of traditional web applications are still turning up as robust mobile applications running in conjunction to mobile browsers. These applications are compensating on constraints which have arisen due to the lack of compliance to static web standards [3].

This paper focuses on the evaluation of research and commercial applications which are used by tourists (and not only) to get information, navigation, guidance or just cultural information using a mobile device. In this evaluation we envisaged design guidelines of a tourist platform which could be used by tourists on and off the web in a static or in a mobile environment. The remainder of this article is organized as follows: Section 2 introduces the design criteria which were used in this evaluation, Section 3 discusses the included projects with relevance to the design criteria stated in section 2. Section 3 concludes with an evaluation table portraying major design principles for mobile tourism guides.

2. Design Criteria

The main goal of this paper is to extract design principles which can be applied to the technology infrastructure with respect to services offered to tourists via web or mobile applications, on/offline. wanting to see what architectural solutions are given to such a desired mixed mode (static or mobile) user experience. The extracted design criteria are expected to aid application designers and developers in the development of a mobile tourist application. To meet this objective a large number of websites, web applications, and mobile guide applications have been evaluated. We considered including not only milestone research mobile guide applications but also commercial navigational assistants and web-to-mobile applications readily available to all tourists via the web. Indeed, focus is given to mobile tourist guides systems running on any hardware architecture using or not a connection medium.

Most research on evaluation of mobile guides has been presented by scope of issue [4][5]. Kray et al [4] studied map-based navigational guides evaluating guides based upon 5 issues: basic features offered, situational factors, adaptation capabilities, user interaction and architecture. Chen and Kotz [5] considered the issue of context-aware to evaluate mobile guides. Our work additionally tries to answer two questions: what design principles can be used by application-designers for the design of mobile tourist guides; what technological choices do developers have while embarking on this specific area. Those basic questions brought forward a new sub-set of evaluation criteria which took into consideration our vision of the creation of a nomadic tourist information platform [9] running on readily available mobile technology.

The main categories of design principles found in reviewing literature can be summarized in the following:

- What *architecture* was used; which technology platform was chosen to implement the applications in stake; could these be used in today's mass mobile technology devices?
- What *information models* were adapted for mobile guides; do they make use of personal profiling and or collaborative filtering techniques to offer personalized information and services; could the information model be updated easily?
- What type of *network infrastructure* was needed to support the project on hand (e.g. WiFi, BT, and 3G); could the application adapt to changing networking environments? What was the cost of usage of such systems to the users?
- What type of *positioning technologies* and *map technologies* were used to support indoor and outdoor use; Were maps used to support the user? Could they be used to support route finding, dynamic itinerary support to users? What types of location-based services were offered? How did navigational technology support the user context with respect to information provided to them?
- What types of *input/output modalities* were used? Did the projects offer various types of information using multimodality techniques such as 3D graphics or speech? Could it support different languages?
- What *unique services* were designed and how were they implemented (e.g. using web agents, web services); were these services accepted by tourist users? Did the projects integrate any existing standards-based frameworks or initiatives to support tourist users or were all services propriety based?

3. The evaluation

Many projects related to mobile tourism have been carried out so far. In our survey we focused to research projects listed as being milestone and also m-guide applications which have investigated specific design issues of interest to this paper.

3.1. Architecture / Development Platforms used

The architecture of a mobile system depicts the way a system is designed and reveals the mobile devices targeted. While researching the types of architecture and platforms used in implementing mobile tourism guides it became clear that most systems used some sort of connection to an external source, but how this connection was used varied in different ways. In specific, in the Cyberguide project [6], its technological infrastructure alternated due to the release of different prototypes. Most versions used commercial PDA with a pen input system based on Microsoft Windows using a Visual basic Runtime system. At some stage of the project the Apple MessagePad 100 with Newton 1.3 was tested for the indoor versions using IrDA sensors for location, and also the Dauphin DTR-1 palmtops were tested. The GUIDE system [7] used specific mobile devices namely Fujitsu TeamPad 7600 portable PC with 2 hours of autonomy and a transflective monitor. The system implemented a HotJava [13] browser which was embedded in the application interface. When network coverage was lost it was implicitly shown to the user in the way of a gauge. The Guide system could adapt to network outages by supplying scaled down locally stored version to its users. Also, the LoL@ project [8] was based on conventional Internet Software technology and user interface paradigms, extended by concepts to improve usability for the mobile domain. This application targeted high end mobile phones and smart phones with Java Applet enabled full-fledged web browsers and a touch screen. The mobile terminal used Java applet technology on the client side and Java Servlets on the server side. In the HIPPIE/HIPS project [9] clients were PDAs which used a thin client (web browser) application with client-server architecture requiring a stable network connection to operate. Apart from the use of PDA devices the project stated the use of notebooks to access all web based content.

The TellMaris project [10] was based on a client-server model, which meant all data was downloaded upon request via a wireless connection. The openGL system was developed on Linux, Windows and Windows CE platforms; however the system also ran on the Nokia communicator 92XX. Whereas the Deep Map system [14] was based on the agent-oriented software paradigm which allowed for easy reuse of components in different systems. The Deep Map prototype was implemented using two technologies; one of a belt worn Xybernaut mobile assistant IV having a visual output on a flat touch sensitive screen mounted on the arm and the other a laptop placed in the user's backpack. This research system was a multi-agent system which was developed with two interfaces: A web interface accessed by users via a PC and a mobile system used in tourist mobile situations. The Crumpet [15] project was based on a standards-compliant open source agent framework, extended to support nomadic applications, devices, and networks. The system was built using a three tier structure having mobile clients at one end, the user services on the other end and the use of multi-agents in between both. At the stage of usability testing a PDA was used as the client device using GPS as positioning technology. Yet, it was argued that any terminal with a screen able to display rendered maps and simple HTML pages could be used.

The SmartKom [16] used a distributed component architecture using an agent based multi-blackboard system. The integration platform is called MULTIPLATFORM (Multiple Language Target Integration Platform for Modules), built on the top of open source software making it open, flexible and scalable software architecture able to integrate heterogeneous software modules implemented in diverse programming languages and running on different operating systems. SmartKom includes more than 40 asynchronously running modules coded in four different programming languages: C, C++, Java, and Prolog. The same software architecture and components were used in three fully operational application scenarios: SmartKom-Mobile implemented using a Compaq iPAQ Pocket Pc, SmartKom-Public was a multimodal communication kiosk for airports, train stations or other public places, SmartKom-Home/Office realized a multimodal portal to information services. Using the Fujitsu Stylistic 3500X portable webpad as the hardware platform it provided electronic programming guide (EPG) for TV, controlled consumer electronic appliances such as VCRs and DVD players, and gave users access to standard applications like phone or email.

The REAL project [17] uses both PalmOS and Pocket PC platform for indoor and uses a SONY VAIO notebook outdoor for computational power but for graphical and textual presentations a special clip-on for glasses from MicroOptical was used in conjunction with a customized Garmin GPS unit as a pointing device. The notebook also incorporated the IBM Embedded ViaVoice format based speech synthesizer and dynamic rule grammar based recognizer. For both indoor and outdoor systems the 2D and 3D-graphics are generated via the embedded Cortona VRML1-browser.

The Mycitymate [20] system is a 2 part platform providing information namely of city locations like venues, café, pubs, bars, accommodation etc. The MyMytilene city [21] was a prototype which entirely based on Java, on both the web server and the client tier. Regarding the supported format of tourist content, XML-family technologies where chosen to enable compatibility with web standards and interoperability. The mobile application was developed on the top of Java ME Platform (previously known as Java 2 Micro Edition or J2ME).

3.2. Information Model

The information model of each system varies in the type of information provided to the user. It was noted that the more detailed information given to a tourist, the more complex the information model was. The knowledge of the user’s location and usage context resulted to context-aware information systems offering personalized information to each tourist. Some systems were noted as using an adapting personal profile and others used collaborative filtering techniques to offer a more personalized information system.

As of the Cyberguide information model, it was divided into four independent components named as: the Cartographer which had knowledge of the physical surroundings, the Librarian providing access to information of sights, the Navigator which was aware of the tourist's location and surroundings and the Messenger which offered communication services to tourist to communicate with sights (University staff) and for the system to communicate with visitors or groups of visitors. Whereas, the LoL@ implemented a hierarchical approach to model information using a browser metaphor of hypertext links, linking to text and multimedia information. The Hippie project was based on context sensitive models which apart from location, positioning and direction-detection also used an adaptable personal profile, acquired from the user explicitly and implicitly, logging the users' preferences which resulted to a context aware system; the system knew of its surrounds by having access to the organizations information system. The HIPS project was based on an Adaptive Hypermedia information model having a web-based infrastructure.

The Deep Map information model was quite complex as it was connected to the spatial and the other databases. Apart from the use of text, audio, video, 3D and VR as output using a dynamic multilingual information model. It also used '4D' techniques to portray representations in 3D of original buildings which no longer existed. In the CRUMPET project, the adaptation of services resided on the notion of filtering based on a user profile which was gathered by getting information of user interests, abilities and characteristics. If the user frequently requested information of a particular category, this particular category of information was known to be preferred by the user thus allowing the system to offer more personalized information.

The REAL application integrated two subsystems: the system IRREAL (Infrared REAL) for indoor navigation tasks based on infrared senders, and the system ARREAL (Augmented Reality REAL) for outdoor navigation based on GPS-satellites. IRREAL uses passive location sensitivity, whereas ARREAL relies on the active counterpart.

In the mycitymate application, the user had the ability to customize and build a guide based on personally chosen user generated content. The mycitymate project used a 3-tier architecture on the web server side and a hierarchical information model on the mobile application side. The information which was chosen of sights to be downloaded could not be updated but could be commented. Premium guides are offered via a channel system wherein users can create audio guides and given the ability to sell them to other users via the mycitymate platform.

3.3. Network Infrastructure

Regarding the network infrastructure, apart from which type of connection was used to link the mobile device to a central information management system, the way the system handled network outages was a key issue in the paper.

The Cyberguide used a Wireless network to implement a messaging service; it was designed to cater for communication between tourists and the system. The system could not adapt to changing networking environments or predict networking shortages. The Guide system was based on a city installation of a wireless LAN infrastructure. This wireless LAN was used as a location finding source and also a source of a centralized information service which a user could pull information from or be pushed information directly to the mobile device according to its position. In cases of network failures a caching mechanism was implemented to counter for such an outage. The LoL@ implemented a network-centric 3-tier application architecture using UMTS (3G) or GPRS network via a mobile phone. The fact that the LoL@ project required constant network connectivity where all content data was stored on a database server and prepared on demand resulted to data intensive costs for the user which found as a major disadvantage during user tests, where visitors were reluctant to use the system considering the high roaming fees which accumulated [8]. No adaptation capabilities were designed as such failing with network shortages.

The TellMaris system used a WLAN to support the service, yet, it apparently could use a GSM. No reference was found for support of cognitive network resource adaptation. The Deep Map prototype system used a wireless LAN infrastructure as the basis of the client/server architecture. The project noted that a GSM network could be used to increase the area of use but effectively would narrow down bandwidth available for services offered. The system design did incorporate the adaptation to network shortage but as such in literature found was not implemented at the time.

3.4. Positioning/Map Technologies

The use of maps and positioning technology was thought as being key issues of most mobile tourist applications. Most systems used a map of some sort and were stated as using GPS for outdoor positioning and IrDA for indoor positioning as appropriate. The Cyberguide system included mapping, information retrieval, positioning and communication services. All maps and information was stored locally on the devices. All outdoor maps were vector-based allowing for scaling and path generation whereas indoor maps were raster-based. The user could access information via the map interface which also showed icons of Points of Interest (POI). By clicking on these POI's the user could access information about that sight. The map showed the position of the user and the POI's in vicinity. The outdoor CyberGuide system used GPS for positioning; as for indoor, IrDA sensors were used, yet no adaptation techniques were implemented in the case of failure of these positioning techniques.

The Guide system was one of the first installations to confirm the use of a map for electronic tourist guides. These maps were raster-based and were presented to tourists on demand to show the area of issue. Wireless hotspots were strategically setup in a way as to offer broad location positioning services. This type of technology was mainly chosen because the infrastructure was already in place but also argued that in specific built up areas of the Lancaster city a GPS system would not be adequate to get positioning information. As of the LoL@ project a central feature was its navigational and routing capabilities. To determine users position a hybrid positioning system was used: cell ID positioning and GPS positioning technology. The system used an interactive location refinement procedure prompting the user for verification of position which improved accuracy in location finding. It was noted that each time the visitor reached a POI, they checked it on the map as 'visited' which was automatically entered into a personal diary with time details in the order of entry. The Hippie systems used IrDA sensors in front of every exhibit and at all room entrances for localization services which generated simple spatial references of objects and spatial references at a room level. An electronic compass was used to track user's orientation.

In the TellMaris mobile version, the system displayed both 2D and 3D maps simultaneously. The 3D map data was broken up into cells. The project used a number of repositories which stored the map data and corresponding routing information for that area. The mobile guide had access to the repository communicating the current position and receiving data in respect to the given location. The core of Deep Map was the geographical information system (GIS) and other databases. The GIS database stored spatial data while there was a database to store temporal data (i.e. historical information of sights) and a separate database to store topological information such as user information and information about places (i.e. restaurants, cafes, shops). The CRUMPET project integrated GIS as a means to integrate large volumes of geographical data. This meant that the project offered individual information on topics such as personal tours, navigational assistance and route finding. Map adaptation examples include culture specific map colouring, map generalization, user-orientation dependent maps, focus maps and personalization.

The REAL project developed a pedestrian navigation system that combined active and passive location sensitivity in such a way that the change-over between both adaptation paradigms was barely noticeable. For outdoor location services GPS was used and an electronic compass was incorporated in the system for direction finding. IrDA beacons were used to locate a user indoors.

3.5. Input/Output Modalities

Some projects implemented a standard input modality using some sort of input device, whereas other projects offer various types of information using hi technology multimodality techniques such as 3D graphics or speech. All I/O modalities are reviewed in this section also noting the type of multilingual support implemented.

The CyberGuide system gave textual information via a user interface of buttons, the system was considered as having a unimodal user interface and there was no reference to bilingual support. The content of the Guide system was multilingual and based on a distributed and dynamic information model. The LoL@ project was implemented for 3 languages (including speech input support) and had the ability to detect visitors selected language via the SIM card of the device or by manually choosing localization language; support for input based on voice commands was also implemented. Speech recognition was implemented using the Nuance Speech toolkit. This toolkit has heavy hardware resource requirements, as such a dedicated server was used to host the speech recognition software and all voice commands were transmitted from the mobile device via Voice-over-IP solution based on Session Initiation Protocol (SIP) and the GSM voice codec for server processing.

The Deep map project allowed users to use natural language as input and listen to rendered audio as output. The system was robust enough to handle spontaneous multilingual voice commands in an outdoor environment. The speech recognizer was restricted to a few thousand words, in which had to be processed into to spatial requests, which in turn were translated into database queries. Using a semantic layer which encoded interactions independent of target languages, Deep Map could support dynamic multilingual interactions. SmartKom supported dynamic multi-lingual interaction by introducing a semantic layer that encoded interactions in a way that was independent of the actual target language.

3.6. Unique Services

Most mobile tourist applications offer services of some sort. These services are seen as an essential part of a mobile tourist guide, regardless of users' appreciation. Nevertheless, each system offering a unique service is evaluated herein.

The Cyberguide system could document user visits which at a later stage could be sent via email to the visitor. The Guide system gave enough flexibility to visitors to use upon request, providing them an intelligent tour guide builder that developed customized tour guides based on time constraints and dynamic changes to the user's environment (stopped, for coffee, slow walker). The Guide system also offered support for Interactive Services; a communication tool for visitors to contact the local Tourist Information Center, messaging tool amongst visitors. It also had a built-in ticketing service where visitors could book accommodation and buy tickets avoiding queues. The LoL@ system implemented a tourist diary service offered upon confirmation of arrival to a sight or by accessing the My Data menu item to enter information. This was later uploaded to the server and enabled viewing the log of visited sights.

Likewise, the Hippie project allowed for interpersonal communication and general public communication of ideas through message sending. The mobile system allowed for personal annotation which was added to the user's personal space to be accessed at the post-visit stage. Other prototypes of the HIPS project implemented dynamic generation of presentations depending between the user and the object and how long users stood in front of the object. The TellMaris project quoted a number of services which would be implemented to be offered for both portable PC and mobile systems. For portable PC systems services like weather forecasts, hotel reservation and navigational guidance services were thought of. For mobile devices, users would be able to request information about various sights, find closest facilities or to buy specific products. Yet, none of these services could be found at the implementation stage [1]. The CRUMPET system offered a simple user interface and handling of services including a recommendation system based on personal interests, interactive maps with overview of areas with maps highlighting sites of interest and -apart from information about tourist attractions- it used unobtrusive proactive tips notifying of nearby sites.

The Mycitymate project has developed a service where users can publish their location and locate 'mates' (friends). The use of HTTP and manual position check-in was used to implement this service.

	Information Model	Position/MAP Technologies	Input/Output Modalities	Architecture/ Network Infrastructue	Unique Services
Cyberguide	On-device storage. Proprietary application Distributed Dynamic Information. Context Aware..	Map based IrDA and GPS. Automatic logging system	Pen / Screen Not Multilingual	Visual basic Run time system – PDA WLAN Non cognitive resource adaptable	Guided tours. Messaging. Broadcasting. Post visit logging.
GUIDE	Centralized Hypermedia personal profile. Push & pull information.	Map - Guidance WLAN positioning. No adaptation	Pen / Screen Multilingual	JAVA – Portable PC WLAN Adaptable to failing resource	Communication Ticketing service tour generation
LoL@	Centralized Hypermedia model	Map - Guidance/Route Cell-id and GPS. User adaptable positioning. Manual logging system.	Pen / Key Pad 3 language Multilingual	JAVA APLET enabled VoIP Speech input UMTS Adaptable to failing resource	Pre-visit Post -visit Commenting diary service
Hippie/HIPS	Centralized Hypermedia model Personal Profile. Push & Pull Context aware	Guidance Electronic Compass IrDA sensors – object level and room level	Pen / Screen Not Multilingual	Microsoft .Net PDA - Subnotebooks Client -Server browser WLAN	Pre-visit Messaging. Broadcasting. Post visit logging
TellMaris	Proprietary application, not context aware	Map - Route finding. GPS	Pen/Screen 3D graphics Modality	Windows CE PDA Nokia S60 platform WLAN GPRS, UMTS	Exploratory
Deep Map	User context and context aware	Guidance Vector maps Route finding. User adaptable positioning.	Pen/Screen Multilingual support	Standards-compliant open source agent framework WLAN GPRS, UMTS	Agent based services
CRUMPET	Explicit and Implicit personal profile. User-aware unobtrusive proactive tips Context aware	Itinerary planning. Guidance Vector maps Route finding. location-based services	Pen/Screen Multilingual support	Client -Server Standards-compliant open source framework WLAN, GPRS, UMTS Cognitive resource adaptation	Guided tours Group meeting scheduler
SmartKom	Centralized Hypermedia model Personal presentation model	Guidance Maps Route finding GPS adaptable	Pen/Screen, speech Multimodality input / output. Multilingual	Agent Architecture. Multi-blackboard system. GSM, GPRS, UMTS	Communication Localized information
REAL	Localized information. User-aware. unobtrusive proactive tips. Proprietary application	Active location sensitivity Passive location sensitivity	3D-pointing device. 3D graphics Modality Speech input	PalmOS/Pocket PC GPS + Electronic compass (outdoor) IrDA indoor WLAN,GPRS, UMTS	Exploratory
MyCityMate	Explicit personal profile. Static Collaborative filtering. Proprietary application	Raster based maps Static underground railway maps Google map api using GPS positioning.	Keypad	J2ME application based system GSM, GPRS, UMTS Adaptable to failing resource.	Communication Registered position broadcast. Rating system, Labelling system Commenting system
Mytilene e-guide	Hierarchical information presentation Explicit personal profile Proprietary application	Raster based map Orientation	Keypad	J2ME application based system BlueTooth	Exploratory Push model

Table 1 Features of the reviewed mobile guides, navigational assistants and city guides.

4. Conclusions

Table 1 summarizes all systems stated in this paper against the evaluation criteria used to focus on the six areas of interest. It is evident that with respect to the information model most systems implemented proprietary applications using explicit and implicit means to offer adaptable information of a personalized nature customize.

This evaluation presented in this paper revealed the design principles which need to be taken into account at the analysis and design stage of mobile tourist guide. Key issues which were brought out of this evaluation fall into 5 categories.

The *architecture* which can be used, the *information model*, the map and *positioning technologies* which can be used to implement location-based services, the *modalities* which can be used to cater for input and output methods and the *unique services* that should be accounted for inclusion in mobile tourism applications. In general, most architectures were based upon the 3-tier model, yet it was seen for modularity purpose the use of compliant agents would bring about an open modularity for ease of expansion.

The information models which can be used directly reflect the amount of information a user can receive and how this information is relevant to the user and the users' context. Regarding positioning technologies, most systems used a map as a central feature which in turn offered navigational and routing capabilities. Referring to I/O modalities, the systems implementing speech modalities for input or output were said to be resource-constrained, requiring large chunks of bandwidth to function. Lastly, the unique services offered to users should be designed and implemented in a user-centric fashion, making such services useful and user friendly.

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