Developing a Context-aware Electronic Tourist Guide: Some Issues and Experiences

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ABSTRACT

In this paper, we describe our experiences of developing and evaluating GUIDE, an intelligent electronic tourist guide. The GUIDE system has been built to overcome many of the limitations of the traditional information and navigation tools available to city visitors. For example, group-based tours are inherently inflexible with fixed starting times and fixed durations and (like most guidebooks) are constrained by the need to satisfy the interests of the majority rather than the specific interests of individuals. Following a period of requirements capture, involving experts in the field of tourism, we developed and installed a system for use by visitors to Lancaster. The system combines mobile computing technologies with a wireless infrastructure to present city visitors with information tailored to both their personal and environmental contexts. In this paper we present an evaluation of GUIDE, focusing on the quality of the visitor's experience when using the system.

Keywords

Mobile computing, context-awareness, adaptive hypermedia, user interface design, evaluation.

INTRODUCTION

The rapidly evolving field of mobile computing has massive potential for providing dynamic multimedia information to people on the move. Indeed, it has been predicted that in a few years time a large proportion of web browsing will be carried out via mobile devices. However, restricting the use of mobile devices to such tasks greatly underestimates their potential.

One area of research that is concerned with exploring the ways in which mobile devices can be used to provide more sophisticated services is that of context-aware computing [15]. Context-aware applications utilise contextual information, such as location, display medium and user profile, in order to provide tailored functionality.

This paper describes some of the issues and experiences gained while developing and evaluating GUIDE, a prototype context-aware tourist guide.

The GUIDE system [4,6] integrates the use of personal computing technologies, wireless communications, context-awareness and adaptive hypermedia [2] in order to support the information and navigation needs of visitors to the city of Lancaster. In more detail, GUIDE utilizes a cell-based wireless communications infrastructure in order to broadcast dynamic information and positioning information to portable GUIDE units that run a customized web-browser.

This paper focuses on three main parts of the development of GUIDE, namely:

- The requirements for supporting the information and navigation needs of city visitors.
- The design of a customized web-browser application to meet these requirements.
- An evaluation of GUIDE focusing on the quality of the visitor's experience.

GUIDE REQUIREMENTS

General Approach

We gathered an initial set of requirements for GUIDE from a series of semi-structured, one-to-one interviews with members of staff at Lancaster's Tourist Information Centre (TIC). In addition, several days were spent at the TIC observing the information needs of visitors.

Identified Requirements

Flexibility

One of the key requirements for GUIDE was the need to provide sufficient flexibility to enable visitors to explore, and learn about, a city in their own way. For example, some visitors prefer to follow a guided tour while others may choose to explore on their own, following one or more guidebooks or street maps. So, therefore, the system should be capable of acting as an intelligent tour guide or as a richly featured guidebook depending on visitor's needs.

It is also important that the system enables visitors to control their pace of interaction with the system. For example, visitors should be able to interrupt a tour in order to take a coffee break whenever they desire. In addition, a visitor should not feel overly pressured by the system to leave an attraction prematurely.

Context-Sensitive Information

A further requirement was that the information presented to visitors should be tailored to their context. There are two classes of context that should be used, namely personal and environmental. Perhaps the most significant piece of personal context is the visitor's interests, e.g. history or architecture. Other examples of personal context that should be used include: the visitor's current location and any refreshment preferences they might have. Examples of environmental context to be used include: the time of day, and the opening times of attractions. When creating a tour of the city, GUIDE should use both personal and environmental context to create a suitably tailored tour.

Context should also be used when presenting information to the city visitor. For example, information should be presented in a way that is suitable given the age and technical background of the visitor and their preferred reading language. Context should also be used to adapt the presentation of information depending upon the information that the visitor has already seen. For example, if a visitor makes a return visit to a landmark then the information presented should reflect this fact, e.g. by welcoming the visitor back. Oberlander [12] uses the term *coherence* to describe the notion of tailoring the presentation of information based on what the user has already seen.

Support For Dynamic Information

During our study we found there to be a significant requirement for the support of dynamic information. Such information should be made available to visitors whenever their context deems this to be appropriate. For example, consider the hypothetical scenario in which a visitor touring the city has expressed a particular interest in Lancaster castle. When starting their tour, the castle was closed to the public because the courtroom, situated within the castle, was in session. However, because the court session finishes early the visitor should be notified that the castle is now open to the public.

Support for Interactive Services

Studying tourist activities in Lancaster revealed that a surprising number of visitors make repeat visits to the TIC, often during the course of a single day. In most cases this is because they either wish to ask a member of staff a specific question or they need to make use of a service offered by the TIC, most commonly the booking of accommodation. In order to help alleviate the need for visitors to walk back to the TIC to ask a question the system is required to support some form of electronic messaging service. In addition, the system should also enable visitors to make accommodation bookings without having to return to the TIC.

THE DEVELOPMENT OF GUIDE

The GUIDE system is based on a distributed and dynamic information model that is disseminated to hand-held GUIDE units using a cell-based wireless communications infrastructure.

Selection of the Hand-held GUIDE Unit

We considered a wide range of end-systems for use in GUIDE, including pen-based tablet PCs and PDAs, and finally selected the grayscale transflective version of the Fujitsu TeamPad 7600 [8] as illustrated in figure 1.

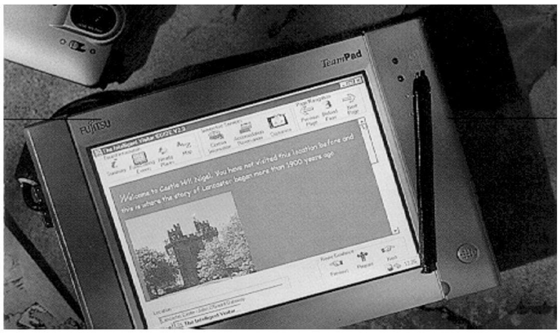

Figure 1: The GUIDE end-system.

The unit measures 213x153x15mm, weighs 850g and is based on a Pentium 166 MMX processor. It has a battery life of approximately two hours (driving the wireless networking card) and is readable even in direct sunlight.

Wireless Communications Infrastructure

The cell-based wireless communications infrastructure used to broadcast both location and dynamic information to mobile GUIDE units is shown in figure 2.

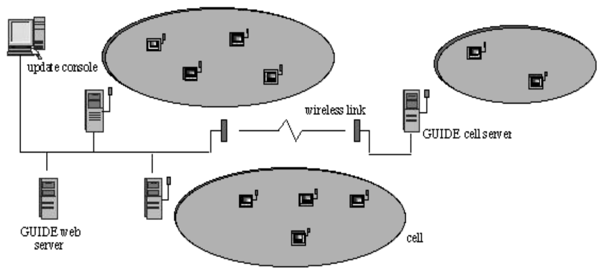

Figure 2: The GUIDE communications infrastructure.

In more detail, the city contains a number of WaveLAN cells, which conform to the IEEE 802.11 standard. Each cell provides a shared bandwidth of 2 Mbit/s and is supported by a GUIDE server. The fact that WaveLAN cells can be relatively large (up to 300m in diameter depending on the layout of buildings) means that GUIDE servers may have to support a potentially large number of GUIDE units. It was, therefore, decided that some form of broadcast based approach to data dissemination should be used for transferring information to the portables units.

Obtaining Positioning Information

In the current system, portable GUIDE units obtain positioning information by receiving location messages that are transmitted from strategically positioned base stations. We adopted this approach rather than one based on Differential Global Positioning System (DGPS) techniques for two reasons. Firstly, the approach requires no additional hardware and secondly because in a built up area it is often not possible to 'see' a sufficient number of satellites to obtain accurate positioning. However, using this approach does result in a lower resolution of positioning information.

The GUIDE Information Model

The GUIDE system required some form of information model in order to represent the following types of information:

- Geographic information.
- Hypertext information.
- Active components that can react to events.

Existing models are inadequate for representing all of the aforementioned information types [6] and so we designed a purpose built information model (figure 3).

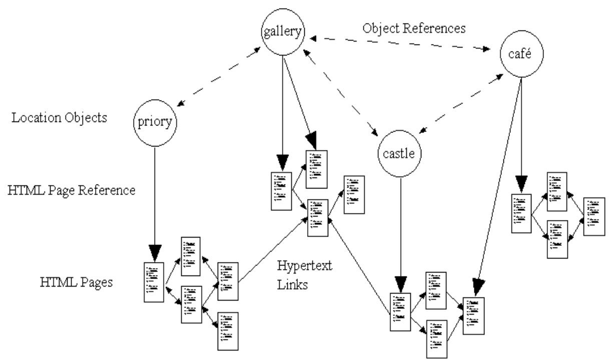

Figure 3: The GUIDE information model.

The information model manages the requirement for representing geographic information by including special navigation point objects. These can be used in conjunction with location objects for determining the best route between a source and destination location. One example of a location object is the city's castle. This object contains state representing various attributes, e.g opening times, and also contains hypertext links to related information.

Each GUIDE unit is able to locally cache parts of the information model and is therefore able to operate even when disconnected from the network. However, during periods of disconnection the cached information model can become stale which could result in out of date information being presented to the visitor.

APPLICATION AND USER INTERFACE DESIGN

The user interface to GUIDE is based around a modified browser metaphor. This decision was made on the basis of the growing acceptance of the web and the increasing familiarity of the browser metaphor as a tool for interaction. We hoped that positive transfer from the use of common web browsers would help make the system both easy to use and easy to learn for users with previous web experience. However, we also wanted to ascertain the extent to which the basic metaphor would be appropriate for the task of supporting the additional functionality required by GUIDE. In addition, we wanted to investigate the extent to which differences and inconsistencies with the standard would prove confusing to users.

In order to use GUIDE a visitor must first enter some personal details, such as their name, interests and preferred reading language. Having entered these details they are presented with the screen shown in figure 4.

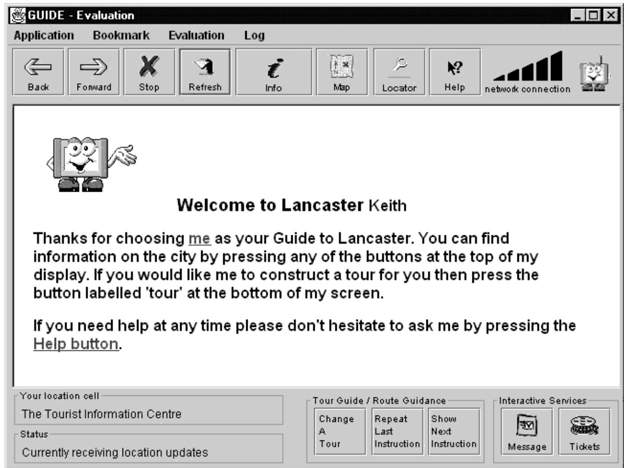

Figure 4: Welcoming the visitor to GUIDE.

In order to help the system appear more approachable to visitors we have attempted to give GUIDE a friendly personality. This decision was based on the observation [14] that, in general, novice users will find a computer-based interactive system more approachable if it is perceived as having a polite and friendly personality.

At this point, visitors have the flexibility to explore and retrieve information about the city using their own preferred methods (a requirement described in the 'Identified Requirements' section).

In more detail, the visitor can touch an appropriate button in order to perform one of the following tasks:

- Information retrieval.
- Navigation of the city using a map.
- Creating and then following a tour of the city.
- Communicating with other visitors or the TIC by sending a text message.

- Booking accommodation.

Alternatively, the visitor could simply head off to explore the city and resort to using the facilities provided by GUIDE as and when required. The ways in which the visitor can request information, navigate the city using a map or create and follow a tour of the city are described in the following three subsections.

Information Retrieval

Touching the info button enables the visitor to ask their GUIDE for information. More specifically, the visitor is presented with six choices for obtaining information as shown in figure 5.

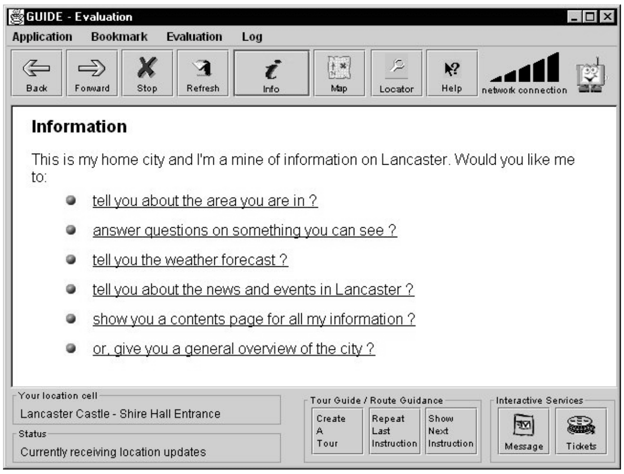

Figure 5: Choices for accessing information.

The first two options are context-sensitive in that they both lead to the presentation of information based on the visitor's current location. In particular, the second option is available in order to allow the visitor to query GUIDE in much the same way as they might query a person with local knowledge of the area. When choosing this option the visitor is shown thumbnail type pictures of things nearby with associated textual descriptions and links.

The latter three options allow the visitor to request information that is not connected with the current location. An earlier version of the GUIDE system did not support these three options but instead constrained the visitor's search for information by trying to pre-empt those specific pieces of information that we believed would be of interest to a visitor at each and every location. This was achieved by providing only a limited collection of hypertext links on every page. A series of initial trials revealed that this method for enabling users to access information was unsuitable. During the trials, visitors would, on occasion, became frustrated when the system did not provide the appropriate hypertext link for accessing specific information.

On a more general point, our experience with this aspect of the GUIDE system has taught us that designers of this kind of context-aware system should be careful not to be over zealous when deciding how to constrain information provided by the system based on a certain context.

Navigation Using a Map

The GUIDE system supports visitors wishing to navigate the city by enabling them to choose between viewing an overview map of Lancaster or a map of the local area.

At an early stage in the project we discussed whether or not the system should present maps because of the apparent sufficiency of providing succinct location-aware directions. However, from early trials with the system it soon became clear that a significant portion of visitors want to view a map at some point in their visit.

Creating and Following a Tour of the City

On touching the 'Create A Tour' button the visitor is asked to select those attractions that they wish to visit on their city tour. In more detail, the visitor is presented with various categories, such as 'Historic' and 'Recreation', from which to choose attractions. However, one of the problems with asking the visitor to choose attractions is that he or she does not necessarily appreciate what is special in a given town. For this reason, GUIDE provides a 'Popular Attractions' category that contains such special attractions.

When creating a tailored tour the system currently takes into account the following factors:

- The opening and closing times of the requested attractions.
- The best time to visit an attraction, e.g. avoiding opening time if there is often a queue.
- The distance between attractions and the most aesthetic route between them.

Once a tour has been created, the visitor can request GUIDE to navigate them from one attraction to the next by clicking on the show next instruction button.

It is important to note that the recommended ordering of the tour can change dynamically. This can occur when a visitor stays at a location longer than anticipated or if one of the attractions announces that it will close early. The system regularly calculates whether or not the current order for visiting the remaining attractions is appropriate given current time constraints.

The visitor can either agree to be taken to the next attraction recommended by GUIDE or override this recommendation by selecting a different attraction to be the next destination. The system provides this choice in order to prevent the system behaving in an overly authoritarian manner. It does, after all, seem reasonable to allow a visitor to delay their current tour and get directions to the nearest café instead.

However, providing this flexibility involved a significant increase in interface complexity and this part proved most difficult to visitors (see evaluation results).

Having asked the system to 'take me there' the visitor is presented with some directional information.

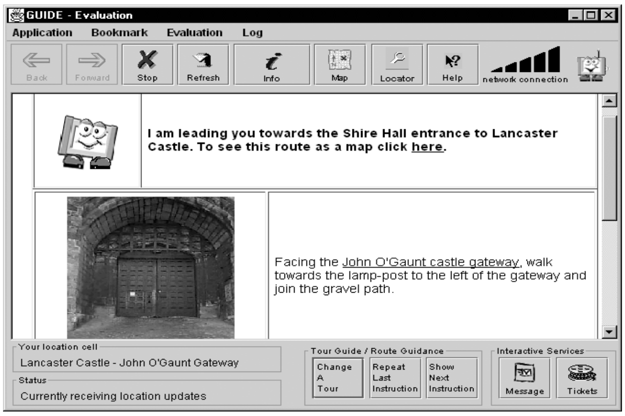

Figure 6: The presentation of navigation information.

The screen-shot (figure 6) illustrates the visitor being presented with succinct but detailed directions to their next location in their tour. In addition, the visitor is shown information on their current location, i.e. the gateway to the castle, and a hypertext link is available should the visitor wish to find out more information.

Providing an Awareness of Disconnected Operation

The current way in which the GUIDE system is engineered, i.e. using a cell-based communications infrastructure, results in situations where the mobile GUIDE unit does not have network connectivity. The fact that GUIDE units can cache large parts of the information model locally enables much of the system's functionality to remain available throughout periods of disconnection. However, disconnected operation clearly affects other aspects of GUIDE functionality such as location information, the messaging service, access to interactive services, e.g. ticket booking, and the reception of dynamic information.

Our key concern was that the system could appear unpredictable to visitors during periods of disconnection and that this would adversely affect their trust of the system. To help alleviate this problem, the user interface to GUIDE has been designed to encourage the user to form a suitable mental model of the system, i.e. one in which the functionality of the system is not static but dependant on whether or not wireless connectivity is currently available. This is achieved by providing the user with an appropriate level of mobile-awareness [3] to enable them to appreciate the affect of changes in connectivity on the system.

In more detail, we decided to incorporate a metaphor into the GUIDE user interface that would provide visitors with feedback regarding the current state of connectivity and also encourage them to associate this with available functionality. To choose a suitable metaphor, we considered how connectivity feedback is provided on mobile phones. The user of a mobile phone is given feedback of their current connectivity in the form of 'bars of connectivity' and when a user receives no bars of connectivity they expect limited functionality, i.e. the inability to send or receive calls.

In addition to the 'bars of connectivity' icon, the user interface also provides visitors with an awareness of the state of location updates. This is achieved using two text message boxes (positioned at the bottom-left of the display) one of which is used to state the visitor's current (or last known) location whilst the other provides feedback regarding the reception of location information.

The fact that the user interface is based on the direct manipulation paradigm implies that only buttons that actually do something should appear active. For this reason, we chose to 'grey-out' the ticket-booking icon when the facility is unavailable due to disconnection. We had also considered disabling the messaging icon when operating in disconnected mode, but instead chose to modify the messaging dialogue box to state that the message being composed would not be sent until on-line operation was resumed. We chose this approach to enable visitors to compose messages when out of communications coverage (a facility also common on mobile phones).

EVALUATION BY EXPERT WALKTHROUGH

Approach

The reason for evaluating the GUIDE system by expert walkthrough was to provide a crude first pass evaluation of the system's usability prior to its use by visitors.

Four experts, with backgrounds spanning user-centered design and computer supported learning, were asked to test the full range of GUIDE functionality for a period of approximately one hour. Experts were asked to use a talk-aloud protocol while using the system and were then interviewed and asked to criticize the system.

Findings

The expert walkthroughs revealed a number of problems with the system as described below.

- The button layout should be consistent with that of other browsers. This was fixed for the prototype used in the field trial.
- Animated feedback should be given to signify when a page is downloading. This was included for the prototype used in the field trial.
- The information button should be increased in size in order to encourage its use when the user may otherwise feel under encompassed. This adjustment was made for the field trial prototype.
- The system should learn the walking pace of the visitor and adjust the tour times appropriately.
- The presentation of lists of attractions, e.g. nearby attractions, should be adapted such that attractions already visited are moved further down the list.

- The visitor should be given some notion of how much information is still to be viewed on a particular topic and how much remains unseen.
- It can be difficult to select hypertext links using the touch sensitive screen. This was partially remedied by increasing the font size used.
- The existence of back and forward buttons and buttons for requesting to view the next or previous navigation instruction can be confusing because of the apparent semantic overlap. This was partially solved by graying-out the back and forward buttons when following a tour as opposed to a hypertext link.

Time constraints meant that only some of the suggested improvements could be made to the prototype before proceeding with the field trial evaluation. Another constraining factor was the mobile unit itself, i.e. its limited processing power and restricted screen size.

EVALUATION BY FIELD TRIAL

The main objective of our evaluation at this stage of the project was to validate and refine our initial set of requirements against a set of end-users. In addition, we wanted to know whether or not people were prepared to accept the use of a computer-based context-aware tourist guide. Consequently, we wanted to measure the quality of the visitors experience [9] as opposed to performance times for getting from A to B or accessing information X.

Approach

The evaluation of the GUIDE prototype by field trial was subject to a number of constraints. In particular, we felt acutely aware of the fact that we would be impinging on the leisure time of tourists. For this reason, we asked visitors to use the system as they would wish to use it and for only as long as they felt happy, rather than asking them to perform some predefined series of tasks.

Our method for evaluation was based on direct observation, with visitors encouraged to use a talk-aloud protocol for audio recording. In addition, we maintained a time-stamped log of their interaction with the system in order to gather a record of the number of links followed. Following each test, a semi-structured interview was performed in order to obtain the visitor's subjective opinion of the system.

We felt that this approach was suitable given the main objective of the evaluation. By shadowing users we could observe those parts of the interface causing problems. The semi-structured interview enabled us to follow up on any problems that were encountered during the trial and also enabled us to tailor the duration of the interview to match the time constraints of the visitor.

Findings

Over a period of approximately four weeks we had 60 people volunteer to use the system. The breakdown of these people in terms of age, gender and experience with the web is shown in table 1.

Age Profile	Number	Male	Female	Web Experience
10-20	6	4	2	6
21-35	15	7	8	7
36-55	26	12	14	8
56-70	13	6	7	1

Table 1. Profiles of visitors involved in the evaluation.

Validation of requirements

The majority (53/60) of visitors appreciated the flexibility provided by the system, i.e. the ability to use the system as a tour guide, a map or a guidebook. However, seven visitors thought that the system had too many choices available and expressed a desire for a 'less is more' system that could be easier to use.

All visitors expressed the opinion that the location-aware navigation and information retrieval mechanisms provided by the system were both useful and reassuring. In addition all visitors said that the ability to receive dynamic information, e.g. the 'specials' menu of a café, was a worthwhile feature.

However, the provision of access to interactive services, such as booking accommodation, had a more mixed response from visitors. Indeed, (5/60) of visitors would much rather speak to someone when booking accommodation (even if this meant queuing) and (48/60) of visitors said that they would want some form of confirmation that the booking had taken place. Suggestions for this included: a phone call back to the visitor's mobile phone or confirmation from the TIC.

Visitor's Subjective Opinion on Information Presentation.

All visitors appreciated the idea of being allowed to follow links to receive greater levels of detail (or related details) on an information topic. However, seven of the visitors expressed some concern that they might have missed information on a particular topic.

Despite the antagonism expressed by some expert users towards certain friendly interface features (e.g. the Microsoft paperclip), none of the visitors made negative comments regarding GUIDE's friendly personality.

The vast majority (59/60) of visitors stated that they enjoyed using GUIDE to explore the city. However, one person became frustrated when using the system because information was not available on a particular attraction.

The vast majority (59/60) of visitors said that they were prepared to trust the information presented by the system, including the navigation instructions. Interestingly, all visitors said they would be more inclined to trust such a system when provided by a reliable source, e.g. the TIC. A number of visitors suggested that their level of trust varied with the apparent accuracy of the information presented.

Visitor's Subjective Opinion on the GUIDE unit.

A reasonable majority (45/60) of visitors were basically happy with the dimensions and weight of the portable GUIDE unit. Of those that were not, only two stated that they would have preferred a smaller (PDA) sized device while 13 said they would have preferred a thinner device.

Interesting Results Based On Visitor Profile

All visitors in the 10 to 20 age profile seemed to revel in the technology and visited approximately twice as many links (per minute of usage) as those from other age profiles. This does not necessarily mean that visitors from this age group were learning more, but does suggest that they were more eager to explore the information available.

The vast majority (21/22) of visitors without previous web experience felt comfortable using the system to follow a tour and retrieve information by navigating hypertext links after a brief five minute training session.

Visitors Acceptance of Awareness Information

A large majority (54/60) of visitors said that they were aware that their GUIDE unit utilized wireless communications in a similar way to a mobile phone and that when no bars of connectivity were shown on the interface then reduced functionality would be available.

A reasonable majority (47/60) of visitors said that they appreciated that the system knew of their location to within a certain area by receiving location updates.

RELATED WORK

The earliest work on developing a location-aware tourist guide was Cyberguide [11]. An extended version of the system [13] was developed that utilised wireless connectivity in order to enable visitors on demonstration days to observe the location of other visitors.

Closely related work in the area of intelligent context-aware electronic tourist guides is currently being conducted as part of the HIPS (Hyper-Interaction within Physical Space) project [1].

Work on presenting 'intelligent labels', i.e. tailored information, to museum visitors is being carried out under the auspicious of the ILEX project [5]. Information is based on the visitor's profile and what they have seen previously.

FUTURE WORK

For future work, we intend to investigate the potential benefits of supplementing the existing GUDIE infrastructure with the latest low-power, micro-cellular, wireless communications technologies, such as Bluetooth. In particular, we hope to extend GUIDE services to within buildings and investigate the potential for developing additional context-aware interactive services. With this extended communications infrastructure in place we intend to assess the potential for performing highly computational tasks, such as the calculation of a tour, remotely. A number of the issues that can arise from performing remote computation in a mobile interactive system, e.g. the affect on interactive feedback, are investigated in [7].

Another future direction for GUIDE will be to utilize the growing acceptance of connected personal computing devices, e.g. WAP phones. It should be possible, in the near future, to enable visitors to download software onto their own device (with built-in Bluetooth support) in order to enable access to context-aware information and services.

A further avenue to explore is the potential for making the visitor's profile persistent. This raises some interesting possibilities, for example, if a visitor has shown an interest in castles on a previous city visit then this could be stored in their profile and used to tailor the presentation of information on future visits.

DISCUSSION AND CONCLUSION

This paper has described our development and evaluation of GUIDE, a prototype system for providing city visitors with context-aware information.

Through our evaluation of GUIDE, we found a surprisingly high level of acceptability across a wide range of users. However, for some visitors the flexibility provided by the system was a little bewildering and this illustrates the need to enable visitors to choose the level of functionality that they require. In addition, visitors should be able to choose GUIDE units based on different form factors and input devices. For example, use of the NaviPoint [10] input device could enable a system that supports one-handed operation.

A number of implications arise should systems like GUIDE become popular. For example, some form of agent will be required to enter dynamic information into the system and maintain/monitoring the accuracy of information. In Lancaster, the TIC is requesting additional council funding in order to employ a member of staff to act in this role.

Another implication is the potential effect of a system like GUIDE on the local business model. It will be interesting to discover the critical mass needed, i.e. the number of visitors using GUIDE, before local businesses consider GUIDE an important avenue for marketing their products.

The following conclusions could be used by others working on designing interactive systems based around mobile computing and/or context-aware systems.

- Interaction with a context-aware/location-aware system is not affected by the design of the user interface alone. In fact, interaction with GUIDE is, to a large extent, governed by the design of the infrastructure, i.e. the strategic placement of cells in order to provide appropriate areas of location resolution and network connectivity.
- Our experience with evaluating the presentation of context-aware information has taught us that designers need to be careful when deciding to pre-

empt the information requirements of users based on current context. For example, when we restricted the information available to visitors, such that they could only access information on the attractions at their current location, some visitors became frustrated because they could not query the system on things visible in the distance.

- It is important to consider the potential advantages and disadvantages of borrowing or modifying familiar metaphors for use in different scenarios. For example, the modified browser metaphor used by GUIDE caused some confusion because of the semantic overlap between the standard back and forward buttons and the buttons for requesting to view the next or previous navigation instruction.
- In the leisure industry there appears to be a growing acceptance of the use of technology. Indeed, the uptake of personal technology by members of the public, such as mobile phones, and personal organizers, suggests that more and more members of the public are prepared to make use of technology if it provides tangible benefits.

Following on from this last point, for a system like GUIDE to be accepted by the public at large it needs to show clear benefits over the traditional facilities available to tourists, such as paper-based guidebooks. Based on our initial evaluation, we believe that members of the public do appreciate the system's benefits.

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