Sharing (Location) Context to Facilitate Collaboration Between City Visitors

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1. Introduction

The development and evaluation of the GUIDE system [5][6][7][8] demonstrated the potential value and acceptability of a mobile context-aware interactive assistant to city visitors. However, one of the concerns that has arisen through the development and evaluation of GUIDE is that it may lead to less social interaction by city visitors, e.g. less communication with actual tour guides, members of the Tourist Information Center, etc. Although this was certainly not the intention of the GUIDE system, the criticism is reasonable based on the fact that visitors are likely to ask GUIDE for information (e.g. guidance instructions) or services (e.g. ticket booking) that would have traditionally involved personal communication.

In a hope to redress the balance, we are currently extending the GUIDE system in order to support cooperation and encourage a sense of community between users. For one example of how this might be achieved, consider the following scenario:-

> *"John, a visitor to Lancaster, is looking for a café to visit and has asked his GUIDE to assist him in finding a suitable café. John is shown the relevant web-pages of a number of potentially suitable cafés based on their proximity and John's preference for vegetarian food. However, John is still unsure as to which café to choose and so reads a list of comments left by other visitors for the various cafés under consideration. In addition, John is shown that another GUIDE user, Mary, is currently located in one of the cafés listed. John would like to have an unbiased opinion on whether the café is currently quiet and accommodating and so decides to send a quick message to Mary enquiring about the café."*

Although supporting this kind of cooperation is clearly relevant to the research fields of Groupware and CSCW, to date, little research has investigated the ways in which mobile location-aware systems can be used to support cooperation and interaction between users. Moreover, there has been little research into the development of location-aware systems that enable mobile users to receive an awareness of other users whose location in the real world corresponds to those places being explored in the virtual world.

This paper describes the issues that have arisen while extending the GUIDE system to support this rich form of cooperation between geographically distributed visitors. The issues addressed include: supporting the sharing (and privacy) of location context, achieving the appropriate presentation of location context, managing the capture and storage of positioning information and analysis of the new demands on the communications infrastructure.

2. Background

The GUIDE system has been developed to provide city visitors with a hand-portable context-aware tourist guide. The system has been successfully deployed in the city of Lancaster and is publicly available to visitors who wish to explore the city. The system is built around a cell-based wireless communications infrastructure based on Lucent Technologies' 802.11 compliant ORiNOCO system. This infrastructure has a dual role, firstly, it is responsible for broadcasting location beacons in order to provide positioning information, and, secondly, the infrastructure is used to disseminate both static and dynamic information to mobile GUIDE units. Each cell has associated *cell-servers* with local storage and processing that effectively act as a proxy cache to the central GUIDE web server. Currently, six communication cells have been deployed within the city covering the major tourist attractions. Although the range of ORiNOCO is approximately 200m in free space, ORiNOCO signals have poor propagation characteristics through buildings and therefore by the strategic positioning of cell-servers, we have been able to create some relatively small cells. However, the resolution of positioning information provided by the cells is course grained and one communications cell can contain a number of attractions. For this reason, interaction with GUIDE is to a large extent governed by the design of the infrastructure [6], i.e. the strategic placement of cells in order to provide appropriate areas of location resolution and network connectivity.

In order to provide acceptable scalability a broadcast based approach has been adopted to information dissemination, one implication of this is that servers do not maintain any state relating to GUIDE clients, including their current position.

A visitor interacts with his or her GUIDE unit through a local web browser embedded within the GUIDE application. In effect, all HTTP requests are processed by a local web proxy, which may, in turn, need to interact with other objects in order to service the request. This aspect of the GUIDE system is described in detail in [7]. In order to support the generation of tailored web-pages, we enable page authors to reference or query the state of GUIDE objects, e.g. location objects or the visitor's profile, by augmenting pages with special GUIDE tags.

The system utilizes a purpose-built information model [8] in order to represent places, such as attractions and key buildings, within the city. The design of the information model and the GUIDE application enables city visitors to virtually explore parts of the city, e.g. to read about the City Castle while still in the Tourist Information Center. In addition, it allows visitors to use the system as a form of augmented reality, e.g. by viewing background information about the City Castle while standing outside the main gate.

3. Sharing The Location Of GUIDE Users

The sharing of location information raises a number of issues. In particular, the notion of supporting privacy of location information needs to be considered. Other issues for consideration include achieving the appropriate capture of location information and managing the storage of this information. The following subsections describe these issues in turn.

3.1 Privacy Issues

A number of location tracking systems have encountered difficulties because of the unwillingness of users to allow their location to be known to the system, as experienced with the active badge system [13].

In the current GUIDE system, the server side maintains no state information regarding the location of clients. Furthermore, no GUIDE users are given reason to feel that their location is being explicitly tracked and that this information could be available to any third party, including another GUIDE user. Indeed, during the system's evaluation no concerns pertaining to privacy of location were raised.

Some visitors are likely to feel concerned if they feel that personal context, such as their location, is available to others. For this reason we have enabled users to specify if they wish to remain anonymous or if they do not wish to have their location recorded. This information is stored in the user profile object.

3.2 Capturing the Location of GUIDE users

3.2.1 Acknowledging the location of Clients with the Server

As described in section 2, the server side of the system does not track the location of GUIDE units. Instead, each GUIDE unit maintains its current location and this information is sensed via the reception of location beacons. These beacons are broadcast every 3 seconds in order to provide the visitor with reasonably rapid feedback when walking into a new communications cell.

In order to enable the server to capture the location of GUIDE units, the immediately obvious approach would be to have clients send an acknowledgement upon receiving a location beacon. However, this approach would generate a significant amount of network traffic and therefore compromise the desire for client scalability as described in [5].

One alternative to this approach would be to reduce client induced network traffic by requiring clients to only acknowledge cell handovers. However, this approach is currently unsuitable because the cell coverage in Lancaster is not complete. As a result, a client could leave a communications cell but the server would still assume that the client had not changed location.

The chosen solution is based on a compromise that requires clients to acknowledge every tenth location beacon that is received. In the worst-case scenario, this can lead to the server having location information relating to a given GUIDE user that is thirty seconds out of date. However, given the way in which location information is being used, i.e. for providing visitors with basic location awareness, this potential for inconsistency is not considered to be a significant problem.

3.2.2 The Requirement for Tight-coupling between Communication Cells and Places

In order to provide place awareness pertaining to a given visitor, the server clearly needs to place the visitor at a specific location, e.g. the City Castle or the Folly Café. However, the location information provided by the communications infrastructure was not initially designed to provide this granularity of positioning information. Instead, it was designed to provide course 'cell-based' grained positioning information in which the cell could contain multiple places or attractions.

In order to identify the place where each GUIDE user is located there needs to be a tight-coupling between the resolution of positioning information currently provided by the communications infrastructure and the area occupied by attractions presented in the GUIDE information model.

In order to achieve this tight-coupling we are currently extending the existing communications infrastructure with Bluetooth micro-cells using the Bluetooth development kit [9] produced by Stonestreetone Ltd. Given the current high cost of deployment (5000 U.S. dollars to equip one cell-server and one mobile unit), we are initially installing one Bluetooth cell in one of the city's cafés. If this approach proves insufficient or unsuitable then we will reinvestigate the use of alternative positioning solutions, e.g. GPS or Ericsson's Mobile Positioning System (MPS).

3.2.3 Storing the Location of GUIDE users

Two main strategies have been considered for storing the location of GUIDE users within the system infrastructure, namely: on the GUIDE server and replicated across the client end-systems. With the latter approach, an update would need to be sent to all clients each and every time a GUIDE user changed location (note: since the information can be broadcast to all clients within an ORiNOCO cell, this approach is not as inefficient as it first appears).

The key benefit of storing the group's location context on the client is that this information can be accessed quickly and will be available even when the client is disconnected from the network. However, the longer this period of disconnection the greater the likelihood of the information becoming out of date. Alternatively, the advantages of storing the group's location information on the server are: network traffic will only be generated when a client makes a specific request, location information will be consistent and managing privacy through access control techniques is relatively straightforward. One possible drawback with this approach is that disconnected visitors cannot access location information, but given the dynamic nature of this information this is not expected to be a significant problem.

4. Facilitating Cooperation

Our intention has been to create a system in which GUIDE users are encouraged to cooperate and feel a sense of community with other users. This is supported by enabling a GUIDE user that is reading about an attraction to:

i. Create a comment for association with the attraction, e.g. "The espresso served at this café is superb". Alternatively, the visitor can associate a comment regarding usage of the GUIDE system in general, e.g. "I found it useful to use the map facility while following a tour ". Such comments can be read via system's Help page.

ii. Realize when another GUIDE user is (or has recently been) physically located at the attraction.

4.1 User Interface Design

We have added links to pages that relate to attractions within Lancaster in order to facilitate the reading or creating of comments associated with the given attraction and to simplify the process of sending a message to someone who is actually located there. Figure 1 shows how these links appear on the page describing Lancaster's Folly Café.

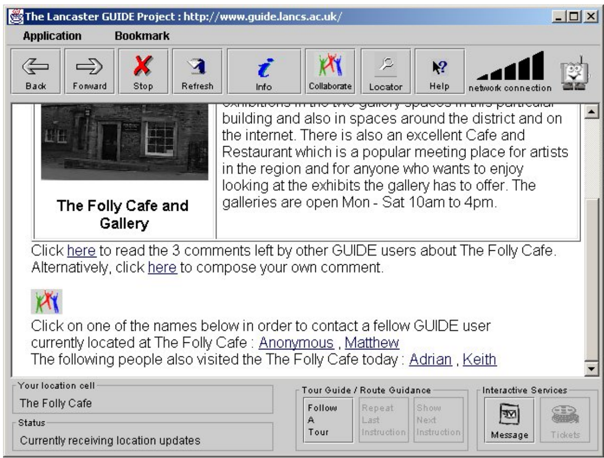

Figure 1: Example of a GUIDE page presenting location awareness to the visitor.

In the example shown in figure 1, if the GUIDE user clicks on the name 'Keith' the send message dialogue box will appear with the recipient's name automatically filled in.

Alternatively, a visitor can click on the 'collaborate' button at any time in order to discover the location of other users around the city (given the appropriate permissions) and read or publish comments about their actual location.

4.2 Enabling the Markup of Location Awareness

In order to provide pages with the ability to query the location awareness information a new 'Collaboration' tag was created as shown below.

<GUIDETAG COLLABORATE *LOCATION*>

As with other GUIDE tags, this tag can be embedded in an HTML page for preprocessing by the GUIDE filter object prior to display (see [7] for a detailed example).

On reaching the collaborate tag, the GUIDE filter object expands the tag by checking that the visitor has network connectivity and (given that this connectivity is available) makes a remote request for a list of GUIDE users currently in the cell. The server responds to the query by returning the identity of those visitors currently recorded as being present at the specified location. For privacy purposes, the actual name of a visitor is only passed back to the client if the visitor has agreed to be contactable (and the permissions for this are stipulated in the user's profile object). If a visitor has requested anonymity then a unique id is assigned and returned for that visitor, e.g. anonymous1, in order to mask the visitor's identity.

5. Future Work

One of the key areas for future work is to evaluate the support for cooperation and location sharing by a real set of end users. Such an evaluation is required in order to ascertain whether cooperation will indeed occur and whether or not visitors will generally accept the sharing of their location with other visitors. Furthermore, it will be interesting to see whether users are prepared to trust the comments of other visitors and whether or not visitors are prepared to invest the time to compose comments or respond to the queries of other GUIDE users.

Another area for future work is to further examine the issue of access control. The traditional notion of access control is based around the notion of relationships, e.g. [12] and this is clearly appropriate for GUIDE, e.g. only allowing the sharing location information to members of a family group. However, we also plan to investigate the issues raised by supporting privacy in relation to place. For example, a visitor might only be prepared to let their location be revealed to others who are in the same place, this might be because the person can implicitly trust the other people in that place. One example of such a place might be a members only club. This notion of utilizing spatial boundaries for access control is reflected in the work on SPACE by Bullock [4]. Consider also the situation in which a visitor might be prepared to be open to interruption when sitting in a café, but not when rushing around an art gallery that is about to close. There is clearly a great deal of potential for using context, such as location, to enable some form of agent to determine the when cooperation is appropriate.

An area that is of much current interest is the creation and standardisation of sophisticated location models, such as that proposed by Leonhardt [10]. Future work on GUIDE will need to investigate the adoption of such a model in order to cope with the complex relationships that arise from having places within places.

6. Related Work

A significant amount of related work exists that has investigated the tracking of users by utilizing some form of indoor communications infrastructure. This work was primarily introduced through work on the Olivetti active badge system [13] and has evolved to highly accurate systems such as the RADAR system [1].

However, the area currently being investigated is very much inspired by the research into supporting cooperation between users in a virtual space, such as providing users with awareness of other users currently viewing the same web page, as demonstrated in the CoBrow system [11]. The work of Benford *et al* on mixed reality boundaries [2] has also inspired much of our current work and is concerned with the merging of physical and digital worlds. One example of this work has been to investigate the staging of a poetry performance within real and virtual theatres.

The body of research concerned with enabling users to cooperatively navigate through complex information spaces, e.g. a city model, is referred to as Social navigation [3]. One common form of social navigation is based on recommendations between users and this is clearly related to the sharing of comments now supported by GUIDE.

7. Concluding Remarks

This paper has described our experiences of extending the existing the GUIDE system to facilitate a richer means of social interaction and cooperation between visitors using the GUIDE system. To this end, we have adopted the novel approach of bridging the gulf between virtual and real worlds by providing GUIDE users who are exploring an attraction virtually with an awareness of those visitors that are physically located at the corresponding attraction. Implementing this support has required changes to GUIDE at numerous levels, including:

i. Modification to the GUIDE application's user interface,
ii. A Redesign of the server in order to enable the storage and support the querying of location information,
iii. Extending the user profile to constrain access to location information and provide anonymity,
iv. A Re-evaluation of the GUIDE communications infrastructure.

This latter point has been caused by the need to have a tight-coupling between the resolution or granularity of positioning information currently provided by the communications infrastructure and the area occupied by attractions presented in the GUIDE information model. In particular, if awareness information is to be provided for a given attraction then the positioning information available should only relate to that attraction and not include other attractions within the area covered. In order to obtain appropriate location resolution we are currently extending the GUIDE communications infrastructure with micro-cellular Bluetooth-based wireless technology.

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