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Paper-Based Mobile Access to Databases

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ABSTRACT

Our demonstration is a paper-based interactive guide for visitors to the world's largest international arts festival that was developed as part of a project investigating new forms of context-aware information delivery and interaction in mobile environments. Information stored in a database is accessed from a set of interactive paper documents, including a printed festival brochure, a city map and a bookmark. Active areas are defined within the documents and selection of these using a special digital pen causes the corresponding query request along with context data to be sent to a festival application database and the response is returned to the visitor in the form of generated speech output. In addition to paper-based information browsing and transactions such as ticket booking, the digital pen can also be applied for data capture of event ratings and handwritten comments on events. The system integrates three main database components—a cross-media information platform, a content management framework for multi-channel context-aware publishing of data and the festival application database.

1. INTRODUCTION

One of the major challenges of mobile data management is how to support interaction for users on the move. Most research projects focus on small devices such as mobile phones and PDAs, and yet it is accepted that these are less than ideal for information systems of any complexity [5]. Restricted screen size makes it difficult to compare and combine information and to support various forms of collaboration. We therefore decided to investigate the possible use of other technologies and modes of interaction for mobile access to data. At the same time, our goal has been to develop general infrastructure to support the rapid development of applications requiring context-aware and multi-channel access to data based on advanced content publishing concepts [2].

A particularly novel form of interface that has been a focus of a number of our projects is the use of emerging technologies for interactive paper to provide paper-based interfaces to information systems. Paper has many affordances that make it attractive as an information medium, especially in mobile environments. It is light, cheap, robust, requires no power and can easily be annotated in various ways. Furthermore, it can be folded and torn, increasing the ease of taking particular items of interest with you and is easy to read in dim and bright environments and from different angles. Clearly it also has limitations in that it is a static representation of information and the presentation favours only certain forms of searching such as alphabetical listings based on names of places or events. It was our goal to bridge the paper digital divide by augmenting paper documents with rich database functionality, thereby gaining the best of both the physical and digital worlds. The key idea of paper-based interfaces is to present commonly accessed static information on paper and then enable users to activate digital services from paper for access to supplementary dynamic and context-dependent information.

Tourism has served as an application domain for many projects on mobile information systems and a number of commercial PDA-based guides are now available. However, paper maps and guidebooks are still the main tourist accessories. Tourists spend a lot of time comparing and combining information and it is therefore important that they can easily switch back and forth between options and simultaneously display related information such as maps and descriptions of historical sites or events. Working with paper documents such as maps and guidebooks, users make extensive use of bookmarks and annotation, even using fingers as temporary bookmarks to keep track of places within a book. It is important to recognise that tourism is primarily a social activity and the interaction with fellow travellers and locals in navigating around a city and planning activities is a major part of the experience. Studies show interesting ways in which tourists work with multiple documents, often distributing the tasks of finding information and using actions of pointing and positioning of documents to relate information items to each other and also to their environment [3].

To investigate the potential of paper-based interfaces, we therefore chose tourism as our application domain and developed a system called EdFest [4] to support visitors to Edinburgh Fringe, the world's largest arts festival. Users could interact with the system through a set of interactive paper documents. The user has a digital pen that can be used both as an interaction and a writing device for data input. Output was via sound using a text-to-speech engine. The paper-based user interface is offered in parallel to

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more traditional web browser interfaces running on desktop PCs or PDAs. The system was tested at the Fringe Festival in August 2005 and was also demonstrated at the Fringe's e-ticket village.

2. ARCHITECTURE

There are numerous research projects and commercially available products that link paper to digital services based on some means of detecting user actions on paper. For the realisation of our interactive paper platform we used the digital pen and paper solution provided by a Swedish company called Anoto [1]. The special digital pen has a camera embedded alongside the writing stylus to capture images of an almost invisible pattern of infrared absorbing black dots printed on paper documents. The dot pattern encodes unique (x,y) positions within a virtual document space.

While the Anoto functionality to continuously track the movement of a pen on paper provides the basis for realising interactive paper documents, a server is required that can interpret the position information and invoke the appropriate digital services. Therefore, we developed a general server platform that could be used to support any type of interactive paper application and enable both writing capture as well as pen-based interaction. The key to achieving this was to develop a general extensible cross-media information management platform, called iServer [6], that allows any form of physical or digital resources to be linked together based on a resource plug-in mechanism. To support interactive paper, we developed an iPaper plug-in that uses geometrical shapes within pages as selectors to define active areas in paper documents. As part of the iPaper plug-in, we implemented an input device handler, the *iPaper Client* shown in Figure 1, that communicates with the Nokia Digital Pen over a Bluetooth connection. The positional information is decoded within the pen and sent to iServer for further processing.

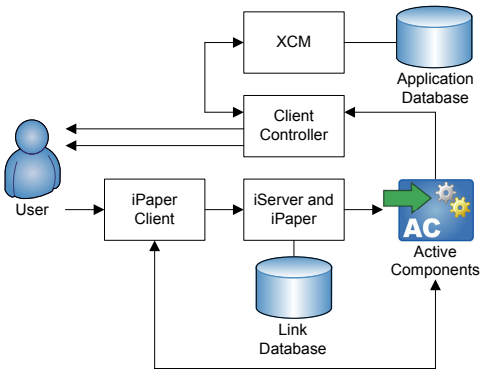

Figure 1: System components

When iServer receives a request from the iPaper Client, it resolves the selected position to the appropriate linked resource. A request can either return a simple piece of information or it can be part of a more complex interaction, where a result is only returned at the end of the interaction. iServer provides the functionality to link not only static information but also active content which is represented by *active components*. The selection of an active component results in the execution of its associated program code on the iPaper Client and on iServer. An active component that is executed on the server side may directly access information resources that are, for example, stored in external databases. In the architecture shown in Figure 1, an active component may contain a URL-encoded request which is used to retrieve information from the application database. For example, an active area within a page might be mapped to the request `http://www.edfest.ethz.ch/xcm?anchor=info`. The request then will be sent to the *Web Publishing* platform (XCM) [2]. Note that some active components do not directly return a result to the user but instead process subsequent requests from the iPaper Client.

Any request from an active component that is sent to XCM is also handled by the *Client Controller* proxy server. The Client Controller augments the requests with contextual information such as positional data before forwarding it to XCM. The Client Controller manages a context engine that gets its contextual information from various sensors. In the setup that was used for the interactive festival guide, a GPS module monitoring a user's current position was one of the sensors attached to the Client Controller.

The XCM Web Publishing component manages the application database, which contains information about the events, performances, venues, users, etc. Additionally, in a special metadata database, XCM stores information about the definition of interfaces in terms of document structures and XSLT presentation templates. Document structures, content views and layout information are defined in terms of metadata objects that govern the standard publishing process of XCM. In the case of the EdFest application, XCM delivers VoiceXML files for the voice engine and different HTML pages for the stationary kiosk, pre- and post-visit desktop web browsing. A response may contain information for multiple output channels and the Client Controller dispatches it to the appropriate rendering component.

By integrating the components introduced above—namely iServer, XCM and the Client Controller—an extremely flexible and powerful platform for experimentation with mobile information systems is achieved. It enables context-aware applications with multi-modal, multi-channel interfaces to be developed quickly and even allows for the simultaneous testing of alternative interfaces and run-time system evolution. Also, these applications may span physical and digital spaces allowing all sorts of physical objects and locations to be digitally augmented.

3. EDFEST SYSTEM

In the EdFest system, users are able to access all functionality of the interactive Fringe guide through a set of interactive documents. The set of digitally augmented paper documents together with other EdFest interaction components is shown in Figure 2. The documents include an interactive *paper brochure* containing a list of events ordered by categories (e.g. comedy, theatre etc.), an interactive *paper map* showing the locations of all festival venues and a two-sided interactive *bookmark* providing access to additional festival services. Furthermore, the figure shows the *Nokia Digital Pen* as well as a *Bluetooth earpiece* that was used for voice interaction. Each of the three paper documents can provide access to additional digital services on its own. However, there are also some digital services that involve more than one paper document, thereby linking multiple physical documents. In the following we describe some of the functionality available from the interactive paper documents.

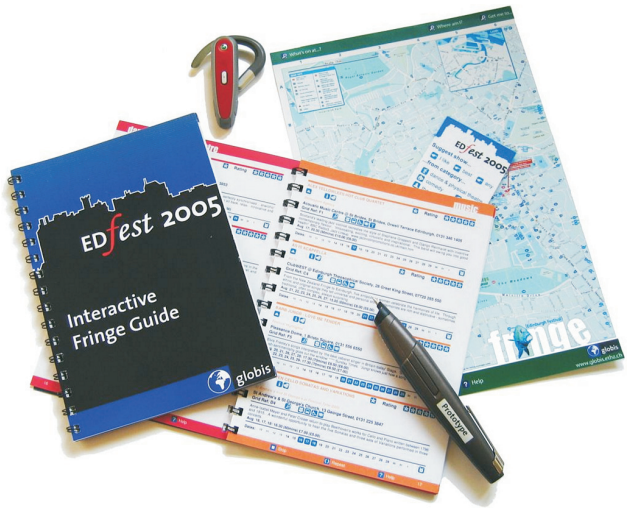

Figure 2: EdFest interaction components

The design of the interactive brochure was based on that of the official Fringe brochure where they give a compact summary of information about an event, including the dates and times of performances and the cost of the tickets. In our interactive brochure, we included pictograms as active areas which, when activated, provided supplementary information from our festival database through a text-to-speech interface. Examples of such information include descriptions of bar and catering facilities on offer at the event venue, warnings about the use of bad language or nudity, bus information for getting to the venue and information about disabled access. At the bottom of each event entry, the official brochure gives a timeline view of the festival showing in bold the dates of event performances. We replaced the bold entries with pictograms which, when selected, give information about ticket availability on these days. This example shows how the static printed information can be augmented with up-to-date digital information about ticket availability.

Reviews play an important role in the selection of specific events. A key feature of our system was therefore to provide an easy means for users to input and access ratings and reviews. At the top right of each event entry, there is a rating section where users can access the current average rating by clicking on a '?' pictogram to the left of a rating label and input their own rating by selecting one of the '1–5' pictograms to the right of the label. They can also submit their own comments on events by writing them in the blank comments pages provided at the back of the brochure and then linking them to an event in the brochure. Optical character recognition is applied to analyse the handwritten text and the recognised text is read back to the user via the text-to-speech engine for immediate feedback. Comments can be accessed by other users by clicking on a specific pictogram in the event entry.

The second document, the interactive map, provides functionality to access information about venues. By pointing anywhere on the map, ideally on the number of a venue itself, the user can access a description of the venue that is closest to the selected position. A 'Where am I?' option on the map tells the user where they are located in terms of a map grid reference e.g. "Grid position F4 lower left corner". By placing the pen on the map, the system will direct the user towards the exact position with commands such as "Move the pen a little to the right". This map locator functionality can also be used to find the location of events by clicking on the locator pictogram given in the brochure event listings, thereby providing a link from one document to another. Other options are to find the next event starting at a venue and to get navigation information.

Given the number of events, the brochure is better suited to the lookup of particular events or detailed study rather than being able to find possible events of interest happening at a particular place or time. We therefore provide advanced search facilities through the design of a general bookmark document. One side of the bookmark allows a user to formulate an event search by specifying parameters such as category, date, time and location.

The other side of the bookmark provides a list of preferences that the user can set, a booking service and a minimap which provides the same functionality as the actual map based on a schematic view of the city showing main streets and landmarks used for orientation and navigation. The ticket booking system is a multi-step transaction started by selecting the 'start reservation' pictogram on the bookmark. The user is then asked to select an event from the brochure and then a performance date for that event. They then select the number of tickets on the bookmark and the system responds with a summary of the booking information. The user clicks on the 'reserve' pictogram to complete the transaction and the system gives a confirmation message that includes a reservation number.

4. CONCLUSIONS

The EdFest system shows how emerging technologies for interactive paper can be used to provide innovative ways of interacting with databases and of integrating printed and digital information. One major advantage of the paper-based interface in mobile environments is the fact that it provides easy access to the static core data without power. The digital system offers an optional, value-added service providing access to supplementary information, dynamic data and transactional services. Furthermore, the ability to capture handwriting on paper provides an easy and natural way for users to input data on the move.

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