Supporting Mobile and Nomadic Learning

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Abstract

This paper presents three efforts to support children engaged in mobile and nomadic learning both in and out of the classroom. The HyConExplorer is a mobile, context-aware hypermedia system developed to help pupils access and produce digital content during project work in the field. The eBag is the equivalent of an electronic school bag and provides pupils access to their digital materials through large public displays. Seamless proximity based login to the eBag is handled by a Bluetooth sensory system monitoring the children's mobile phones. Finally, we present PP2P, a peer-to-peer framework for mobile devices to discover and utilize other (stationary) devices in the user's surroundings while mediating a feeling of direct and concrete interaction between the communicating appliances.

1 Introduction

Mobile computing has over the past 15 years become increasingly widespread, not only in the laboratories where it originated, but outside, where most people today carry devices supporting (at the very least) multi modal communication and often with computational resources available only in desktop computers a few years back. These devices provide a whole new way of working and thinking about what we can do with computers and how computers can help us in our daily activities.

This paper describes the work on mobile computing done within the auspices of the InteractiveSpaces[1] research group. Our work has focused on different aspects of mobile work, predominantly with school children as users, as they are both challenging users and eager adopters of new technology. We have with the systems described herein explored some of the aspects of nomadic work.

The HyConExplorer [3] allows nomadic users to access and produce in situ information. The HyConExplorer is a GPS based system available for tablet PCs and Java Smart Phones. In contrast to the HyConExplorer, where the interaction takes place on a mobile device, the eBag system [5] supports mobile people through

[1] http://www.interactivespaces.net/

stationary, public displays for data manipulation and presentation. Personal Bluetooth IDs are used for seamless, proximity based login in the eBag system but focus is here on supporting *local mobility* [8], typically within the school building. The physical peer-to-peer (PP2P) system combines the two approaches and supports mobile users carrying mobile equipment to discover and communicate with stationary devices in their vicinity and thus focus on both mobile people and their mobile equipment.

2 HyConExplorer

The HyConExplorer is a mobile context-aware hypermedia system built to support users in browsing, searching, and annotating the physical world. The system is designed to let school children and others working in the field access and produce situated information related to their context. The HyConExplorer is implemented on top of the HyCon framework and runs on tablet PCs and J2ME enabled Smart Phones. The HyCon framework is logically divided into four distinct layers for storage, services, terminal application, and sensor input [4, 7].

Like other location- and context-aware hypermedia systems [1, 6, 9] the HyConExplorer augments the physical space with digital structures and lets users access information associated with their context. The HyConExplorer data model supports linking of information to any digital or physical object which can be identified (e.g., by URLs, RFIDs, or GPS (x, y)-coordinates). Thus, the system can anchor Web pages or user-created annotations to physical locations and can be thought of as providing overlays of situated information on maps of cities and places.

However, the HyConExplorer is more than just a context-aware browsing and navigation system. As a context-aware hypermedia tool, the system supports users in creating rich media annotations (with photos, videos, and audio clips recorded on the tablet PCs and Smart Phones), links, and guided tours through information resources automatically tagged with captured context information (GPS (x, y)-coordinates, time, and creator information is used in the current prototypes) for later retrieval. The annotation functionality provided by the HyConExplorer supports users in creating in situ documentation which can be shared with other users visiting the same place at a later time. The HyConExplorer has been used in this way by teachers and pupils during field trips (see [3]). Web pages and documents created by the teacher were linked to locations prior to the field trip; and a suggested path through the locations was created in the form of a guided tour. The pupils could then follow the tour in the field, investigate the linked resources, and add their own findings as annotations commenting on the teacher's material. Figure 1(a) depicts pupils working on an assignment in the field with the HyConExplorer tablet PC prototype.

Novel to the HyConExplorer is a reverse geo-coding technique termed Geo-Based Search (GBS). GBS performs background searches on the Web for information related to the user's changing contexts. To find Web pages covering both a topic of interest and the particular geographical area the user is located in, GBS computes postal addresses from GPS coordinates and combines these addresses with user supplied keywords to form search strings appropriate for the Google search engine. GBS supports real-time, context-sensitive integration of Web information and allows relevant search results to be linked to the user's physical location and further

(a) (b)

Figure 1: Two examples of school children engaged in mobile work: Figure 1(a) shows pupils in the field browsing, searching, and creating documentation with the HyConExplorer prototype. Figure 1(b) shows pupils engaged in group work using the eBag system.

annotated. For an in-depth discussion of the HyCon GBS implementation see [4].

3 eBag

The eBag [5] can be seen as a digital counterpart to each pupil's physical school bag, and its purpose is to serve as a personal, digital repository in which pictures, video, music, text documents and other digital material for use in and outside the school environment can be placed. As modern education includes working with project oriented assignments, the eBag also supports group collaboration by sharing of material and mechanisms for activity awareness between group members. A key property of the eBag concept is that each pupil do not carry a laptop, but instead uses the infrastructure of the classrooms or project rooms to access, manipulate, and produce digital materials (see Figure 1(b)). This way of working can be described as nomadic work, where the pupils work in the *digital oases* of their environment. This is contrary to traditional mobile work where the pupils carry all their digital material with them on mobile devices (laptops, PDAs, etc.). To support this kind a nomadic work our eBag prototype includes a context-aware sensor layer, which supports proximity based login and logout.

Similar to the HyConExplorer the eBag prototype is built as an application upon the HyCon framework. A brief overview of the eBag infrastructure is presented here, for a more detailed description see [5]. We use a database management system (MySQL) for persistent storage of eBag profile information such as owner name, eBag icon picture, password, registered Bluetooth devices, friends list, digital repositories, and more.

Initially we have used a WebDAV server as our repository back-end for the actual digital content of the eBag, but this can of course be supplemented by other digital repositories such as online photo albums, dedicated music or video web services, and the like.

The server layer implements the communication interfaces that modify the eBag profile information, and supports an awareness service between members of a project group by allowing a member to update his or her eBag profile with a status message (e.g., "in the library" or "interviewing the shop owner", etc.) directly from the eBag prototype application or by sending a SMS message from his or her mobile phone to our SMS gateway.

The terminal layer of the eBag prototype implements the GUI which the pupils are interfacing with. The eBag is initially presented with an eBag icon which can be activated to open the eBag and access the actual content.

A key feature of our sensor layer is the use Bluetooth sensor equipment which allow us to control the signal power for the inquiry. Thus, the signal power can be regulated to a certain distance (one meter, two meters, etc.) and only the Bluetooth units within this proximity will be discovered. We use this in the eBag prototype to provide a login (and logout) mechanism for the eBag. Each pupil is given a Bluetooth mobile phone, and the Bluetooth ID of the phone is registered with the pupil's eBag profile. When a registered phone is discovered by one of the Bluetooth sensors, the pupil's corresponding eBag icon is presented on the display associated with the Bluetooth sensor. Proximity based login has many advantages, particularly in highly mobile and nomadic situations and it makes interaction with a changing range of computers more natural and direct.

4 Physical P2P (PP2P)

Mobility gives you access to many chance interactions, but only if you recognize the possibilities in a given context. To let devices present the user with (digital) possibilities in his or her surroundings we have developed an application framework for applications acting as data producers and data consumers in a peer-to-peer fashion. Any kind of sensing device—thermometer, camera etc.—can register itself as a producer of information in the P2P network. Devices that can handle these data types register themselves on the network as consumers of data; printers and displays could be consumers of JPEG images while stereo systems would accept MP3 audio files.

The framework supports automatic discovery of peers and pairing of peers, that is, consumers and producers which support the same data types. Consumer services are categorized by their capabilities when presented to a producer client: In the previous example, the camera would present the user with a list of available displays and printers found on the network; consumers of other data types would have been filtered out.

We have built the framework upon the Java implementation of the JXTA[2] protocol, which is a well-known P2P framework. Other P2P protocols may be used.

The basic idea in P2PP is that consumer devices advertise their capabilities by a simple string, composed of a device type and MIME type. The device type could be e.g., AudioPlayer or Printer. Depending on the device type a suitable MIME type designates what kind of data the device consumes. The use of MIME types

[2] `http://www.jxta.org/`

for advertising capabilities is inspired by Barton *et al.* [2]. Consumer devices are grouped using the JXTA groups mechanism. Producer devices can search for consumers by searching for devices accepting the MIME type it produces. The result to such a query is a list of device groups. The user can then select a group and get a list of devices within that group. Improving the returned list could be done using Bluetooth (or WiFi) signal strength (as described in Section 3) to situate the consumer devices and the producer device; this would allow us to filter out consumer devices that are not within the users context; a suitable definition of context rests upon the application built on top of the PP2P framework.

We have made several small applications in the framework.

5 Conclusion and Future Work

An interesting direction for future work on the three described projects HyConExplorer, eBag, and PP2P will be on integrating them. Thus, supporting access to the content of the eBag directly from the HyConExplorer, so digital material from ones eBag could easily be fetched and associated with physical locations. When working in an in-door school environment, access to trails or annotations made with the HyConExplorer via the eBag would be useful, and extend the idea of the eBag as a personal digital repository. PP2P as the underlying communication layer for the HyConExplorer would allow field work where each device would not have to upload to a central server, but instead could distribute the gathered information and let the device with highest bandwidth connect to the server, or wait until being back home at the school to transfer the gathered information.

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