

A PERSONALISED MOBILE ENVIRONMENT FOR LIFELONG LEARNERS

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ABSTRACT

With the new generation of mobile phones that are always online, can handle multimedia and connect to local networks using bluetooth technology, an application that will facilitate learning for lifelong learners can be accomplished. To this end, this paper presents a design approach and an architecture for a prototype personalised environment that aims to facilitate contextual lifelong learning by making accessible learning services and opportunities provided by the university or by remote personalised servers that are available in the vicinity of the user.

KEYWORDS

Hierarchical taxonomy, personalised mobile services, contextual lifelong learning, learning spaces.

1. INTRODUCTION

With the advent of the 3G mobile phones, which are always on line anywhere there is network coverage, the features of contextual lifelong learning can be accomplished. These features are that: learning happens in different times and places, usually when a person tries to resolve a problem, share an idea, gain an understanding or reflect on the current situation; and people need to continually enhance their knowledge to address immediate problems and to participate in the process of professional development. [27]

The creation of a mobile application that presents and manages the knowledge needed by lifelong learners seems apparent. Miertschin and Willis [22] present the inclusion of tablet PCs in a freshman introductory computing course. Although the tablet PC is a good choice regarding the goals of the project, its size and dependability on wireless networks mainly on campus does not fulfil the feature of learning that is not restricted to specific places, in this case being the campus. On the same wavelength, Valiquette et al [29] propose a mobile computing program that requires a laptop PC as the mobile device and is restricted in campus.

The above approaches serve well their purpose but they do not accomplish the features of contextual lifelong learning. Sharples [27] proposed general requirements for the design and implementation of a mobile learning resource that aids lifelong learning by using a learning organiser. Such an application should be highly portable, personalised, unobtrusive, available anywhere, persistent, useful and easy to use. These requirements mostly map the use of mobile phones for lifelong learning education. A mobile phone by definition is highly portable, personal, available anywhere and unobtrusive. A thick mobile application can be created that adapts to the user needs, is persistent, useful and easy to use.

On the other hand, there are some limitations of the mobile phones that conflict with the requirements. The connectivity of mobile phones is relevant to the availability of cellular networks. Poor availability will have an impact to the perception of the user for the usability of the system. The small screen can be

restrictive for the creation of a usable interface. The limitations in processing power, memory, and storage limit the application functionalities. Finally, the bandwidth, which is dependant to the strength of the signal and the availability of the network, can be obstructive for the downloading of information.

This paper presents a mobile personalised learning environment for lifelong learning that adapts according to the student's behaviour and needs. This environment interacts with a personal learning space. It comprises of a mobile application and a server side middleware that connects the information of the database with the mobile client and also performs the intensive calculations. The system proposes a solution to the usability issues due to the small screen of the mobile phones, demonstrating a design that hierarchical menus and lists of items map the tasks and activities that a lifelong learners can do. The tasks and activities will be formed as categories, subcategories and items in the personal learning space of the student. The issue of the limitations on processing power, memory and storage has been addressed by the Java Mobile Edition (JME) that will be used to develop the thick mobile client. Finally, the issue of the bandwidth and the performance of the connection could be solved by using the connection adaptation mechanism that is used by Alvarez-Cavazos et al [3].

The paper is organised as follows. The next section presents previous work in the area of mobile learning. Section 3 gives an overview of the approach we used to design our system and the personalisation offered, while Section 4 presents the personalised environment. The paper ends in Section 5 with concluding remarks.

2. RELATED WORK

Alvarez-Cavazos et al [3], present a universal access architecture for digital libraries that includes a mobile client. The mobile client offers a subset of the functionality of a desktop client. It performs some functions to deal with the limitations of the mobile environment. These are a local storage mechanism, which stores documents in the device for later offline usage; a connection adaptation mechanism that provides a constant response time regardless the connection variability; and user interaction support that allows the user to manage his/her personal digital library. The client reads the results received from the middleware and displays them on the screen. The middleware stands between the database that holds the digital library and the mobile devices. This is because accessing the database is a resource intensive procedure that mobile clients are probably unable to deal with. The databases are accessed by the middleware and the results are cached in order to be served to the user on demand. Finally, the middleware performs adaptation of the content so that it fits the display of the devices.

Holzinger et al [15], present a multimedia-based application for mobiles that is called Mobile Learning Engine. The system is designed to be intuitive and easy to use. The application can be used for several didactical and pedagogical approaches such as problem-solving, exploratory learning and situated learning.

Sharples et al [27], provide a list of general requirements for technologies to support contextual lifelong learning. They also describe a mobile system that is targeted for children in elementary school. The system is a tablet PC running a Java mobile application that uses a metaphor (a rabbit avatar) to communicate the different actions to users. The system comprises of a personal learning resource and several tools and activities that create new resources. These tools are drawing, writing and communicating, while the actions connected with the avatar are capturing images, browsing web pages, and creating and annotating images, notes and drawing. During the user testing, the children couldn't handle the size of the tablet pc as it was too big for them and therefore it was not serving the unobtrusive requirement set by Sharples.

Brodersen et al [7], present a web infrastructure for nomadic learning that is called eBag. It is focused on school kids and it is designed to support them working in a project oriented and nomadic learning, inside or outside the school buildings. It presents a login mechanism that is based on bluetooth proximity sensors for accessing web resources.

3. THE PROPOSED DESIGN APPROACH

A big challenge that people face when they start designing a mobile application is the way of fitting the information in the small screen of mobile phones. Many different ideas have already been proposed for browsing web sites using mobiles [4] [5] but there are no guidelines regarding the way of designing a User

Interface (UI) that would be presenting all the information in one screen. Probably this is because each problem should be solved differently when it comes to screen space real estate, and it has been faced like that up to now [14], [24].

Our approach to solve the problem of designing the UI was based on decomposing the activities the user is called to accomplish when using the application. Our application is focused on providing lifelong learners with information relevant to tasks and activities that they need to complete, when they are not at their “base”, this being their home, office or university lab desktop computer. Such activities are information about the courses they are currently taking, information about other learning opportunities offered, and access to the digital library in order to find information relevant to the task they perform and communicating with peers and tutors.

The above activities are modelled as the root categories of a taxonomy that includes all the information relevant to the root categories. Such a modelling resembles the hierarchy of Open Directory Project [25], or other online directories. Therefore, the system relies on a main taxonomy that includes all the information, and is common for all learners. Different users do different use of the taxonomy, visiting only the parts they are interested in, creating a “personally ordered, edited version” of the taxonomy [18] that would match their personal preferences [23].

Providing the users with the whole taxonomy and letting them navigate to the parts they are interested in would be a waste of time and bandwidth for them, as they would always need to navigate only to particular parts of information. There is a need for a personalised view of the taxonomy for each user. Therefore, the application is the means for the user to navigate her personal learning space, which is a personalised subset of the main taxonomy. Initially, this personal learning space is set up by the school to match the profile of the student, depending on the courses she enrolled, but gradually the user is able to change the contents and enrich the information that is linked to her personal learning space.

Mobile phones use menu-hierarchies to let the user navigate through the different menu items that represent the functionalities of the phone [10]. Since the users are already familiar with the use of hierarchies, the UI design of our application follows the same standard. Although they are difficult to manage, they can provide a feasible way to guide the user in navigation [9]. Each category of the taxonomy is an item on a menu, and by following the category, a list of the items and subcategories contained in it is shown. The categories are tasks and activities the user needs to have access to when she is mobile. The visualisation of each category/task in one screen follows the design guideline proposed by Luchini et al [21] that suggests task-based workspaces. Smyth and Cotter [28] note that the reordering of the items in the menu, according to the user preferences, helps the users find what they want more readily. Hence, our application is reordering the items of the menu according to the way the user likes to see them, or depending on the usage of each item, placing frequently used items at the top.

The personalisation of the system requires the creation of a user profile. The user profile is a collection of variables that will be depicting the preferences of the user regarding different elements of the application and also the usage of them. The user should be able to review and change the user model, so that they match her way of working and thinking. Consequently, the system has a screen that the user can review the current user profile and change it at will.

The items in the personal learning space are either text or multimedia. On one hand, there is a digital library, facilitating the searching for information in books and journals for students on the move and on the field of study. On the other hand, there is a wealth of lecture notes and manuscripts in text, audio or video. Each lecturer is able to upload to the taxonomy the lecture slides, assignments, and articles related to the lecture. Offering multimedia on the mobile is recommended to overcome limitations due to the lack of output screens [19]. Except the usual form of this material in text, Ractham and Zhang [26] propose the use of podcasting to deliver information to the students. Using podcasting, the students would be able to download and listen to the lectures, or other information uploaded by the tutors, on the move. The new generation of mobiles that appeared in the market lately, all feature an mp3 player, which could be used to playback the podcasts. Of course, users face two limitations on the use of mobile phones, regarding downloading podcasts. One is the incremental billing cost, and the other is the slow downloading time. Therefore, the podcasts should be small in size, and contain only the information that is needed. Since the audio would be solely speech, a small bit rate and frequency when encoding the podcast would help. The problem faced though is the extraction of only the information needed by an audio file. The user should be able to download and listen only the part of the podcast that would be relevant to what she is searching. This means that large

podcasts, like a whole lecture, should be sliced in small parts that are meaningful and tags could be used to make the information available for searching. [11].

Another form of information that could be uploaded by tutors could be instructional videos. 3G companies already offer video delivery to phones, whether this is sports, or TV series. Liu and Choudary [20] have created a system that broadcasts lecture videos to mobile devices. Such a broadcasting could be used in the personal learning space for the student to either watch a lecture while being away for several reasons, or getting relevant information from the lecture video, while researching on the field. The above system tackles the limitations of limited bandwidth, by using a modified encoding of the video that is optimised for mobile devices.

The items of the categories that are related with teaching material, like the ones described above, are expected to exist in the tutors' websites. Such a website could be a mix of webpages, where each webpage could be for one lecture, or a group of lectures. Such an arrangement of webpages would not fit well in the personal learning space, and would be difficult to browse and manipulate using a mobile device. Blekas et al [5] propose the use of RSS feeds in order to get the essential information from a website. An RSS feed delivers a set of items that are chunks of information, with a title, a description and a link. These items are used to describe items in the personal learning space instead of the webpages that contain this information. This makes browsing and searching of this information easier for mobile users.

Of course, mobile users move and their location changes, and so do the situations they are involved in [32]. One case could be that the user enters a public library to search for information about a specific topic. We assume that the topic is relevant to the programme of study, or an assignment that the student has to write; therefore his user model will have tracked several keywords that describe the topic. It would be of a great help for the user if, instead of searching the whole library catalogue, the catalogue could be personalised, and present only results that match her profile. For this to happen, the library system should somehow get hold of the user profile of the user. This imposes many privacy issues. First of all, the user might not want to share personal information, or share only a part of the information. But, users are willing to share personal information if they will receive some benefit from the personalisation that will be performed, depending whether they trust the system regarding the way their personal information will be used [12].

Brar and Kay [6] propose a system that the user profile will be saved on the user's mobile device, and it can be released in exchange for personalized services. They describe a system that the user can create partial user profiles, which they call personas, where only some of the elements of the personal information will be transmitted, regarding the privacy the user wants. They adapt the W3C specification for P3P [31] in order to inform the users regarding the use of their personal information from the system, and APPEL [30] for the users to specify their privacy preferences.

The system uses Bluetooth, which is common nowadays on mobiles, to inform about its location and also to receive offerings for personalisation from several intelligent systems [1]. Ackerman and Cranor [2] found out that users prefer to be informed when an exchange of personal data will take place, and confirm it, therefore, when the user is inside the range of a bluetooth network in a place like a public library, that could offer personalised content, she is informed about the services the library system provides, the way her details will be used and for how long they will be stored, as these would be described by the P3P policy. Then, she has the option to either send some of her personal data to the system, or decline the offer, and use the system without personalisation. In order for the systems, the mobile device and the intelligent system to exchange information, they should be able to communicate using a standard way of exchanging information. This could be done by using P3P [31] and APPEL[30], or another XML based defined protocol.

Along with the above, the students would benefit from a way that would indicate which parts of the taxonomy were interested to other people of their class or group. Such a system was created by Brusilovsky and Rizzo [8] that creates a map of resources and indicates the times other members of a group have used a specific resource by the saturation of the colour of the cell. In our system we use a similar approach, where each category has a number after it, meaning how many times the other members of the group accessed it.

The mobile device should somehow carry the information of the user profile. This is done by transferring the user profile from the middleware server to the mobile client, using HTTP, or by using bluetooth to transfer the profile from a desktop computer to the mobile device. Figure 1 shows the different types of connections that the mobile client will be able to use.

Table 1 below lists the design choices used for the creation of the system, as discussed above.

Table 1: List of design choices used in the system

Design choice	Reason	Example
Tasks and activities modelled as a directory [16]	Imposes hierarchy and relevance	Tasks and activities represented as categories and items
Hierarchical menus [21]	Task-based workspaces	Each main task is a category
Reordering of items in the menu [28]	Easier access to most used tasks	Most used tasks appear first
Grouping of search results [17]	Categorisation of results into meaningful directory categories	List of percentages that categories participate in the results
Audio as content in taxonomy [26]	More information provided	Audio lectures as directory items
Video as content in taxonomy [20]	More information provided	Video lectures as directory items
Use of RSS to summarise content [5]	Facilitate categorisation	Easier creation of directory items
User profile visibility	Knowledge of the personal information held and fine tuning	UI that allows the user to change the user profile easily
User profile sharing [12]	Personalisation by systems that don't have knowledge of the user.	Transmission of the user profile to a remote server for personalisation
Saving user profile on the phone [6]	Portability	Access to the user profile anywhere
Location awareness [1]	Discovery of adjacent personalised services	Bluetooth sensor that informs remote servers about its presence
Connection with the base terminal	Synchronisation of the user profile	Send and receive the user profile to/from the base system
Social adaptive navigation support [8]	Indication of useful material	Number of students that accessed each category

4. THE PERSONAL LEARNING SPACE

The learning space incorporates a hierarchical taxonomy similar to web directories like Open Directory Project (dmoz.org). Figure 2a shows the whole taxonomy as it is initially formed. The learning space is available to all students and holds the information from all the courses that are available, and also links to other resources like a digital library or a discussion board. Its contents can be text, audio or video. Each student visits only the parts that are interested to her, creating a mental model of the taxonomy that is personally ordered and edited [18]. The default personal learning space for each student is formed by the categories that are relevant to the courses she enrolled, so the personal learning space is a subset of the learning space provided.

The student has the ability to explore the whole taxonomy and expand the personal learning space. Furthermore, the student can expand the personal learning space by creating new categories that do not exist in the initial learning space, and by importing into them new or existing categories and items from the learning space. This gives flexibility to the student to expand and order the personal learning space in a way meaningful to her. The student can also create connections between existing categories that do not exist, but is relevant according to the student's view.

The system architecture in Figure 3 shows the connections between main components of the system. The system consists of three parts. One is the mobile client, the other a web service that acts as middleware between the mobile client and the database and finally the database. The connection between the mobile client and the web service is done using the Internet and specifically the HTTP protocol. This approach was followed in order to make the mobile application lightweight, taking into consideration the limitations of the mobile phones. All the logic and expensive calculations are taking place on the server, and the results are being served as web services and are presented by the mobile device.

The mobile client is having two main functionalities. First, it is tracking the user actions, passing them to the web service, where calculations take place in the server, and then it is reading the result of the

calculations and is serving the corresponding screens, with the data taken from the web service. A cache of the actions tracked and the corresponding results from the web service are held on the mobile, so that in the event of loss of connectivity the system could remain usable, at least for the actions already performed by the user. This will be done by having a small database in the mobile client. Second it can act as a sensor that is discovered by remote systems available, where personalised services are offered.

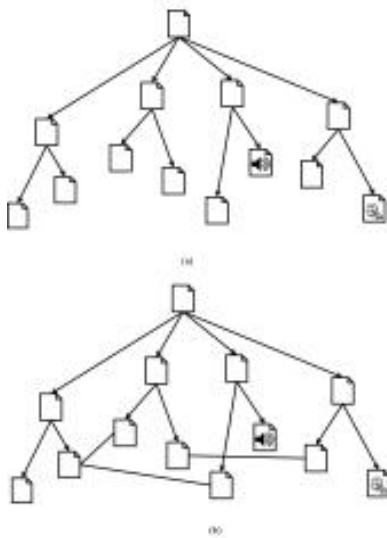


Figure 2: Representation of the personal learning space (a) default view (b) personalised instance

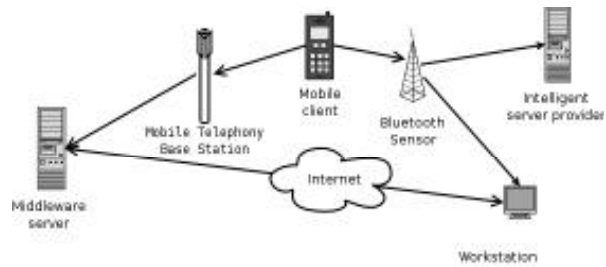


Figure 1: Mobile client connections

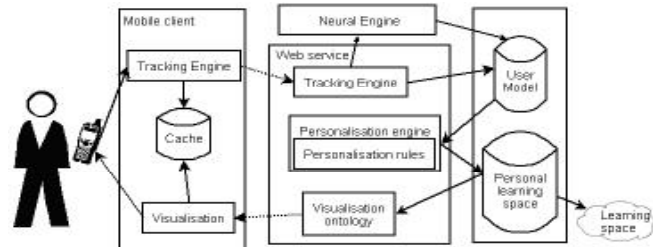


Figure 3: High level architectural description of the system

The web service part is collecting the data from the mobile client and is deciding on what the user asks to see next. It is using a user profile to track the user preferences. This user profile can be changed either directly by the user, through a screen on the mobile device, or be evolving using a neural networks engine.

The user can select between saving the user profile on a base system, such as a desktop PC at home or at the university, or on a university server that runs the web service, or on a mobile device and only release specific amount of personal information for each interaction with the server. If the user profile is saved securely in a personal computer, then the mobile phone could download the user profile by using Bluetooth to build a direct connection. If the user profile is stored on the university server, then it can be downloaded by using HTTP.

The system tracks the interactions of the user with the mobile client, using a tracking engine, and feeds the interactions into the tracking engine of the server. These events are passed to the user profile, either directly, if the user selected to have a static user profile, or after being processed by a set of neural networks that will decide whether the user profile should be changed or not. The user profile on the server is either containing all the information or only the information that the user accepted to. The event captured is then passed to the personalisation engine where a set of rules will run to personalise the data the user asked to see. These data will come from the personal learning space of the user, where they will either reside being cached from previous calls, or they will be fetched from the learning space and be personalised on the fly and stored in the personal learning space. These data will be passed to a visualisation ontology that will decide on the way the data should be presented to the user. Then the data together with the visualisation technique will be passed back to the mobile client to be shown to the user.

Beyond the communication with the server component, the mobile device is able to communicate with remote servers available in a public library or a museum. The communication with these servers is done both by the use of bluetooth technology and HTTP. First, using bluetooth, the phone is discovered by a remote server and an offering is sent regarding the services that are provided, together with the parts of the user profile that are needed and the URL where the web services of the server can be located. If the user accepts the offering, then an HTTP connection is created with the remote server to send the portion of the user profile needed, and to use the services provided.

The services provided by remote servers appear in the personal learning space as new categories at the top level. The full contents of the services are available while the system is in range of the mobile client, but a cached version of documents that were retrieved can be held on the mobile device as it is proposed by Cohen et al [13].

The main screen of the mobile system (see Fig. 4a) shows the top categories of the personal learning space. Generally the user is free to create new categories and assign content from other categories of the taxonomy, or even link content of one category with content of another, creating meaningful semantic links. The categories shown in Figure 4a are the preinitialised values. The user can browse the courses he/she already has taken; search digital libraries, or post comments and questions on a discussion board, where he/she can communicate with other students or the teachers. Finally, there is the option to inspect the user model that describes the user's preferences, and also transfer the user model from the mobile to the base system. When available, there is a list item for each remote server that is available and the user has agreed to connect to. The user can search the personal taxonomy by using the search field at the bottom of the screen.

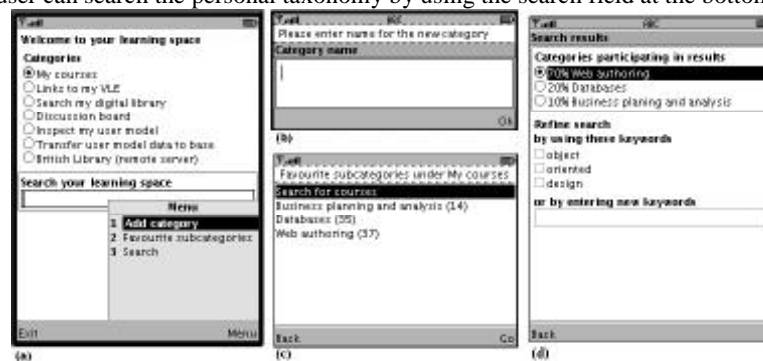


Figure 4: Screenshots of the mobile environment

The user can add a category in any level of the system (Fig. 4b). Finally, the user can get a quick pick of the subcategories of a specific category, by using the “Favourite subcategories” menu item. This will take him/her to a screen (Fig. 4c), where the most used subcategories within a specific category are shown. In that view she can find out how many of her group members visited each category. The search facility (Fig. 4d) provides the user with a break down of the results into the categories of the taxonomy. This helps the user understand and choose the closest context to the one he/she is searching for.

CONCLUSION

Assisting independent learners to access, compose and manage their learning throughout their life in a range of institutional, informal and work-based settings is a challenging issue on the lifelong learning agenda. This paper presented an architectural description of a lifelong learning application for mobile phones and the prototype created. This application facilitates the learning process anytime anywhere by keeping the user connected with content that is relevant with her studies.

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