

E-LEARNING TO U-LEARNING, ADAPTING LEARNING ENVIRONMENTS TO MOBILE DEVICES

Dr Trent Mifsud and Dr Des Casey

Faculty of Information Technology

Monash University, Australia

[trent.mifsud, des.casey]@infotech.monash.edu.au

ABSTRACT

Life pressures make full time on campus study increasingly difficult for tertiary students. More flexible learning models are needed. U-learning environments that operate through both desktop and mobile technologies provide useful tools in implementing these learning models. This paper describes details the experience of making university courseware available for mobile devices via the Walkabout u-Learning Environment.

KEYWORDS

Web-based education, u-Learning, PDAs, mobile development.

1. INTRODUCTION

For many people, in particular tertiary students, multi-tasking and managing time has become increasingly common and the opportunity to focus exclusively on a single task over an extended period in a single place has become increasingly rare. More tertiary students are finding it is necessary to undertake paid employment to continue with their studies. Attendance at campus lectures and tutorials becomes dependent on employment roster requirements. As a result, students have to adjust to their employment commitments by enrolling in fewer concurrently university units and subsequently prolonging their stay at their tertiary institution.

Approach to study adopted by students tend to be a hybrid of learning modes. From attempting to take units in a quasi distance learning mode, attending some classes, obtaining help from friends and catching up as best they can. Clearly the format in which tertiary institutions deliver their courses is too mechanistic for the students' changing circumstances.

Long and Hayden's [1] work surveyed some 30,000 Australian undergraduate students and found that some seventy percent were in casual employment, with an average work commitment of 14.5 hours per week during semester time. Furthermore, 33% of full time students and 47% of part time students said they missed class "frequently" or "sometimes" because of work commitments. Furr and Elling's [2] American study found a similar pattern: 65% of their sample of tertiary students were in paid employment for between five and sixty hours per week. Bennett [3] investigated factors that influenced students in whether they continued or discontinued with their tertiary studies, and found that financial hardship was

the most significant factor in determining whether students discontinued their studies. To address these issues, the Walkabout u-Learning Environment [4] was developed to address the difficulties students face in fixed studying for blocks of time in a given place. Walkabout hosts five university subjects, all dealing with the design and implementation of web sites (three at undergraduate and two at master's level) with a minimum of 100 students using the system. The learning material contains a mixture of theoretical concepts, coupled with the practical skills required to construct web sites.

Until recently access to the Walkabout u-Learning Environment could only be made through a desktop web browser such as Internet Explorer (IE) and Mozilla Firefox. Therefore, without these web browsers, access to Walkabout has not been possible. We must consider that many students are moving around and their nature is becoming increasingly nomadic. Thus, the question presents itself as how do these students access a flexible learning environment when the methods of access are restricted to a desktop computer? The answer is to enable our learning environment to be accessible from more portable devices, such as personal digital assistants (PDAs) that can be physically carried by students and is not as cumbersome as a laptop computer. This is known as ubiquitous access and is a common foundation of what is known as u-Learning. The remainder of this research paper will concentrate on the implementation details of enabling ubiquitous access to unit courseware.

2. MOBILE DEVELOPMENT

Development of applications for mobile and wireless networks is a broad area [5] and the benefits can be realised in the education domain. Although some work has been researched in this area [6], some notable issues have been omitted. Specifically, implementation issues and experiences of developing a mobile u-learning environment need further examination particularly specific the tools that are required. Web applications development technologies, such as ASP.NET, allow both desktop and mobile web applications to be built with a great degree of flexibility. ASP.NET applications are commonly built with the Visual Studio.NET development environment which provides a "drag and drop" development mode, facilitating relatively straight forward prototyping and development.

2.1 Mobile Web Browsers

Just as desktop environments use desktop Web browsers, mobile devices use mobile Web browsers such as Pocket Internet Explorer (PIE), which is bundled with the Pocket PC 2003 Mobile operating system. For mobile enabling Walkabout, the Pocket PC combined with PIE will be used. However, PIE is limited by both the device on which it runs and in functionality. Specifically, the screen size of a typical Pocket PC PDA is 240 by 320 pixels and the actual usable content area is even smaller at 229 by 255 pixels. This is significantly smaller than standard desktop monitor environment where screen resolutions are commonly 1024 by 768 pixels, or higher. PIE is more reliant on well-formed HTML than is its desktop counterpart. Much of the implementation of the desktop version of Internet Explorer is concerned with correcting invalid HTML. The desktop Internet Explorer is forgiving of poorly written HTML. However,

PIE cannot afford such a luxury as it operates on far less powerful devices. Thus, any web based applications for display through mobile web browsers must feature valid HTML.

2.2 Browser Content Targeting

The Walkabout u-Learning Environment requires learning materials to be accessed regardless of the type web browser being used. As noted, the differences between PIE and desktop web browsers are significant. Maintaining separate web sites for different is inconveniently and gives rise to the problem of keeping parity between the different versions. Walkabout has implemented a facility where the requesting web browser is first identified and decisions regarding content and its display format are made accordingly. A standard HTTP request for a web page contains a “user agent” which indicates the type of browser making the request. Code in ASP.NET can be used to interrogate this user agent as a basis for decisions on content and display type. Figure 1 shows some typical code where the user agent is being tested (if (userAgent.IndexOf("PPC") > -1)) to see if the browser is PIE. If this is the case then the user is directed to a web page optimised for mobile display (Response.Redirect("MobileIndex.html")), otherwise the user is directed to a desktop version of the page (Response.Redirect("index.html");).

```
void Page_Load(object sender, EventArgs e) {
    string userAgent = Request.UserAgent;
    if (userAgent.IndexOf("PPC") > -1)
        Response.Redirect("MobileIndex.html")
    else
        Response.Redirect("index.html");
}
```

Figure 1 : Inspecting the HTTP User Agent

Some examples of the user agent strings which are sent with HTTP request are

- Internet Explorer 6 : Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1; SV1; .NET CLR 1.1.4322)
- Mozilla Firefox : Mozilla/5.0 (Windows; U; Windows NT 5.1; en-GB; rv:1.7.6) Gecko/20050225 Firefox/1.0.2)
- Pocket Internet Explorer: Mozilla/4.0 (compatible; MSIE 4.01; Windows CE; PPC; 240x320)

The knowledge of the requesting browser enables the Walkabout u-Learning environment to tailor the output according to the requesting web browser. Some examples of this tailoring can be seen with the use of alternative Cascading Style Sheets, streamed media and JavaScript implemented functionalities.

2.3. Cascading Style Sheets

Cascading Style Sheets (CSS) are used to set on screen properties such as colour and text sizes. A CSS file is used to set these properties for the whole of a web site, obviating the need to set such properties for individual web site HTML pages. In the Walkabout u-Learning environment two style sheets are utilised; one for the desktop and one the mobile environments. It is important to consider that text is harder to read on mobile devices and thus should be adjusted as necessary. Rather than increase the text size on each

web page, we can specify how we want the text and colours to appear in just one file, and apply it every web page. Thus future modifications can be made efficiently through the one file and in one location.

Figure 2 shows the CSS implemented for the Walkabout u-Learning Environment.

<pre>// style.css - for desktop web browsers color: black; font-family: Arial, sans-serif; font-size: 12pt; text-align : center; width:400px; border-style:groove; border-color:#31639C; border-width:1px; padding:10px; margin-top:30px; margin-bottom:30px; background-color : #FFFAFA;</pre>	<pre>// mobileStyle.css for PIE color: black; font-family: Arial, sans-serif; font-size: 10pt; text-align : center; width:229px; border-color:black; border-width:2px; padding:10px; margin-top:2px; margin-bottom:2px; background-color : #FFFAFA;</pre>
---	---

Figure 2 : Style sheets for desktop and PIE web browsers

To prevent text from exceed the width of the PIE browser, the “width” element is set to the maximum row size, which prevents horizontal scrolling which is annoying on mobile devices. This is shown in Figure 3 . To dynamically apply the appropriate CSS, you must include the appropriate HTML mark-up code in the web document. This can be achieved many ways. In Figure 4 the content of a standard web form label to link to the correct link CSS file.

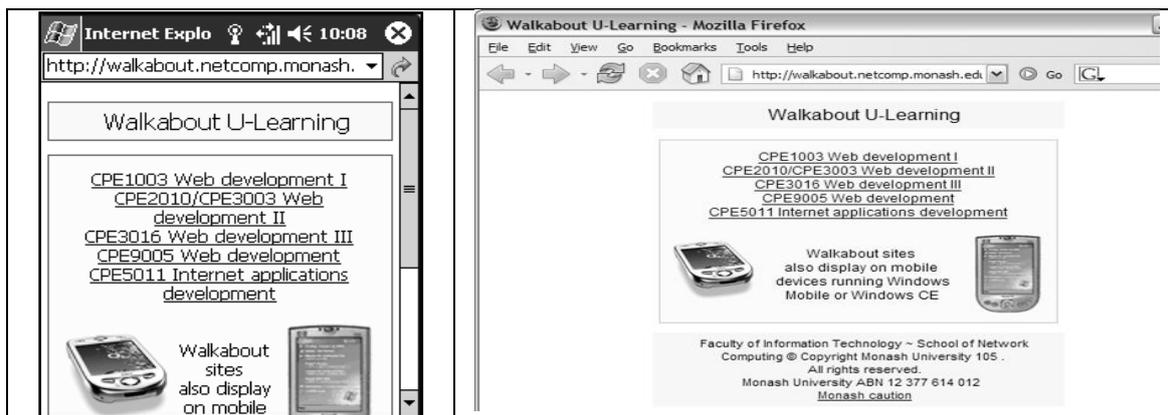


Figure 3 : Walkabout u-Learning Environment Displayed On Different Web Browsers

```
if (userAgent.IndexOf("PPC") > -1)
    this.styleSheet.Text = "<link rel = stylesheet href = 'mobileStyle.css'
type = 'text/css'>";
else
    this.styleSheet.Text = "<link rel = stylesheet href = 'style.css' type
= 'text/css'>";
```

Figure 4 : Applying the Mobile Style Sheet

2.4 JavaScript Menu System

JavaScript is client based code that will execute on almost all versions of PIE; however there are some nuances that must be identified. JavaScript cannot be used to spawn any other windows, known as Pop-Ups, as PIE does not support multiple browser windows. Furthermore, JavaScript error notification is turned off and the subsequent behavior of the web site is likely to be indeterministic if mistakes in code are present.

Walkabout requires an intuitive menu system to manage viewing courseware topics and information. The desktop browser version uses a complex menu written using JavaScript and dynamic HTML (DHTML). However, PIE does not support DHTML and thus common tree folders used for menus cannot be opened or “drilled down”.

2.5 Presentation and Content Abstraction

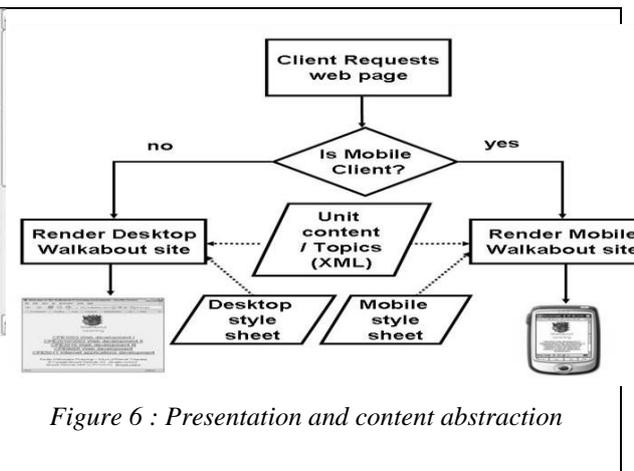
Some appreciation must be given when developing web content for web browsers with different capabilities. Depending on the browser itself, Walkabout will present a different visual interface. Courseware information, regardless of the client web browser, will always remain the same in that we do not wish to display different courseware content depending on the given web browser. Thus, all courseware is stored in a central location, which is decoupled from any presentation format. There are two popular options to store the courseware – in a database or in a text-based XML file. Database repositories for data driven web sites are very common. Most, if not all e-commerce based web sites use a database for storing and displaying information. This could be used for Walkabout; however XML's hierarchical structure maps conveniently into courseware content. Furthermore, editing courseware information stored in the XML file is achieved using any text editor and making relevant changes and saving the file. *Figure 5* shows how courseware is stored in an XML file complete with heading (stored as an XML node), supplementary audio and images.

```

1 -<part number = "1">
2 <heading>Clients and servers </heading>
3 <media>lecture010301.rm</media>
4 <content>
5 -<![CDATA[
6 <!-- -----
7 < START PART 1 CONT
8 <-----
9 <table>
10 <tr>
11 <td> <br> cli
12 <td> <br> se
14 </tr>
15 </table>
16
17 <p />

```

Figure 5 : Editing courseware content based on XML



The concept of presentation and content abstraction is illustrated by Figure 6 . This figure demonstrates how content is stored in one location and used by the Walkabout u-Learning Environment to render web pages based on which web browser the student is using. After determining the browser type, the XML file with the required content is read. Fortunately, tools for reading XML files using ASP.NET are available. These are known library classes which are used to cycle through the XML documents and extract course ware content. These libraries are XmlDocument, XPathNavigator and XPathNodeIterator and their implementation is demonstrated in *Figure 7* .

```
XmlDocument objXmlDoc = new XmlDocument();
objXmlDoc.Load(strXmlFileLocation);
XPathNavigator objXPNav = objXmlDoc.CreateNavigator();
XPathExpression expr =
objXPNav.Compile("descendant::unit[@title='"+strSubject+"']/topics/topic[@unittopic]");
XPathNodeIterator objXPIter = objXPNav.Select(expr);
count = objXPIter.Count;
strNodes = OutputMenu(count);
Topic.InnerHtml= "<a href='topics_title.aspx' target='body'>Title</a>Topic: " + strNodes;
```

Figure 7 : Reading an XML file using ASP.NET

3. MEDIA SERVICES

Many of the learning materials located on Walkabout are supplemented by streaming audio to assist student learning. Previously, the Real Media file format was used streaming audio. As a result, students accessing Walkabout via Pocket PC were unable to take advantage of media streaming as the real media format is not supported by the default media player. We assume students would not want to purchase or download extra software unnecessarily, thus the audio streaming system was revised. Currently, the system streams Windows Media Audio (WMA) using Windows Media Services (WMS). WMA files are audio files that are compressed for listening on the Internet. WMS uses expert functionality to determine if the Internet connection is becoming congested and will adjust automatically so the quality of audio is not affected. It is important to highlight that the audio is streamed as opposed to downloaded. Mobile devices generally do not have generous amounts of storage space and therefore downloading media files is not always possible. Streaming involves progressively downloading sections of the media file, playing them and then discarding them. This is similar to the First in First out (FIFO) methodology used in queuing theory. The size of the queue is the memory buffer WMS dynamically adjusts to ensure successful audio playback.

Thus far the design and implementation issues have been complete managed by the Walkabout authors. If modifications are required, then they can be made easily. However, access to Walkabout requires some dependence on infrastructure that cannot always be controlled and therefore some discussion is provided for different means of accessing Walkabout.

4. WIRELESS CONNECTIVITY

Walkabout is accessible both from conventional desktop/laptop/tablet PCs and mobile devices such as a pocket PC. These mobile devices differ from conventional desktop pc in that they are designed to be carried around and Internet access is achieved through a wireless connection. Wireless connections differ from standard cable connections as they usually have less bandwidth and can be unreliable.

A student has few options to access Walkabout via their PDA. When on campus, a wireless LAN (WLAN) connection is available almost everywhere. The current WLAN infrastructure at Monash University has a theoretical maximum of 1MBPS, which is sufficient. However, access is not possible if a student moves out of a WLAN zone. If a student is not within close proximity to a WLAN connection then bandwidth will decrease [7] . In this scenario, downloading images and streaming the audio is not possible. Thus, other wireless connections should be considered.

Standard GPRS connections are possible if the PDA is capable of making telephone calls and therefore is not restricted to the zoning limitations of a WLAN [8]. However, GPRS at best is expensive [9] and does not offer the high bandwidth required for a multimedia web application. With the restrictiveness of WLANs and cost and performance issues of GPRS, other solutions have arrived. Companies such as iBurst are providing Melbourne (Victoria, Australia) and surrounding suburbs with wireless connectivity. This type of solutions offer download speeds similar to WLANs but have the benefit of broad coverage. We perceive these types of technologies will contribute to the ongoing success of the Walkabout u-Learning Environment.

5. U-LEARNING DEVELOPMENT LIMITATIONS

Not all features of a desktop web site can be replicated for mobile web browsers. In particular, students cannot download a copy of the whole site for home use as they can with a desktop web browser. This is not a useful feature for PDAs, as these devices have memory constraints and lack a required web server. Similarly, other features such as chatting to others students using the I-Party software available for PC users cannot be used. This will be part of future investigations.

6. CONCLUSION

The Walkabout u-Learning Environment has evolved from a desktop web browser based application to a mobile enabled learning aid for students. It is now possible for students who cannot always attend lectures in the traditional learning mode to access courseware via a mobile web browser on their PDA. Access is not restricted to common web pages, but to streamed media as well. This paper has highlighted the technological requirements of making courseware available from ubiquitous locations via mobile devices. This ensures that we instructors can provide u-learning environments that suit the needs of the modern student.

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