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DESIGNING THE TRANSITION INTO THE MOBILE ARENA FOR ENRICHED USER EXPERIENCE

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***Abstract**: The rapid developments registered in the mobile arena impacted strongly upon the learning sector, bringing forth new technologies, resources and strategies. The purpose of this article is to present a series of W3C recommendations in conjunction with the mobile standards in order to improve the user experience of the Web on mobile devices. The authors aim to illustrate the way mobile learning standards can be used in teaching and learning by identifying the best practices for creating mobile-friendly content and applications, enabling easy access to device descriptions, setting up test suites for increased interoperability of mobile browsers, and exploring ways to use the Web on mobile devices to bridge the digital divide. This article aims to provide a development framework for the MOBNET project that "Carol I" National Defence University in Bucharest has developed in partnership with Advanced Technology Systems, the Research Institute for Artificial Intelligence of the Romanian Academy and two other private companies.*

***Keywords:** mobile learning, mobile standards, W3C, mobile interface design*

I. MOBILE USER INTERFACE DESIGN IN LEARNING

Developments in the mobile arena consider teaching with new methods and technology-rich projects. Mobile and wireless technologies, including handheld computers, XDAs, personal digital assistants (PDAs), camera-phones, smart phones, graphing calculators, personal response systems (PRSs), games consoles, and personal media players, are becoming ubiquitous in most part of the world and have led to the development of mobile learning as a distinctive entity [1].

To explore the evolution and direction of mobile learning and to establish a shared understanding, authors have defined the concept of mobile learning from various perspectives. Some approaches focused on technology, others on the mobility of technology, or the mobility of the learner.

The authors consider that mobile learning comprises all kinds of activities, inside or outside the classroom settings, specifically learning that is facilitated and enhanced by the use of digital mobile devices that can be carried and used anywhere and anytime, and that are typically identified by their small screen, lack of standard keyboard and pocket-sized nature [2]. Thus, mobile learning can be considered as the exploitation of ubiquitous handheld technologies, together with wireless and mobile phone networks, to facilitate, support, enhance and extend the reach of teaching and learning [3].

However defined, mobile learning can take learning to individuals, communities and countries that were previously too remote, socially or geographically, for other types of educational initiative [4] and can enhance and enrich the concept and activity of learning, beyond earlier conceptions of learning [5]. To implement mobile learning, we need to consider the mobile standards that cover topics such as display resolutions, storage, memory and processor capacities of digital mobile devices,

and outline what could be considered default specifications for hardware and software for mobile devices and supporting technologies.

In this regard, this article focuses on identifying guidance for the implementation of mobile learning in the setting of the MOBNET Project "Carol I" National Defence University in Bucharest has developed in partnership with Advanced Technology Systems, the Research Institute for Artificial Intelligence of the Romanian Academy and two other Romanian companies. The research domain of the project is advanced information systems for education and it has been financed through the "Partnership" national funding scheme.

The main purpose of this article is to present a series of World Wide Web Consortium (W3C) recommendations [6] in conjunction with the mobile standards [2] to bridge the technical requirements of mobile technologies and the teaching and learning strategies employed in order to improve the learner experience of the Web on mobile devices. Authors aim to illustrate how mobile learning standards can be used in teaching and learning by identifying the best practices for creating mobile-friendly content and applications, enabling easy access to device descriptions, setting up test suites for increased interoperability of mobile browsers, and exploring ways to use the Web on mobile devices to bridge the digital divide.

II. THE CONTEXT OF MOBILE DEVELOPMENT

Regardless of the settings where they operate, users keep wanting new features on their phone, like texting, voice memos, browsing, a camera, music, and television, because they would like these things in their pocket and the phone is already there. Mobile learning takes advantage of this fact and in this article we shall present the use of digital mobile devices as a powerful pocket resource that facilitate and enhance learning.

The mobile activities [2] we can access at the present from various platforms (mobile phones, smart phones, XDAs, PDAs, Media Players) include:

- ***recall***: access to remote or local stored web pages, graphics, photographs, sounds, videos, formatted text documents, spreadsheets, databases, forms, SCORM learning objects.
- ***record***: create images; record sounds and videos; create text files, spreadsheets, databases; record learner assessment, scores, or other learning data.
- ***relate***: post text to web-log for commenting, add comments to blogs, edit collaborative wiki or document on the web; send/ receive SMS/ MMS; initiate/ receive voice calls and VOIP calls; read/ respond to discussion posts; participate in synchronous text chat.
- ***reinterpret***: edit graphic images, photographs; use interactive activity of application on local devices; play educational games; edit text-based documents, spreadsheets, databases or forms; create/interpret 2D barcodes.
- ***associated teaching and learning activities***: discover resources suitable for mobile delivery from resource collections/repositories.

All these are available and can be used to full potential, when the mobile learning experience is supported by a friendly user interface.

2.1 Comparison of desktop and mobile devices capabilities

Real consumers are aware that the web sites that they use not only would not work well on a mobile phone, but also would have little functionality or purpose. As most people are barely willing to read a long document or news story on a relatively comfortable full-sized monitor, it is difficult to know when or why a person would be willing to read the same story on a tiny screen. More than that, users will not be willing to pay for a service that provides text freely available elsewhere.

Most mobile applications have been created as a miniaturized version of similar desktop applications. They have all the limitations of the desktop applications, all the limitations of the mobile devices, and typically some extra limitations due to the 'sacrifices' designers and developers make as they move applications from desktop to mobile devices [1]. This state of affairs is a result of some

fundamental misunderstandings about what mobility means for users. These misunderstandings cause the frequent failure of creating useful, relevant, and enjoyable experiences. The key to success is to break the “miniaturized” trend and provide sound customization. If researchers are to place these considerations in the learning context, they will reach the same conclusion that mobile learning requires more than a “copy” & “paste” operation if we want to make the most of being mobile.

The definitions given to “mobile” relate to context. Mobile development is less about the device and more about the user. It is the learner who is mobile rather than the device [2]. The laptop, while mobile relative to a desktop, retains the same basic physical requirements as a desktop: horizontal surface, room for keyboard and screen, the use of two hands, etc. The mobile device, however, represents a singularity in the evolution of portable personal computing. The user is no longer restricted to a limited set of movements and positions, in order to interact with the device. In essence, the truly mobile device is an extension of the user and not visa-versa.

Unlike a desktop device that is equipped with a keyboard, mobile device input is often difficult as these devices have only a very limited keypad, with small keys, and there is frequently no pointing device. One main difficulty of the mobile Web is that URIs are very difficult to type. Lengthy URIs and those that contain a lot of punctuation are particularly difficult to type correctly. The reduced size of the screen and input make forms hard to fill in. This is because navigation between fields may not occur in the expected order and because of the difficulty in typing into the fields. While many modern devices provide back buttons, some do not, and in some cases, where back functionality exists, users may not know how to invoke it. This means that it is often very hard to recover from errors, broken links and so on.

Cellular data networks offer very different network characteristics such as latency, bandwidth, costs and reliability than fixed data networks. When users interact with the Web from desktop computers or laptops, they can assume that the network will continue to be available through the session, the speed of the network will stay relatively constant, and there will be no extra charges for data transmission. With mobile devices, these assumptions are not always true. While interacting with the Web from a mobile device on a high-speed train, the network may very well go away at various moments (e.g., tunnels) and different geographies might support different transmission speeds (e.g., HSPA and/or 3G might be available in some urban areas, but remote areas might support much slower 2G technologies).

The fact that mobile devices frequently support only limited types of content means that a user may follow a link and retrieve information that is unusable on their device. Even if the content type can be interpreted by their device there is often an issue with the experience not being satisfactory - for example, larger images may only be viewable in small pieces and require considerable scrolling. Web pages can contain content that the user has not specifically requested - especially advertising and large images. In the mobile world this extra material contributes to poor usability and may add considerably to the cost of the retrieval.

Mobile learners typically have different interests to users of fixed or desktop devices. They are likely to have more immediate and goal-directed intentions than desktop Web users. Their intentions are often to find out specific pieces of information that are relevant to their context. An example of such a goal-directed application might be the user requiring specific information about schedules for a journey they are currently undertaking. Equally, mobile learners are typically less interested in lengthy documents or in browsing. The ergonomics of the device are frequently unsuitable for reading lengthy documents, and learners will often only access such information from mobile devices as a last resort, because more convenient access is not available.

Developers should note that some mechanisms that are commonly used for presentation of advertising material (such as pop-ups, pop-unders and large banners) do not work well on small devices. This does not mean that they should be restricted or eliminated, but that it should be optimized to be as effective as possible.

The usability of the Web from a mobile device is limited by various restrictions imposed by the keyboard or the screen dimension. Many devices have limited memory available for pages and images, and exceeding their memory limitations results in incomplete display and can cause other problems.

Mobile browsers often do not support scripting or plug-ins, which means that the range of content that they support is limited. In many cases the user has no choice of browser and upgrading it

is not possible. Some activities associated with rendering Web pages are computationally intensive - for example re-flowing pages, laying out tables, processing unnecessarily long and complex style sheets and handling invalid mark-up. Mobile devices typically have quite limited processing power which means that page rendering may take a noticeable time to complete. As well as introducing a noticeable delay, such processing uses more power as does communication with the server.

In discussing the limitations of mobile devices for delivery of Web content it is easy to lose sight of the fact that they are extremely popular and very common. This popularity largely stems at present from them being *personal, customizable, portable, connected* and *increasingly multi-functional* beyond their original purpose of voice communications. In addition to these factors, the advantages of mobile devices will increasingly include: location awareness, one-handed operation, always on, and universal alerting device.

2.2 Mobile standards considerations

Mobile usability is often highly contextual [7] and mobile learning should make the most of being on location, providing immediate access, being connected, and should acknowledge learning that occurs beyond or in connection with formal learning settings, in places such as the workplace, home, and outdoors.

The mobile standards aim to make the decision-making process easier for teacher and developers by providing information on the nature of mobile devices and the basic standards that optimise their use. Standards in e-Learning are defined by the following attributes [8]: interoperability, *reusability, manageability, accessibility, durability, scalability,* and *affordability*.

The decision-making process related to applying mobile learning should take into account the following basic standards:

- Ensure resources are compatible with the default delivery contexts and minimise demands on memory, processor and presentation.
- Exploit the capabilities of specific devices to maximise quality and usability, either through adaptable content or delivery modes or by providing alternative formats for resources optimised for a range of devices.
- Remember that the speed at which mobile devices can access networked data wirelessly is well below the speeds via a network (e.g. broadband or LAN), with the cost of data rates still very high. Content prepared for wireless delivery needs to be much leaner than content prepared for local networks for example, especially in terms of loading and playback. Some loss in quality is to be expected.

2.3 Delivering web content to mobile devices

In the relatively brief lifetime of the mobile phone, two major technological trends have taken hold: devices trend towards miniaturization and applications, features and functions trend towards expansion [9]. Taken together, they present us with an interesting paradox – squeezing more and more applications into smaller and smaller terminals. This keeps the users satisfied, but makes the devices harder to use. This apparent and obvious challenge has a deep impact on mobile user interface development.

Technology is not a barrier in this case. Due to advances in miniaturization components become smaller than before. Processing power increases even as energy consumption decreases, so batteries cam also made smaller. Adding new applications is largely a question of imagination and software effort. Users want their devices smaller and lighter for ultimate portability, so all the new applications need to be managed with fewer, or smaller, buttons and displays. Still, human sight is not getting better to read smaller fonts, and fingers are not getting thinner to press smaller buttons, consequently, if technological limitations can be overcome, we still have to consider human limitations in relation to using technology.

Designing applications or web sites for mobile phones remains a challenge, and in this article we shall present the main considerations development professionals need to take into consideration to make the transition into the mobile arena.

Most Web pages today are specially designed for desktop capabilities, in term of size displays and browsing software. Accessing such a Web page on a mobile device often results in a poor or unusable experience, as pages are not laid out as intended. Because of the limited screen size and the

limited amount of material that is visible to the user, context and overview are lost and the page usually requires considerable scrolling to be visible, especially if the top of the page is occupied by images and navigation links. In these cases the learner gets no immediate feedback as to whether their retrieval has resulted in the right content. It is particularly important in the mobile context to help the learner create a mental image of the site, by adopting a consistent style that can be considerably diminished by an uneven style.

When it comes to interface design guidelines, developers should consider the adaptation of Shneiderman's "Golden Rules of Interface Design" [10] for mobile devices:

- *enable frequent users to use shortcuts*: this reduces the number of interactions and to increase the pace of interaction.
- *offer informative feedback:* a beep when pressing a key or an error message for an invalid input value, help the user continue accessing content.
- *design dialogs to yield closure*: users are give the satisfaction of accomplishment and completion.
- *support internal locus of control*: users want to be in charge of the system, so it has to be designed such that users initiate actions rather than respond to them.

Besides these four rules, which apply both to desktop computers and mobile devises, the remaining ones will require mobile-adjustment [11]:

- *consistency* across multiple platforms and devices for the same application as users, and implicit learners, may need to switch between their desktop machines and different mobile devices frequently.
- *reversal of actions* may be more difficult for mobile devices because of lack of available resources and computing power.
- *reduce short-term memory load* so very little memorization is required during the performance of tasks, allowing the learner to focus on the content. Developers need to take into account that a mobile learner deals with potentially more distractions than with a desktop computer. Hands-free interaction or even eyes-free interaction can provide valid solutions to assure freedom of movement during interaction.

The attempt to improve the experience of the Web on mobile devices is made in the context of moving towards "One Web". One Web is meant to make available to users, as far as is reasonable, the same information and services irrespective of the device they are using. However, it does not mean that exactly the same information is available in exactly the same representation across all devices. The context of mobile use, device capability variations, bandwidth issues and mobile network capabilities all affect the representation. Furthermore, some services and information are more suitable for and targeted at particular user contexts

Application designers and service providers wish to provide the best possible experience in the context in which their service has the most appeal. While services may be most appropriately experienced in one context or another, it is considered best practice to provide as reasonable experience as is possible given device limitations, except where this is necessary because of device limitations. This would mean that services should be available as some variant of HTML over HTTP.

The widely varying characteristics of mobile devices can make it difficult for a Web site to provide an acceptable user experience across a significant range of devices. For example different devices support different mark-up features and different screen sizes may demand different sized images. Consequently, it is very common when delivering content to mobile devices to vary the details of the mark-up, format of images, image sizes, colour depths and so on to suit the characteristics of the device in question. The process of altering content to enhance the user experience on particular devices is referred to as Content Adaptation.

There are a number of different implementation models for content adaptation. On the one hand, adaptation may be quite simple and consist of determining the device type and choosing the most appropriate set of previously prepared content to match the device characteristics. At the other extreme it may be carried out in a completely dynamic way, with content formatted at the time of retrieval, taking into account not only statically determined properties, such as screen dimension, but also dynamically determined properties, such as the temporary attachment of a fully featured keyboard.

Adaptation can be carried out in a number of different points in the delivery of content to the device: *Server Side* adaptation implies that the content is delivered by the originating content server or

application. *In-Network* adaptation is where the content is altered as it passes through one or more network components. Some network operators, for example, compress images before they are passed over the air to the mobile device. *Client Side* adaptation consists of the device accepting content and displaying it in an appropriate way for its characteristics. Whatever the adaptation model at work, the process of adaptation should not diminish accessibility.

The Default Delivery Context is defined as follows:

Usable Screen Width:	120 pixels, minimum
Mark-up Language Support:	XHTML Basic 1.1 [XHTML-Basic] delivered with content type application/xhtml+xml
Character Encoding:	UTF-8 [UTF-8]
Image Format Support:	JPEG; GIF 89a
Maximum Total Page Weight:	20 kilobytes
Colours:	65536 Colours, minimum
Style Sheet Support:	CSS Level 1 [CSS]. In addition, CSS Level 2 [CSS2] @media rule together with the handheld and all media types
HTTP:	HTTP/1.0 [HTTP1.0] or more recent [HTTP1.1]
Script:	No support for client side scripting

Main general principles that underlie delivery to mobile devices:

i. *Content provided by accessing a URI should yield a thematically coherent experience when accessed from different devices*: in the spirit of the One Web, content should be accessible on a range of devices irrespective of differences in presentation capabilities and access mechanism.

ii. *Device capabilities should be exploited to provide an enhanced user experience.*

iii. *Provide solutions for deficient implementations* refer to differences in interpretation between browsers and also deficiencies in implementation caused by non-support of mandatory features.

iv. *Tests on actual devices*: any web site should be tested in a range of browsers.

v. *Keep the URIs of site entry points short*: as typing URIs on mobile devices can be difficult, users prefer to use alternative methods of obtaining them (e-mail, SMS, other web pages).

vi. *Provide minimal navigation at the top of the page.*

vii. *Provide a balance structure*: between having a large number of navigation links on a page and the need to navigate multiple links to reach content.

viii. *Provide consistent navigation mechanisms*: use the same navigation mechanism across a service to allow users to identify them easier.

ix. *Assign access keys to links in navigational menus and frequently accessed functionality.*

x. *Do not cause pop-ups or other windows to appear without informing the user*: this may confuse the users, or add cost and delay to their interaction.

xi. *Use clear and simple language*: users in a mobile context expect specific pieces of information, rather than browsing.

xii. *Ensure that the overall size of page is appropriate to the memory of the device.*

xiii. *Limit scrolling to one direction*: this allows the user to experince all the content of a web page.

xiv. *Avoid large or high resolution images; if used, images should be resized at the server.*

xv. *Avoid using tables*

xvi. *Do not use frames*: many mobile devices do not support frames.

xvii. *Provide informative error messages and a means of navigating away from an error message back to useful information.*

xviii. *Avoid free text entry where possible, and provide pre-selected default values where possible.*

Designing for multiple and dynamic contexts that learning implies has to consider the environmental conditions where the learner activates, as the usability or appropriateness of an application can change based on these different context factors. Also, in designing for small devices, speech input is a viable alternative for devices too small for extra buttons.

These recommendations need to be taken into account also when developing mobile learning interfaces, as to provide an enriched mobile experience.

III. CONCLUSION

This article proposes a way of informing creative design of mobile information systems by defining the main guidelines in developing mobile interface designs. The proposed approach bridges the gap between desktop and mobile interface design by introducing mobile standards and W3C recommendations. The outcomes of these two approaches can be used as a starting point for development of the interfaces in the MOBNET project.

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