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# Web Content Delivery to Heterogeneous Mobile Platforms

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**Abstract.** It is widely acknowledged that information such as web content should be adapted for mobile platforms to account for restrictions in mobile environments. As emerging mobile platforms such as different kinds of Personal Digital Assistant (PDA) tend to vary largely in their capabilities, we suggest that adaptation should be platform-specific. Common approaches for content adaptation are automated conversion and explicit specification of adapted content, with a trade-off between quality and development/maintenance effort. As alternative avoiding this trade-off, we propose a simple object-oriented framework for content adaptation. To facilitate the use of this framework in the Web, we base our approach on the object-oriented WebComposition model and its XML-based implementation WCML. We apply our object-oriented approach to an example application to demonstrate how object-oriented specification of platform-adapted content reduces development/maintenance effort.

## Information Access from Mobile Devices

Information access from mobile devices has to take a range of restrictions into account, which exists in mobile computing environments in comparison to desktop environments. Both, properties of wireless networks and of mobile devices have to be considered. Regarding mobile devices, most notably screen real estate, computing power and power consumption are relevant. In this article, we refer to Personal Digital Assistants (PDA) with their largely varying properties to motivate the need to adapt information for delivery to mobile devices. The proposed solution though does not merely apply to PDAs but to heterogeneous mobile devices in general.

Several restrictions influence whether and how information can be presented on PDA devices. Each of these restrictions has to be taken into account when building content that should be delivered to and viewed on a PDA, or other mobile devices. Below, the most important restrictions are discussed.

- *Power Consumption.* Many researchers have indicated that battery live and power consumption are an essential constraint that mobile devices struggle with; special care has to be taken that applications save these important resource. For example, power consuming output methods such as audio should be avoided on mobile devices.
- *Computing Power.* Mobile devices usually have less computing power than stationary computers; computing power also varies largely among PDAs or more generally among mobile devices. Therefore, content requiring a lot of computing power, for example compressed video, is usually not suited for display on PDAs.
- *Display Properties.* PDAs and other mobile devices have very little screen real estate compared to desktop computers. Furthermore, display properties among different PDAs vary too a large extent. Table 1 shows a comparison of resolution, size and colour depth supported by different PDAs. This table indicates clearly a quite impressive difference of the display possibilities of different devices: the resolution ranges from 160x98 to 640x480 (factor 20), the size from 3,3x2,1 cm to 13x8 cm (factor 15), and the colour depth from 1 bit grey scale displays to TFT with 16 Millions of colours.

**Table 1.** Display Properties

| Device | Display resolution | Display Size | Capability |
|---|---|---|---|
| Franklin Rex | 160x98 | 3,3x2,1 cm | 2 grey scale |
| 3Com PalmPilot | 160x160 | 6x6 cm | 2 grey scale |
| Nokia Communicator | 640x200 | 11,43x3,6 cm | 8 grey scale |
| Psion 5 | 640x240 | 5,1x13,5 cm | 16 grey scale |
| WindowsCE PalmPC | 240x320[+] | Ca. 8x6 cm | Grey scale |
| Windows CE Handheld | 640x240 | Ca. 16x6 cm | Grey scale or colour |
| Apple Newton 2000 | 480x320 | 12,98x8,32 cm | 16 grey scale |
| Toshiba Libretto | 640x480 | 6,1'' | 16,7 Mio colours |

[+] Except Casio PA-2400 Cassiopeia 420x240

- *Communication.* Beside the characteristics of the mobile device itself, restrictions in the communication infrastructure are quite important. Table 2 gives a general overview of different options for wireless communication and their characteristics. Information to be delivered to mobile devices may have to be adapted to bandwidth availability and transmission cost.

**Table 2.** Communication Properties

| Type of Communication | Connection Cost | Bandwidth |
|---|---|---|
| I/R Communication | - | 115 kbit |
| Radio Communication | - | 2 Mbit |
| GSM Modem/Phone | 1,20$/60sec (in Germany) | 9,6 kbit |

The above consideration of constraints that apply to information delivery to mobile devices shows the need for adaptation to more than one parameter. For example, web content may have to be adapted regarding the choice of media, the layout of pages, and the overall volume of data, depending on computing power, display properties and available bandwidth.

The remainder of this paper is structured as follows. In the next section, we will discuss two common approaches for adaptation of information, more specifically web content, to mobile platforms. In section 3, we will propose a new approach based on an object-oriented framework for content adaptation. Section 3 also introduces an XML-based markup language based on WebComposition, an object-oriented model for web applications. Finally, section 4 illustrates an example-application applying the framework

## Approaches to Web Content Adaptation for Mobile Platforms

In the remainder of the paper, we discuss information access from mobile devices in the context of the World-Wide Web as primary information medium. The World-Wide Web as such has a very simple model for content delivery to clients and does not provide for adaptation to different clients or to clients on mobile platforms in particular. HTML as dominant document type does only support the adaptation of image resolution to low-resolution browsers. For further adaptation of web content, in particular with respect to clients on mobile platforms, two different approaches are common:

- Automated conversion
- Explicit specification of adapted content

*Automated Conversion.* This approach is based on the use of filters for conversion of web content to a presentation suited for mobile devices. *PocketWeb*, the first PDA browser for the WWW presented in 1994 at WWW-2 was based on this approach, for example to convert images to bitmap in adaptation to the capabilities of the first Newton MessagePad [4]. In PocketWeb, adaptation is primarily based on display properties. In contrast, *MobileWWW* and *MobileODBC* [1] adapt the transmitted content volume automatically to the available bandwidth, based on measuring the QoS of the available network and comparing it to the user preferences regarding download-time and maximal costs. According to these preferences the content was compressed with loss for audio, video and pictures and then transferred.

Automated conversion and adaptation of content is quite advantageous for creators of applications or content, because in an optimal case no additional effort has to be taken to adapt content for mobile devices. The disadvantage of the approach is that the semantics of the content is not taken into account. While automated conversion may yield acceptable results in many cases, it is not reliable and can lead to delivery of

content that is not useful anymore. For example, compression can lead to unreadable output of graphics that are indispensable for the understanding of displayed content. In addition, after automated conversion, content media may be scaled appropriately but still the content layout may prove awkward, for example forcing the user to scroll on the small display.

*Specification of Adapted Content.* As automated conversion is often unacceptable, it is quite common to explicitly specify adapted content for mobile devices. For example, in ESPRIT project MILLION, mobile information access to a web-based application was realised by specifying HTML documents following style guidelines for HTML delivery to a PDA [7]. Instead of style guidelines, specific description languages have been proposed for content delivery to small mobile devices. These efforts are driven by large consortia, for example the WAP forum proposing the *Wireless Markup Language* (WML) [9], and the W3C consortium suggesting *Compact HTML* (CHTML) [10]. With a language like WML or CHTML, content can be designed in a way optimised for mobile devices. This is a good solution for content and applications created exclusively for one class of mobile devices. The solution degrades though, if the goal is to gain access from heterogeneous platforms, for example from desktop browsers and different kinds of mobile browsers, because then all content has to be build several times (for each type of browser, and in addition maybe even for different communication bandwidth).

Both proposed methods, automated conversion and special language, have their trade-offs regarding content development for heterogeneous mobile platforms. In the following section, we propose to use object-oriented techniques for specification of adapted content, aimed at reduced effort for building and maintaining content for heterogeneous platforms.

## Object-Oriented Development of Web Content

### An Object-Oriented Framework for Content Adaptation

We propose an object-oriented approach to provide information for heterogeneous browser platforms. The approach aims at provision of content adapted to specific browsers but uses object-oriented concepts to avoid replicated content definition. The idea is based on the well-known model-view concept (or *Observer* pattern [2]) to maintain different views of the same content. In this case, different views being content presentations are adapted to specific browser platforms. Besides model-view, the idea is to capture commonalties among different views in generalised views, and to apply object-oriented inheritance to derive specific views.

While it is straightforward to devise an object-oriented model or framework for the given problem, it is unfortunately not easily applied to web-based information

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