

# E-Learning Systems Content Adaptation Frameworks and Techniques

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## INTRODUCTION

Content adaptation is defined as the process of selection, generation, or modification of content which include text, images, audio, video, navigation, interaction, any object within a Web page, and associate service agreement (Forte, Claudino, de Souza, do Prado, & Santana, 2007) to suit user's context (TellaSonera, 2004). With the proliferation of mobile devices such as personal digital assistants (PDA) and smart mobile phones which have the capability of accessing the Internet anytime and anywhere, there is an increasing demand for content adaptation to provide these devices with appropriate content that is aesthetically pleasant, easy to navigate, and achieve satisfying user experiences. This article first provides an overview of frameworks and techniques in Web content adaptation that are being developed to extend Web applications to non-desktop platforms. After describing general adaptation techniques, this article focuses particularly on the adaptation requirements for e-learning systems, especially when they are accessed through mobile devices.

## WEB CONTENT ADAPTATION

Most existing Web applications are geared towards desktop platforms; as a result, only a limited class of users can have access, thus restricting the potential customer growth of the enterprise. With increasing proliferation of a diverse set of mobile devices accessing the Web under different network conditions and users' context, the need for content adaptation is significantly increased. To circumvent this problem, various commercial products and research prototypes dealing with Web content adaptations have emerged such as Spyglass (Spyglass-Prism, 2001), Intel QuickWeb (Intel QuickWeb, 1998), IBM Transcoding proxy

(Smith, Mohan, & Li, 1999), Digestor (Bickmore & Shilit, 1997), Mobeware (Angin, Campbell, Kounavis, & Liao, 1998), TranSend (Fox, Gribble, Chawathe, & Brewer, 1998), WingMan (Fox, Goldberg, Gribble, Lee, Polito, & Brewer, 1998), Power Browser (Buyukkokten, Garcia-Molina, Paepcke, & Winograd, 2000), DOM-Based extraction (Gupta et al., 2003), and XADAPTOR (He, Gao, Hao, & Yen, 2007). The types of content adaptation that these systems have looked into are mostly multimedia-rich transformation or the removal of multimedia content (Gupta et al., 2003). In contrast, there are other areas, such as mobile learning, which require the development of Web content adaptations for mobility with respect to user environment, devices capabilities, and network conditions. These areas have distinct features that are yet to be researched extensively. This article provides an overview of some of the promising frameworks and techniques in content adaptation.

## RE-AUTHORING

According to Bickmore and Schilit (1997), one straightforward method is to re-author the original Web content. Manual re-authoring can be done, but obviously is the most ineffective way and requires that the Web pages must be accessible for re-authoring. This sometimes poses some practical constraints. However, the underlying principles and questions that are faced are identical for both automatic and manual re-authoring: What are the strategies used to re-author the pages? What are the strategies used to re-designate the navigations? What presentation styles can be achieved? These are the questions facing any content adaptation process. The underlying principle is to isolate and distinguish the Web content objects, presentation objects, navigation objects, and interactive objects for desktop publication,

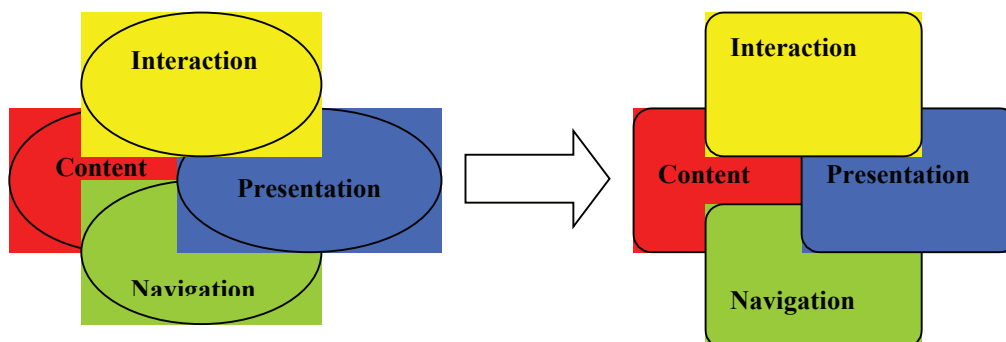
and re-map them into other device-capable objects. Figure 1 shows such a re-mapping process. Once the strategies have been defined and the process is matured, manual re-authoring can be converted into automated re-authoring through HyperText Transfer Protocol (HTTP) proxy server or server-side techniques such as Common Gateway Interface (CGI), or Servlet or client-side scripting. The re-authoring approach can either be mobile device-specific or tailored to multiple classes of devices. For multiple devices re-authoring, transformation-styles sheets (XSLT) and cascading-styles sheets (CSS) can also be used.

From another perspective, re-authoring can be viewed along two dimensions: syntactic (structure) versus semantic (content) and transformation (convert) versus elision (remove). Syntactic techniques operate on the structure of the page, while semantic techniques rely on the understanding of the content. Elision techniques basically remove some information, leaving everything else untouched, while transformation techniques involve modifying some aspect of the page's presentation or content. The Digester system (Bickmore & Schilit, 1997) used the re-authoring technique that included outlining, first sentence elision, and image scaling, and built an abstract syntax tree to provide content adaptation. The Digester system used a proxy-based heuristic approach for its automated re-authoring. This method worked well for small-screen mobile devices. However, one should be aware that the elision process might remove certain content and affect the capturing of user profile. There is also a possibility of making customization less accurate.

## TRANSCODING

According to Bharadvaj, Anupam, and Auephanwiriyaikul (1998), modifying the HTTP streams and changing its content in situ is called active transcoding and is done dynamically without user intervention. Transcoding can be performed in both upstream and downstream directions. An implementation of this technique is MOWSER (Mobile Browser Project, 1996). MOWSER is an Apache proxy server agent written in Perl. MOWSER used proxy to perform transcoding. Various transcoders are currently available for use in content adaptation. For example, VCDGear and Pict-View are video and image converters, respectively. In MOWSER, the incoming HTTP stream is modified by the proxy to include the capabilities and preferences of the mobile users. The users' preferences and capabilities are stored in the server. Modification and update of preferences is done by a CGI form on a URL at a Web site maintained by the proxy. The proxy then fetches the files with the most suitable format to the requesting client. This implementation assumes that different formats are available for content adaptation. This is not an issue, as different formats can be created on the fly and cached in the server for future requests. Transcoding of images and videos is done using scaling, sub-sampling, or sub-key frame techniques. Transcoding of HTML pages is done by eliminating unsupported tags and allowing the users to select their preferences. This implementation, however, does not touch on the aspect of navigation. This technique, therefore, might not work well if adaptive navigation is required. Most recently, the transcoding technique has been adopted to enhance mobile learning in the Blackboard learning system (Yang, Chen, & Chen, 2007).

Figure 1. Desktop web objects re-authored into mobile device capable objects



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