

A Classification for Content Adaptation System

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ABSTRACT

Content adaptation is an attractive solution for the ever growing desktop based Web content delivered to the user via heterogeneous devices, in order to provide acceptable experience while surfing the Web. Bridging the mismatch between the rich content and the user device's resources (display, processing, navigation, network bandwidth, media support) without user intervention requires a proactive behavior. While content adaptation poses multitude of benefits, without proper strategies, adaptation will not be truly optimized. There have been many projects focused on content adaptation that have been designed with different goals and approaches. In this paper, we introduce a comprehensive classification for content adaptation system. The classification is used to group the approaches applied in the implementation of existing content adaptation system. Survey on some content adaptation systems also been provided. We also present the research spectrum in content adaptation and discuss the challenges.

Categories and Subject Descriptors

A.1 [Introductory and Survey]: content adaptation; H.3.5 [Information Storage and Retrieval]: Online Info. Services

General Terms

Design, Human Factors

Keywords

Content Adaptation, Adaptive Hypermedia, Classification, Profile, Mobile Computing

1. INTRODUCTION

As human life becomes hectic, yet to 'stay in touch' is crucial and desirable, many small scale devices (e.g. mobile device, Netbook) and network technology (e.g. wireless, hotspot area) were introduced into the market to provide us with mobility and seamless Internet access; almost anywhere and anytime. While

this is attractive, however, most of the information and applications on the Web were designed with desktop computer in mind (larger object's size, multi-column paragraph, animation, high quality audio and video). This contradictory has resulted that the Web content do not adapt well with user mobility. Moreover, the development pace of mobile based Web applications is not at par with the hardware technology progress. In order to increase usability of mobile Internet services, content adaptation is required. In general, content adaptation is an approach to provide some automatic means to convert any existing content to a version suitable for rendering in a client device requesting for that content [1, 2].

The common scenario of content adaptation is described in Figure 1. User via the client device requests to view a particular Web page. Proactively, on user behalf, the content adaptation engine collects the user preference, client device profile and Web page data (including content) and metadata. Then, the engine processes the collected data and produces the content adaptation configuration including the page content structure. This configuration is mapped with the content structure and used to compose the content presentation. Finally, the adapted page is ready and sent to the user. The practical period to perform the content adaptation is between user request and the Web page download time.

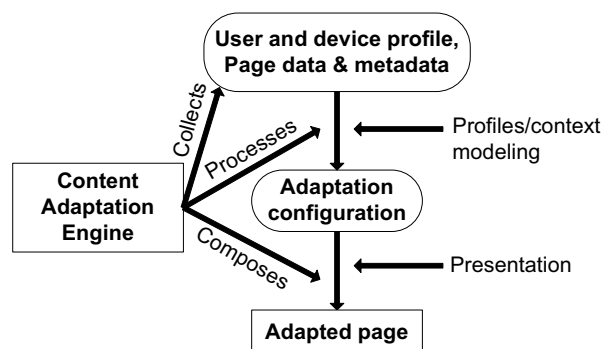


Figure 1. Content adaptation loop

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The rest of this paper is organized as follows. In Section 2, we introduce the possible classification of content adaptation system. We then present, in Section 3, the survey on some adaptive /content adaptation systems. Finally, section 4 presents the research spectrum and the potential challenges to the research community to deal with.

2. CLASSIFICATION OF CONTENT ADAPTATION SYSTEM

There are several fundamentals areas in content adaptation that need to be well understood, before any content adaptation system can be designed. As in Figure 2, these areas can be classified into six components: where to perform the content adaptation (locality); who should perform the adaptation (strategy); what to be adapted (mechanism); why performs adaptation (purpose); adapt to what (context); and how to adapt (method).

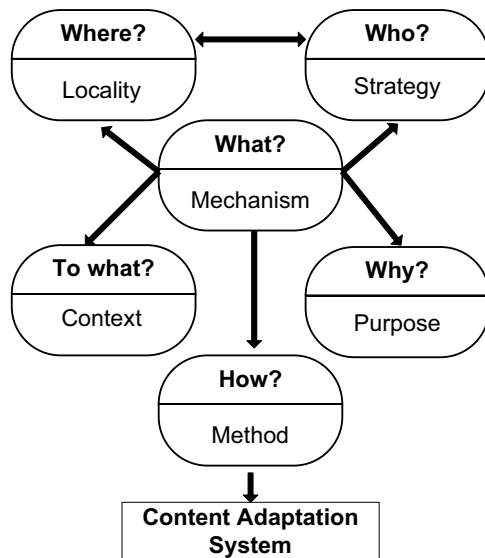


Figure 2. Content Adaptation System Classification

In general, content adaptation can be grouped into two, static adaptation and dynamic adaptation [3]. In static adaptation, multiple versions of the page content is pre-processed and stored. When user request for the page, the appropriate version will be matched based on the user and device context. This will reduces the download time but requires pre-processing task and bigger storing allocation. InfoPyramid [1] and PVP+SVP [4] are the examples that applied static adaptation. In contrast, dynamic adaptation enables the content to be adapted real time (on the fly). The adapted version for the specific context will be composed during user request. Dynamic adaptation can provide the most suitable adapted version to the ever growing context (both user and device), however it may suffer network and processing limitation. Kontti [5] and [6] are some of the content adaptation systems applying this dynamicity. Some examples of Web applications that require content adaptation are Web Information system, Learning Management system, Information Retrieval system and Library system.

2.1 Mechanism of Content Adaptation

Mechanism is a terminology referring to what to be adapted. The main mechanism of content adaptation is to adapt the data or content before it is sent to user. Content can be adapted in several ways such as appearance adaptation by repositioning the content's layout or changing number of columns [7]; size adaptation by

resizing the image or Web page dimension [8]; format adaptation by changing the media format (e.g. image format from bitmap to jpeg) [8]; characteristics adaptation by varying the content's fidelity¹ of the Web page [2]; and encapsulation adaptation by extracting the most important aspect of the content [9].

2.2 Strategies of Adaptation

Adaptation strategy is a concern regarding who should be responsible to carry out the content adaptation. In [10], three strategies are highlighted: the underlying system (where the application resides), the application, or both (system and application). In the first strategy, underlying system needs to perform the adaptation of the Web page. For example, before the adapted Web page is sent to the user via mobile device, the mobile operating system downloads the requested Web page, adapt the content accordingly, and deliver it to the user. The latter strategy is vice versa, where the application plays the role of adaptation. In this case, the requested Web page (so called application) adapts its content to the targeted device. Most of the existing content adaptation applied this strategy [1, 2, 5, 6]. The last strategy requires cooperation from both system and application to carry out the adaptation. This is the best strategy but requires synchronization between system and application, as applied in Odyssey [11].

2.3 Localities of Content Adaptation

Locality is referring to the location of where the content adaptation operation taken place. It can be classified into two non-overlapping groups, centralized and distributed. Further, the centralized class can be divided into three: client side, server side and proxy side. Each of them performs in certain aspects and also may suffers from certain limitations.

In client side approach, the client itself (e.g. smart phone) needs to perform the content adaptation, and then send the adapted version to the user's screen. This is suitable for static adaptation such as in [1, 4], however, for dynamic adaptation, some of the resources such device capabilities and network bandwidth may not be sufficient at time. As a result, adapting at client side is not favorable. While in server side approach, content adaptation is performed at the server, where the original Web page resides. For example, while user trying to browse a particular Web page, the server collects the context information then performs the adaptation (either by the system, application, or both) and delivers the adapted page accordingly. [1, 4, 12, 13] are some of the systems that perform adaptation at the server side. However, this approach may experience requests' overload and heavy traffic. Meanwhile, for proxy side approach, the proxy is responsible to perform the adaptation. When the user request for a Web page resides in a remote server, a particular proxy downloads the Web page and collect the context (both user and device), and adapted it accordingly before sending it to the user. [2, 5, 14, 15] are some of the examples applying this approach. Proxy side adaptation provides the best version for a specific media type but not suitable for adaptive hypermedia system. Finally, adaptation can be done at different locations, so-called distributed approach. More

¹ Fidelity is referring to different qualities of the same object. For example, fidelity of a particular image can be in black and white, 2 bits, or high colour scheme.

specifically, we can break the adaptation tasks and pass it to different location (dependable on available resources at the assigned location). For example, transcoding of image data can be done at the server (this requires more resources), while adapting the Web page-based dimension can be done at the client side with scarce resources. Definitely, it requires a scheduling management, or will be inefficient. BARWAN [16] is the earliest system implemented distributed approach, followed by research in [17].

2.4 Purposes of Content Adaptation

Every content adaptation system is developed to satisfy a particular purpose. In general, the purpose can be divided into two types, general purpose and content-type-specific. General purpose system usually used to adapt Web page properties, objects and some other common characteristics. Most of the earlier adaptive hypermedia systems belong to this category. It is usually fixed and hard-coded, so it is more secure and easy to be controlled. But in the other hand, it leads to the difficulty to adapt changes when new objects being introduced. InfoPyramid [1], Odyssey [11] and Power Browser [12] are some of the examples. More recent projects such as Xadaptor [14] and VTP [15] used scripts and agents to facilitate flexibility and extensibility. In contrast, the content-type-specific system is designed to handle specific task of adaptation of data type. For example, if the system's goal is to adapt image type, it only caters the image adaptation. Many researchers such as in [2, 6] focus on this type of system, as it will provide better result for that type.

2.5 Methods of Content Adaptation

Some of the methods for content adaptation are transcoding (changing the content fidelity); content layout re-arrangement; and distillation (extract the most important aspect). More specifically, some researchers focus on content decomposition technique such as text unit detection [12], where the page is broke into text unit that can be displayed, hidden and summarized; block-based content decomposition [18], where a HTML page is factorized into blocks with assigned scoring value, which then the highest score will represent the content; efficient fragment generation [19], where the desired content will be displayed based on shared behavior, personal characteristic and lifetime; multi-column to single-column layout transformation [7], where the content's column will be adjusted to a smaller portion, while potentially adjacent media objects are crosscut; and unit of information-based (UoI) decomposition [9], where atomic information unit is defined as a semantic unit compromising a sets of segments and media objects that have to be presented together, when it is selected. Most of the approaches perform well with well-formatted Web page and content, but also may experience information lost during the composition phase.

2.6 Context of Content Adaptation

Context refers to who should be considered for the content adaptation and maximizing the adaptation [2]. In fact, the content adaptation should be carried out based on priority. Context can be divided into two: device centric and user centric. In device-centric approach, the adaptation will be based on the capability of the targeted/client device. The adapted version will depend much on the client's device profile alone, before it is displayed to the user. The system produces the best renderable quality. While in user-centric approach, it consider the user's preferences and it

surrounding. Besides, the adaptation is also determined based on the user's inferred interests. These preferences are considered as high priority in dealing with user-centric approach. Some of the recent researchers focusing on user centric are [2, 13].

3. SURVEY ON SOME CONTENT ADAPTATION SYSTEM

In this paper, we will provide some descriptions of the existing content adaptation system ranging from the late 90's to the recent years. Please note that the adaptive/content adaptation systems were selected randomly, without any specific intention. The purpose of this survey is to provide a rough overview of overall progression along this direction.

Table 1. Survey on some CA system

System	Descriptions
InfoPyramid [1]	One of the early static adaptation systems that used a representation scheme to represent hierarchy for multimedia data. The system stores multi version content and will be selected to suit best the targeted device. This general purpose system suitable to be adapted at client, server or proxy side.
Odyssey [11]	Use application-aware adaptation strategy where the adaptation is done by both the system and application. Application interacts with the remote server via the wardens before performing adaptation. Unrecognized data will not be adapted.
Power Browser [12]	Breaks each web page into text units that can easily be displayed, hidden, visible or summarized. Two major methods for summarization used are macro-level summarization (relies on structural analysis) and micro-level summarization (using information retrieval techniques).
PDCAS [2]	Content-specific-type system for generating suitable pdf file. It features a decision engine that generate necessary adaptation decision based on user's satisfaction, and transcoding is applies based on the decision.
QoSAS [13]	Based on the framework for a QoS-aware adaptive system that adapts web content based on both user-perceived-QoS and user interest related to the Web content.
Konti [5]	Address the challenges of supporting mobile content in new media format. The design principles of the system consist of functional user experience, extendibility, decomposition, structure preservation, delivery context and performance.
Xadaptor [14]	A dynamic adaptation system that use rule-based approach to facilitate extensible, systematic and adaptive content adaptation.
VTP [15]	VTP architecture can accept and execute the transcoding preference script provided by the client or the server to transform the corresponding data or protocol according to the user's specification. This dynamic system uses agent concept.

4. RESEARCH SPECTRUM

Adaptive hypertext/hypermedia research in the early 90' was aimed to increase the hypermedia functionality by making it personalized to a particular user model; usually by adapting text and link. Due to the increase of multimedia content on the Web and the usage of mobile devices, the mobile computing era has emerged, and together, content adaptation was born. Research focuses moved from personalization and static adaptation to quality oriented (including device, user and network context) and dynamic adaptation with multimedia data in hand (see Figure 3). Adaptation methods such as transcoding, distillation and decomposition were introduced to facilitate the ever-growing content.

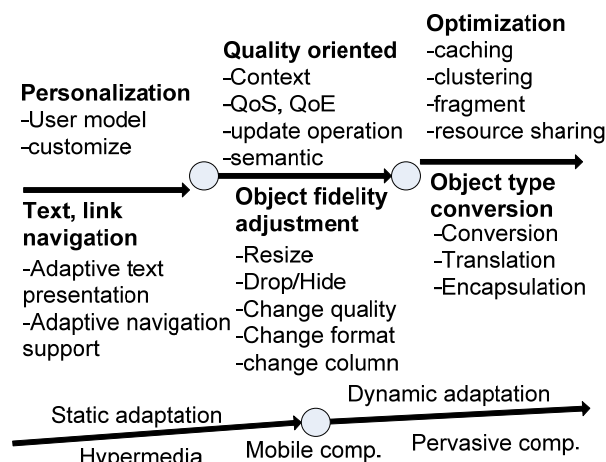


Figure 3. CA Research Spectrum

More recently, as the pervasive computing was introduced to provide 'seamless technology' around us, optimization strategy is necessary. The main challenge is now to perform content adaptation from multitude of distributed resources while maintaining computing efficiency. Method for dynamically sharing resources between wired and wireless computer within the neighborhoods is attractive to offer better content adaptation.

5. CONCLUSION

This paper builds on and contributes to the work in content adaptation, as it becoming an attractive solution. In this paper, we have presented a brief classification that explained the mechanism, strategies, localities, purposes, context and methods of content adaptation. Then, we provided a survey on some adaptation system ranging from the late 90's to the recent years to illustrate the overall progress. Finally, we highlighted the research spectrum in this area and discuss some related issues.

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