Using Description Logics for the Provision of Context-Driven Content Adaptation Services

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ABSTRACT
This article presents our design and development of a description logics-based planner for providing context-driven content adaptation services. This approach dynamically transforms requested Web content into a proper format conforming to receiving contexts (e.g., access condition, network connection, and receiving device). Aiming to establish a semantic foundation for content adaptation, we apply description logics to formally define context profiles and requirements. We also propose a formal Object Structure Model as the basis of content adaptation management for higher reusability and adaptability. To automate content adaptation decision, our content adaptation planner is driven by a stepwise procedure equipped with algorithms and techniques to enable rule-based context-driven content adaptation over the mobile Internet. Experimental results prove the effectiveness and efficiency of our content adaptation planner on saving transmission bandwidth, when users are using handheld devices. By reducing the size of adapted content, we moderately decrease the computational overhead caused by content adaptation.

Keywords: Content Adaptation, Context-Driven, Description Logics, Mobile Internet

INTRODUCTION
Mobile computing poses big challenges to Web content delivery services in several significant ways. First, increasing volumes of handheld devices (e.g., Personal Digital Assistants (PDAs) and mobile phones) have been used to access Web content nowadays; however, most of the existing Web content is originally designed for desktop devices instead of handheld devices. Second, mobile users usually move constantly; their residing environments thus may change accordingly and Web content delivery should also subject to the changes for a better performance. For example, if a user moves into a blurred environment (e.g., due to a sunny or gloomy weather), the content should be consequently enlarged or the background color should be...

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turned brighter. Third, people’s status may change dynamically, which may consequently request adjusted content delivery. For example, if a user on a multimedia phone conversation walks into a room for another physical meeting running in parallel, the audio should be turned off. The corresponding audio transmission thus becomes unnecessary.

Therefore, tools and mechanisms are in need to provide mobile users with transparent and seamless content delivery services. To achieve this ultimate goal, it is essential to deliver personalized and adaptive content according to users’ situated environments. In this article, the two terms “situated environment” and “context” are used interchangeably, both referring to context receivers’ surrounding information that has an impact on content delivery and presentation such as receivers’ personal profiles, receiving devices, communication network, location, activity, and time (Schilit, Adams et al. 1994; Dey & Abowd 1999; Satyanarayan 2004; Mukherjee, Delfosse et al. 2005; Julien & Roman 2006).

The conventional approach to provide Web content supporting various types of computational devices is to prepare and maintain different versions (formats) of the same Web content for different devices. For example, a Web page typically holds one HTML version supporting desktop devices and one Wireless Markup Language (WML) version supporting wireless devices. This approach is straightforward but labor-intensive yet error-prone. Content providers have to prepare different layouts and formats for the same Web content, which results in tremendous overhead. To support a new device, all previous Web pages have to support a new format. Even worse, any change in the Web content may result in consequent changes in every related version, which is highly inflexible. Obviously, this approach is neither practical nor feasible for providers of a large volume of Web content.

To bridge the gap between content providers and mobile consumers, content adaptation refers to a technique that provides the most suitable content presentation by means of transformation. While some researchers focus on content adaptation techniques on multimedia types, such as image and video adaptation (Mohan, Smith et al. 1999; Mukherjee, Delfosse et al. 2005; Nam, Ro et al. 2005; Vetro & Timmerer 2005; Xie, Liu et al. 2006; Wang, Kim et al. 2007), some other researchers focus on exploring how to conduct proper content adaptation based on receiving contexts (Lum & Lau 2002; Hua, Xie et al. 2006; He, Gao et al. 2007). Although the literature has witnessed these effective content adaptation efforts and techniques, they typically do not support automatic content adaptation decision; nor do they support configurable and extensible contextual environment specifications.

In contrast with the previous works lacking a clear semantic basis, this research intends to study a semantic foundation for content adaptation. Specifically, this research aims to investigate solutions to four research challenges:

C1: How to formally detect and represent mobile user contexts?
C2: How to design configurable and reconfigurable adaptation rules?
C3: How to manage and automate content adaptation management?
C4: How to automatically generate adaptation output format?

To the best of our knowledge, our research is the first effort to apply description logics (DLs) to formally define context profiles and requirements, and to automate content adaptation decision. We also introduce a Meta Medium Object concept and an Object Structure Model (OSM) to formally model an adaptable medium object. Then we construct a context-driven content adaptation planner that is designed and developed to automatically transform Web content to an appropriate format based on users’ surrounding contexts, especially when users are using handheld devices over the mobile Internet. Another benefit of our method is that it may reduce content access time. For example, if a user is accessing a film while driving, then
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