Future Generation Computer Systems 27 (2011) 256–264

Contents lists available at ScienceDirect

Future Generation Computer Systems

journal homepage: www.elsevier.com/locate/fgcs

QoS-based adaptation service selection broker

Mohd Farhan Md Fudzee, Jemal H. Abawajy *

School of Engineering and Information Technology, Faculty of Science and Technology, Waurn Ponds Campus, Deakin University, Geelong, Victoria, 3216, Australia

ARTICLE INFO

Article history:
Received 24 December 2009
Received in revised form
18 February 2010
Accepted 4 September 2010
Available online 21 September 2010

Keywords:
Content adaptation
Distributed systems
Multi-criteria decision making
Services
QoS
Performance analysis

ABSTRACT

Electronic documents are becoming increasingly rich in content and varied in format and style while at the same time client devices are getting increasingly varied in their capabilities. This mismatch between rich contents and the end devices' capability presents a challenge in providing seamless and ubiquitous access to these contents to interested users. Recently, service-oriented content adaptation has emerged as a potential mechanism to address some of the problems arising from the content–device mismatch. The major problem with service-oriented content adaptation scheme is that an adaptation task can potentially be performed by multiple services. In this case, selecting appropriate services among the many available services is necessary to increase the overall performance of the system. In this paper, we propose a multi-criteria adaptation service selection broker that provides the possibility to select the best service among the available candidates. The performance of the proposed service selection framework is studied in terms of efficiency of service selection execution under various conditions. The results indicate that the proposed policy performs substantially better than the baseline approach.

1. Introduction

The rapid development of digital media technologies has enabled the emergence of novel media content types for various domains including e-Commerce, e-Education, and e-entertainment. As a result, there is a phenomenal growth in consumable electronic information on subjects such as entertainment, security, education, and technical documentation targeted to diverse users in the form of content and services.

While online documents are becoming increasingly rich in content and varied in format and style, the original content is normally developed for a specific platform and is naturally made-up of media objects of different types with complicated structure and layout [1]. At the same time, client devices are getting increasingly varied in their capabilities (e.g., processing power, input and output facilities). For example, most existing Web content is originally designed for display on desktop computers. Therefore, direct content delivery to handheld devices without layout adjustment and content adaptation often leads to disorganization of information [2]. Moreover, not every handheld device can play all media types. For example, a non-multimedia mobile phone cannot play continuous video clips. This mismatch between the content and devices is addressed by using adaptation methods. Essentially, we can either adapt the resources to match the content or adapt the content to match the device capabilities. In this paper, we will focus on the latter case. In content-to-device adaptation, the content is tailored according to the user preferences, network characteristics and client device capabilities [2].

An efficient content adaptation system must be able to adapt the content for every client in every situation in order to address the wide range of clients [1]. Recently, a service-oriented content adaptation (SOCA) has been advocated as a potential solution to the content–device mismatch problem [3–7]. A service in SOCA represents a set of functionalities offered by the content adaptation service providers. These services are provided by service providers located across the wide-area network. Establishing content adaptation as a service allows the use of a large number of adaptation mechanisms located in many places in the network. As the service-oriented adaptation scheme is essentially distributed in nature, an adaptation task can be performed by multiple services. This leads to different service composition possibilities as such making service selection challenging. In this case, selecting appropriate services among the many available services is necessary to increase the overall performance of the system. Hence, a mechanism is required to map the adaptation tasks to the appropriate adaptation services. This is referred to as the adaptation path determination problem [6].

In this paper, we propose a layered service-oriented content adaptation framework. Since there could be several possible adaptations services, we propose a novel multi-criteria adaptation service selection broker that enables users to select the best service among the available content adaptation service candidates. The broker uses a new adaptive path determination algorithm that selects the best possible distributed adaptation services.

* Corresponding author. Tel.: +61 3 52271376; fax: +61 3 5227 2028.
E-mail addresses: mfmd@deakin.edu.au (M.F. Md Fudzee), jemal@deakin.edu.au (J.H. Abawajy).

0167-739X/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.future.2010.09.005

The innovative aspect of our work is that this is the first paper that introduced a layered SOCA that uses distributed brokers to address the content adaptation problem. Also, the score computation takes into account the different quality of services (QoS). The performance of the proposed service selection framework is studied in terms of efficiency of service selection execution under various conditions. The results indicate that the proposed policy performs substantially better than the baseline approach.

The rest of the paper is organized as follows. In Section 2, related work is reviewed. In Section 3, a service-oriented content adaptation architecture is presented and the formulation of the path determination problem are described. Section 4 presents the proposed adaptive multi-criteria path determination policy. The performance evaluation and discussion of the results are presented in Sections 5 and 6 respectively. Finally, we concluded the paper in Section 7.

2. Related work

Content providers are under constant pressure to make their content available in a variety of formats and for a variety of purposes [8]. The content adaptation challenge is how to make the original content readily available on a wide range of access devices with varied characteristics while ensuring satisfactory service quality for interested clients. One way to address this problem is by creating and maintaining different formats of the original content suitable for the targeted access devices. This approach is used in InfoPyramid [2]. In this case, content is formatted differently for displays that have different capabilities, and is also delivered differently for devices that have a different connectivity [8]. Although the pre-adapted content versions approach is simple to implement, it suffers from a number of serious drawbacks. To create a pre-adapted content version, a human designer can be involved to hand-tailor a version for some specific rendering requirement [8]. Keeping multiple copies of the original content will lead to tremendous overhead and places an unwieldy burden on the content authors. Moreover, any changes in the content may require changes on every version of the contents, which renders this approach error-prone. In addition, a new device may require a new format. Clearly, this is neither practical nor feasible for providers of large volumes of content.

An alternative content adaptation approach is to automatically generate any content version from one single original version such that the content is adapted to the device and the user preferences. This requires a content adaptation system with the appropriate logic to analyse the content and all aspects of the delivery context and formulate the content adaptation strategy that will deliver the most satisfactory user experiences. There are many content adaptation approaches that generate any number of content versions from one single original version [2,8,3,9–14,4]. These systems are generally classified as client-side [10], server-side [11,13], and proxy-side [9,12]. In a proxy-based approach, content adaptation and context monitoring is managed by external server called proxy. In the client-side approach, the client itself (e.g., netbook, PDA, smart phone) needs to perform the adaptation, and then send the adapted content to the client. The advantage of this approach is that the device capabilities can be determined directly. The problem with this approach is that the client may not be capable of undertaking the adaptation. In the server-side approach, adaptation is performed at the server. The server-side approach performs very well for a relatively small number of users, but will suffer from overload if too many concurrent requests arrive. The common thread among these approaches is that they tend to be fully or partially centralized. These approaches suffer from several shortcomings (e.g., single point failures, not scalable).

Distributed service-based content adaptation schemes which distribute the adaptation activities to several service providers located across the wide-area network have recently emerged as a potential mechanism to address some of the problems arising from the content–device mismatch [3–7]. The aim of service-oriented content adaptation is to provide an enhanced user experience by offering value-added content and also to provide flexible and scalable service-based content delivery mechanism.

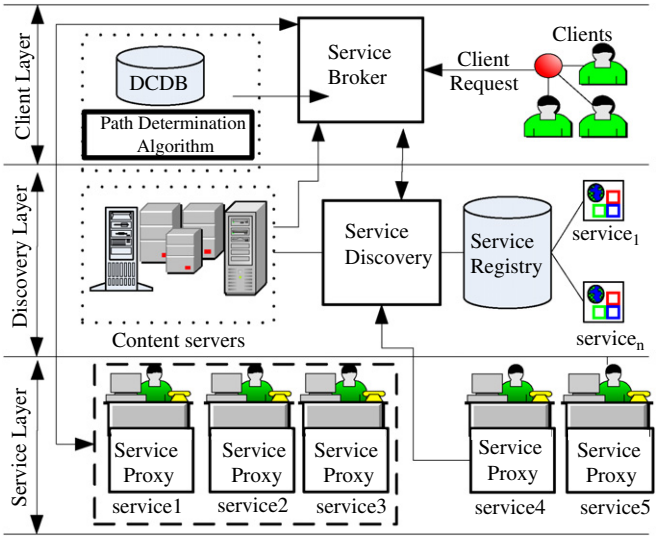

Fig. 1. Service-oriented content adaptation.

To address the adaptation path construction problem, a directed acyclic graph (DAG) is discussed in [4,6]. The transformation prescript graph for DAG is organized in serial manner and bounded by the media format. To address the problem of choosing the optimal path, a static path determination criteria (SPDC) policy is discussed in [3,6]. SPDC suffers from a number of shortcomings. For example, availability represents the existence of a particular service at any given time. Accumulating availability value into a node score will lead to a wrong conclusion about the availability of the content adaptation service. Furthermore, SPDC's score computation policy misleads the optimal path determination. Our proposed algorithm avoids the shortcomings associated with SPDC. Unlike SPDC, we use two relationships for computing service scores; positive and inverse relationships.

Also, we concentrate on selecting a single optimal path as opposed to those discussed in [3,6,1]. Optimal path refers to the combination of services that best suit the client's selection criteria to facilitate the adaptation tasks [3,15]. For instance, if we have multiple optimal paths, then we need to have other decision rules to choose the best one, with which complicates the determination. Therefore, having a single optimal path is essential to increase the service selection execution performance.

3. Service-oriented content adaptation framework

In this section we will give a brief description of the proposed service-oriented content adaptation framework. We will also formulate the adaptation path problem.

3.1. Reference system architecture

Fig. 1 shows a layered architecture of the service-oriented content adaptation (SOCA) scheme. The framework consists of components that provide access to content servers, formulate the user request to source format, manage and provide content description (meta-data). In the service-oriented content adaptation scheme, the content servers store the content and they are distributed across the Internet. Similarly, there are several content adaptation service providers located in many places in the network. The