AN IMPLEMENTATION OF QOS ADAPTIVE MULTIMEDIA CONTENT DELIVERY

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Abstract
The rapid development of technology in Internet and wireless communication makes it possible for people to access multimedia contents and services using handheld devices. However, most multimedia contents and services in the Web are optimized for desktop computing environment. They contain rich media data, which are not suitable for handheld devices with limited capabilities and resources. Moreover, depending on user preference and application scenarios, not all the data are relevant or critical to the application. In this paper, we present a scheme for adapting multimedia contents on the wireless devices for QoS-aware delivery. Especially, we seek to adapt multimedia contents based on system and network resources available, client terminals, user preferences and other environment characteristics.

Key Words: Multimedia Content Adaptation, QoS

1. Introduction

Over the past few years, the volume of multimedia contents has increased a lot. Similarly, mobile devices such as PDA and mobile phone have grown in popularity and capability. Along this trend, people have become enthusiastic about watching multimedia contents through their handheld or mobile devices. The capabilities of such devices vary widely but are limited in terms of network bandwidth, processor speed, display constraints, and decoding capabilities. As a result, there are many restrictions in viewing multimedia contents through mobile devices. Therefore, there is a growing need for applications to deliver multimedia data to a variety of devices while adjusting its quality based on the resources available.

Ubiquitous computing is the ability to extend applications and services normally conducted on personal computers to handheld and wireless devices enabling any where, any time, with any device access to multimedia information systems. Ubiquitous computing environment involves a variety of devices with different capabilities in terms of processing power, screen display, input facilities and network connectivity which can vary between wired and different types of wireless links. The diversity of these devices will make it difficult and expensive to author multimedia contents separately for each individual type of device. Therefore, the technologies that can adapt multimedia contents to diverse client devices will become critical in this heterogeneous environment. Multimedia information needs to be customized according to user preference, client capabilities, network and natural environment characteristics. This customization process includes transcoding (format conversion – e.g. XML to WML), scalable coding (spatial and temporal resolution reduction – e.g. bit-rate reduction) and transmoding (modality conversion – e.g. video to image, video to audio).

In general, adaptive multimedia content delivery systems have been focusing on specific problems such as varying network conditions, locations and devices [1, 2]. The purpose of such adaptive systems is to deliver multimedia contents to users any time, any where on any device. In order to achieve this kind of adaptation, we need a standard way to describe the multimedia content and perform content adaptation, and describe the physical environment (e.g. device and network condition) along with a method to deliver the content within the constraints of the physical environment. The MPEG-7 [3] and the evolving MPEG-21 [4, 5] standards, along with the concept of Universal Multimedia Access (UMA) [6], address the first requirement, by defining a set of Data types and Description Scheme (DS) for describing the physical environment pertaining to device and network conditions. The second requirement is addressed by standard MPEG-21 Part 7 (DIA: Digital Item Adaptation) to describe the physical environment including the device and network parameters [5]. In this paper, we exploit both MPEG-7 and MPEG-21 standards to achieve multimedia content adaptation under the heterogeneous environment.

The organization of the rest of the paper is as follows. In section 2, we briefly introduce the related adaptation schemes. In section 3, we illustrate the overall system architecture of our adaptive QoS framework. In section 3, we describe the profiles for the content adaptation. In
section 4, we present the implementation details of the system, and in section 5, we conclude the paper.

2. Related works

Content adaptation can be classified into two main types according to when these different content variants are created [7]. In the static adaptation, when the client requests the video, the server analyzes the context and selects the best alternative form of the multimedia content and sends it to the client. With the static adaptation approach, the content provider can have a tight control over what is transcoded and how the result is presented [8]. In the dynamic adaptation, it refers to the process of adapting desired multimedia content and delivering it on the fly according to dynamic requirement presented to the server which could be based on the current characteristics of the client environment [9]. For example, when network bandwidth is unstable, we can reduce the frame rate, resolution or color depth of the video delivered.

Depending on the location where the adaptation operation should be done, many researchers describe three possible places for implementing adaptation in computer networks [7, 10]. Adaptation operations can take place in the server, the client or the proxy. In the server-based adaptation, fewer examples using this approach are found [11]. Although server or senders as content providers have full control on content quality and have more computational power to make reliable adjustment on content quality, this adaptation has a major drawback that is required additional computation and resource consumption are required on the server which are the lacking of scalability. In the case of proxy-based adaptation, there are many systems which is implemented their adaptation schemes separately in a proxy between the server and the client. The advantages of this approach are its scalability, cost effective and transparent design. Although, this approach has many advantages, it still has efficiency problems affected by computation resource and time. Finally, in the client-based adaptation, the client device is responsible for adaptation and uses the device information and its capability to guide the adaptation process. In the Odyssey [12] system, all the adaptation process is done by the client, which is the receiver of data from a remote data sender. Such a receiver-initiated adaptation strategy has a benefit of scalability, since servers do not need to be changed when there are new applications requesting for adaptation.

3. Adaptive QoS framework

Figure 1 shows the system architecture implemented to deliver multimedia content QoS adaptively over wired and wireless connections. We have used different client devices such as Laptop, Pocket PC (PDA) and Cellular phone. When the client device connects to the server under various network conditions, the server determines whether it is possible to display multimedia contents on the client device. If the server concludes the client device is not adequate for displaying, then it requests the client to provide the available device and current network information. The information may include client hardware,
The adaptation describes the terminal capabilities as well as network characteristics, natural environment, and user preference [5]. More specific information is outlined below and the sample terminal and network description is shown in Figure 3.

4. Profiles for the adaptation

The adaptation describes the terminal capabilities as well as network characteristics, natural environment, and user preference [5]. More specific information is outlined below and the sample terminal and network description is shown in Figure 3.
### Terminal capabilities
User can adapt various formats of multimedia for viewing on a particular terminal by the terminal capabilities such as codec and I/O capabilities. Codec capabilities specify the format that a particular terminal is capable of encoding or decoding. I/O capabilities include a description of display characteristics, audio output capabilities.

### Network characteristics
Network capabilities and network conditions affect multimedia adaptation for transmission efficiency. For instance, we can lower the network bandwidth of a video stream if the available bandwidth is insufficient. Network capabilities define the maximum capacity of a network and the minimum guaranteed bandwidth and network conditions describe network parameters such as the available bandwidth and delay characteristics.

### Natural environment
Natural environment pertains to the physical environmental conditions around a user such as lighting condition or noise level, or a circumstance such as the time and location.

### User characteristics
Usage characteristics include a description of user information, usage preferences and history. User preferences define preferences related to the user hardware such as PDA, handheld PC. For audio, the specification describes preferred audio power and equalizer settings. For visual information, the specification defines display preferences such as the preferred color temperature, brightness, saturation, and contrast.

### 5. Implementation
In this paper, we have implemented a prototype system for delivering multimedia content in a QoS adaptive way. The system selects appropriate multimedia contents through the adaptation engine based on the evaluation of various multimedia content alternatives to adapt the client device. The client platform is developed by Microsoft Embedded Visual Tools with the DirectX Platform Adaptation Kit (DXPAK). We use DirectShow for streaming video files encoded in Windows Media Video Format (.wmv), Advanced Streaming Format (.asf), and Audio Video Interleave Format (.avi).

![Figure 4](image-url)

Figure 4 shows the adaptation process on the PDA client based on the device capability and user preference. According to the client’s profile, the requested video is transcoded and displayed into different formats such as different frame rate and frame size.

The adaptability of our system by the network characteristics (mainly the bandwidth of the connection) is shown in Table 1. We evaluated the system performance under various networking conditions. Through monitoring the network condition, we can obtain the terminal and network profiles for each modality. Then the collected adaptive parameters can be fed to the adaptation engine for determining any degradation. When network bandwidth consumption is saturated, the PDA client can display the video. However, the adaptation engine starts degradation by transmoding under the scarce bandwidth. During this degraded situation, the user can still listen to the audio with images through key-frames or read the closed caption.
6. Conclusion

In the coming ubiquitous computing environment, the same multimedia content may have to be transcoded or transmoded in different forms according to network and device capabilities. Content adaptation is a major issue that needs to be dealt with for developing an adaptive video delivery system. Towards this, this paper presents the design of an adaptive QoS scheme based on multimedia content adaptation. The scheme adapts multimedia content-based on current system and network state, client devices, user characteristics and natural environment characteristics.

In this paper, we use the dynamic multimedia content adaptation to reduce bandwidth required for delivery. We also design the adaptation scheme and implement the framework for adaptation driven by user perceived quality rather than just bit-rate reduction. Our system support media adaptation not for video only but cross-media adaptation using other media components such as audio, image and text.
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