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Media Content Adaptation Framework for Technology Enhanced Mobile e-Learning

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Abstract: The increasing demand for ubiquitous access to technology enhanced learning environment has faced a challenge of heterogeneity in terms of networks, mobile device, platforms and finally, the learning content in various formats. In order to alleviate the challenge of the said diversity, content adaptation is essential. However, because of the diversity of the mobile users, networks and the rich media learning content, it is a major challenge for the access of learning content by the desired devices in the mobile learning environment. In order to alleviate the challenge of learning content mismatch, content adaptation is essential. This paper describes a content adaptation framework for mobile e-learning.

Keywords: E-learning, Learning Object, Media Content Adaptation, Mobile learning
Categories: H.3.5, H.5.1 H.5.2, H.5.3

1 Introduction

The increasing demand of pervasive media access,, multimedia coding standards, and ubiquitous computing technologies have enabled mobile access to media contents in mobile learning environment. This demand comes with an increasing diversity of client devices. The client devices include desktop to smart phones that have different device profiles in terms of resolution, frame rate, and bandwidth capacity. As a result, the diversity of clients and their pervasive connections bring new challenges with regards to delivery of rich media learning content to mobile users, based on their preferences [Hossain, and El Saddik 2006].

Nowadays, learning is no longer restricted to a classroom. Information resources are all over the place that is separated from the learners by time and space. Mobile E-learning defines the process of joining learners with these remote resources through diverse mobile devices, such as Laptop, personal digital assistants (PDAs), and smart phones. Most of the learning contents that are designed for personal computers are unsuitable for accessing through handheld devices because of the resource constraints, user preferences and learner's needs. Therefore, in order to mitigate the problem of learning content mismatch, content adaptation for the learning content is essential. The process of converting or transforming a media stream from one form to another form is called content adaptation [Hossain, and El Saddik 2006]. Sometimes, content adaptation is referred to as either transcoding or repurposing.

Media content adaptation for diverse e-learning [(Iqbal and Shirmohammadi, 2007); (Deed and Edwards 2011), (Forment et al. 2010)] clients is challenging because of their diversity in terms of limited capability, diversity, and user preferences. To alleviate the said challenges of diversity, a framework is needed that allows media content adaptation; fulfil different mobile learning user requirements, conceals device diversities as well as resource limitations to make simpler the deployment of media adaptation. Considering the above, the objective of this paper is to discuss the key issues of a content adaptation system in order to deliver accessible, customized or nomadic learning experiences to learners of mobile e-learning environment with different preferences, access needs and skills. The essence of this media content adaptation is to make mobile e-learning content available in a suitable adapted form, which can be accessed by handheld devices at anytime from anywhere by mobile users by overcoming the constraints imposed by the surrounding environment.

The remainder of this paper is organized as follows. Section 2 presents a motivating scenario. In Section 3 related studies are discussed. Section 4 presents the system architecture, functionality details. Section 4 describes the proposed framework and its functionality. Section 5 presents experimental results and analysis, and finally, concluding remarks are made in Section 6.

2 Motivating Scenario for a mobile learning environment

At first, we would like describe two scenarios which will facilitate the reader to realize why customized e-learning content for mobile learning environment to heterogeneous users is essential.

Yosef is a software Engineer as well as a student of an e-learning course in Ottawa. He is going to attend a conference in Vancouver. The flight was delayed. While he was waiting in the Ottawa airport, he opens his laptop and watches the TV program for his course using existing airport LAN in the airport. The high-quality resolution of the TV program is supposed to adapt to a lower resolution in order to watch from Laptop. In the meantime he heard a video conference call from his friend in Manitoba through his cell phone to participate group discussion for his course project. It may be mentioned that his cell phone, which has video conferencing capability. The cell phone is connected to UMTS network which is suffered from lower quality due to the limitation of UMTS network. Even though his friend is using appropriate networks and PC, his cell phone is unable to present video and audio

stream as it is expected. Therefore, video and audio stream is required to be adapted in order to transmit through the changing network seamlessly.

After arriving in Vancouver airport, he was looking for Taxi cab. While he was waiting, he opens his PDA in order to check the time slot for his course from CBC. Due to display limitations and processing power of PDA, he was unable to get QoS guarantee i.e. he is not satisfied. Here, the stream should be adapted according to PDA's capability. After a while, he took a taxi to the Conference place. While he was in the taxi, he finds a computer with flat screen monitor embedded in the car. While going to the conference place, he was watching the TV program for his course from CBC. While watching the program from CBC, Yousef noticed that the quality of the audio and video is changing several times, as the car may change its network to different lower and higher bandwidth. Therefore, the audio and video stream is required to be adapted according to the car's network and location.

Figure 1 shows a scenario. In this scenario, mobile e-learning users join in a live video conferencing for a collaborative group study. The device of each user has different rendering capability in terms of devices, networks and user preferences. Live video is recorded from one e-learning user and is delivered to another user. However, due to the diversity of the e-learning user's profile., the captured video stream cannot be delivered according to the need of the user. Thus, the system needs to adapt the learning content based on the user's varying requirements. Sometimes, one conversion is not sufficient; we may require multiple conversion or adaptation services in a sequence before sending the customized media content to the user.

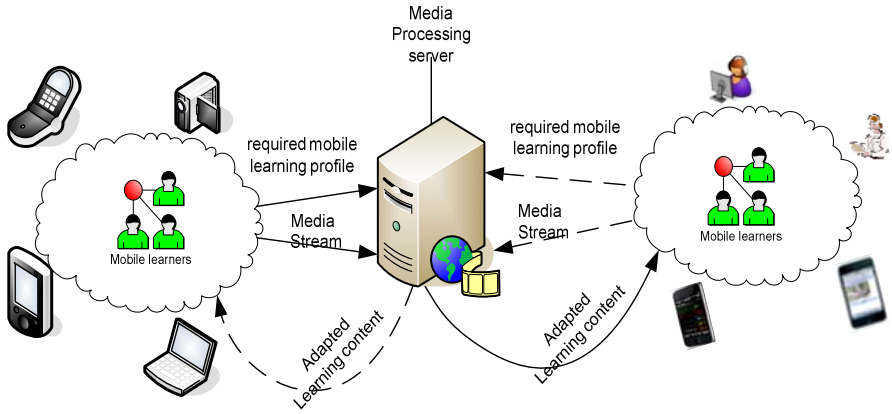

Figure 1: A of media content adaptation scenario for a mobile e-learning (video conferencing) environment

3 Related Studies

Content adaptation refers to the conversion process where, a media content that is originally designed for a particular device, platform, or user, is converted to fit other devices, platforms, or users [Hossain, and El Saddik 2006]. This conversion may be

related to a coding standard (e.g., H, 264, MJPEG, H.263), a coding parameter (e.g. frame rate, bit or spatial resolution), and/or user preferences.

Based on the location, where the adaptation occurs, content adaptation can be divided into three ways: server-based [Mohan et al. 1999], client-based [Bjrk et al. 1999], and proxy-based [Bandaru and Mandal 2003]. In this approach [(Bandaru and Mandal 2003), (Hossain, and El Saddik 2006]. the proxy server normally is located between the server and the client. The proxy that sends requests to the server on behalf of the client, receives content from the server, analyses and adapts the content, and finally delivers the adapted content back to the client.

Proxy adaptation has a number of advantages [Knutsson et al. 200], such as better opportunities for proxy caching [Ardon et al. 2003)], better client-perceived latency, leveraging the installed infrastructure, and adapting properly with the increasing number of clients. Thus, the proxy based approach is one of the best solutions for the successful delivery of media-based mobile learning content to the user.

In our previous works [(Hossain, and El Saddik 2006), (Hossain and El Saddik, 2007)], we provided, how the proposed adaption works, its architecture, and its functionality. So, the next section is based on our earlier work [Hossain and El Saddik, 2007]. However, this work provides the extent of mobile learning users' satisfaction with regards to learning content using the said framework.

4 The Proposed Framework

The proposed system framework's functionality shown in Figure 2, which consists of the following main components:

Server System: The media content server receives or stores all the profiles, including the user's preferences, services provided by the server, the client's capabilities, and proxy information. After connecting with the proxy, all profiles have been created in the XML format.

Client: The mobile client includes desktop, laptop, smart phones, and PDA, to receive the adapted media learning content.

Proxy: Proxies connect with both the server and the clients to perform adaptation. Adaptation proxies may have a number of Adaptation services.

Firstly, similar to our previous work [Hossain and El Saddik, 2007] the server sends an 'invite' message to the client, and in response the server receives 'Ok' message that has client profile. After connection to the server, the server stores client's profile. After that, the server communicates to each of its connected proxies. From each of the connected proxies, the server requests the profile of the proxy that includes connected proxy, and related adaptation services specified in the connected proxies. After receiving all information from the proxies, the server generates, simplifies and discovers best adaptation path based on the requirements of the mobile e-learning clients. Once the best adaptation path is discovered, it starts streaming the captured and/or pre-encoded learning content using the Real Time Protocol (RTP) [Schulzrinne et al. 2003]. It may be mentioned that server discovers the adaptation path that provides learning media content based on the mobile learner's satisfaction in terms of visual quality of the learning content.

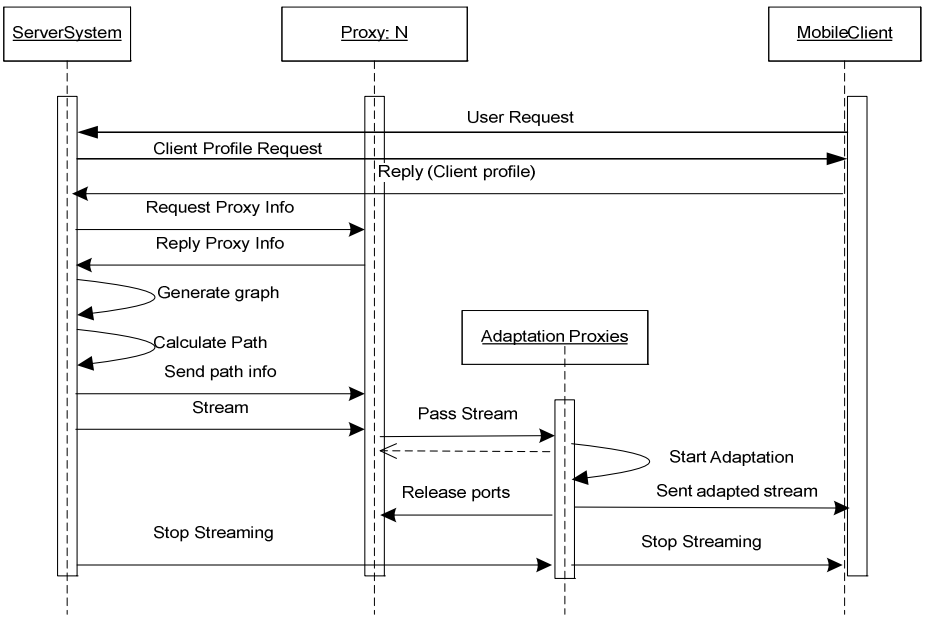

Figure 2: Overall functionality

In the adaptation framework, RTP is used over UDP to deliver application data. The RTCP [Schulzrinne, 2003] is used to verify and interchange control information.., Once the best path through the proxies is discovered, the server starts sending path as well data by packetizing the format into the RTP/RTPC format. At the other side, the proxy listens to RTP streams through different ports. If the port is not used on the best path, the port is released back to the proxy pool.

Upon receiving a stream, the proxy checks if it has any path information for that stream. If it exists , and it creates the appropriate adaptation service. If path information is absent, then the proxy postpones its operation until it gets information. Once it gets complete information, it creates a depacketizer for the stream, get the encoded data and delivers it to an adaptation service. The adaptation service decodes the stream and encodes it into the desired output learning content format. The encoded stream is then packetized back into the RTP/RTCP and sent to the next path. When the e-learning client receives the stream, it depacketizes the stream, decodes it, and displays it. The scenario is described in Figure 3 [Hossain and El Saddik, 2007], as a subsystem that can receive a raw media stream (e.g., learning content from mobile users) and then convert it into another content format.

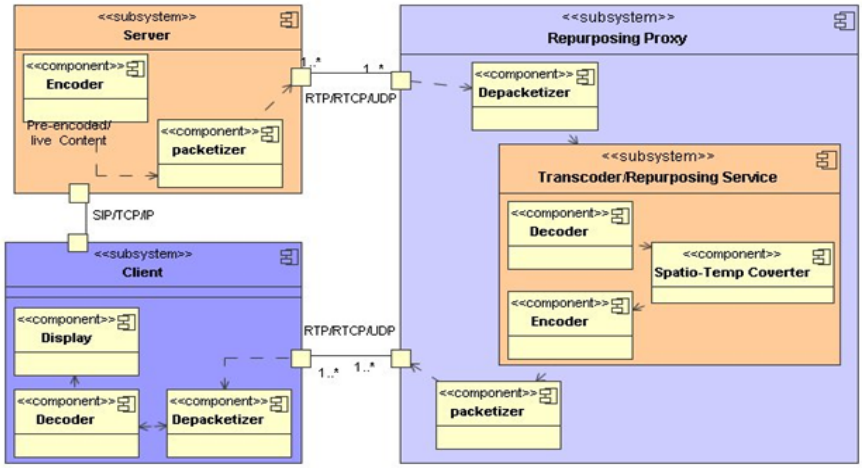

Figure 3: Subsystem view of Adaptation/repurposing system architecture

5 Results and discussion

We have conducted small scale usability study to evaluate our proposed framework. This study consists of 15 volunteers. At first they were briefed about the system and then the users were asked to use the system to view desired learning content. Based on their usage experience, they were asked to answer a number of questions on a Likert five-point scale. The users completed a questionnaire, where they were requested to provide ratings for the difficulty in viewing desire learning content, and their opinion about satisfaction.

From the survey as shown in Fig. 4 we have found that approximately 26% of users have agreed that the system is highly satisfactory in selecting media service to view desired learning content, and 54% of the users agree that it is satisfactory, while 6% of users have different opinion of the satisfaction.

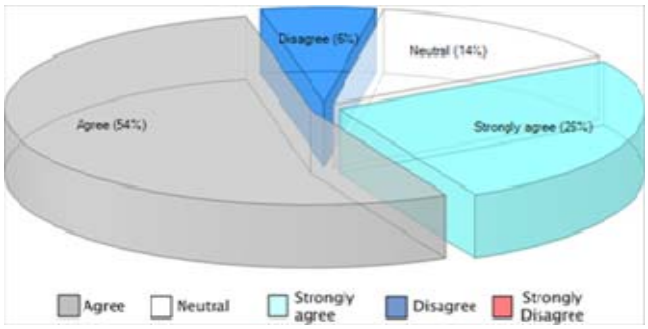

Figure 4: Overall User satisfaction with the system

Figure 5 illustrates the user's satisfaction based on visual quality of the adapted media content. About 29% of users feel that the visual quality of the learning content was highly satisfactory, and 49% of the users agree that it is satisfactory. However, 20% of the users hold opposing views for the satisfaction score, as these users have video or image quality viewing experience.

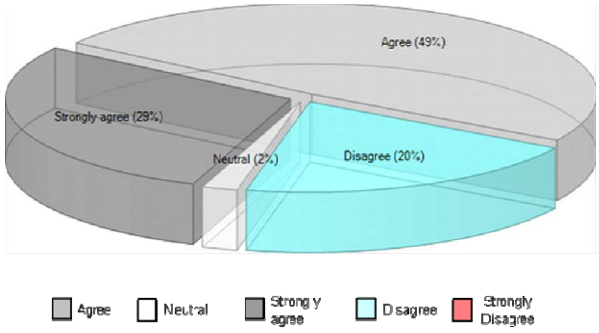

Figure 5: User acceptability on the visual quality of the learning content

6 Conclusions

Media e-learning object or content adaptation is a crucial task that targets to adapt and deliver learning media object to client devices of mobile e-learning users. This paper addresses several issues of media content (learning object) adaptation in the e-learning environment. It also describes the system architecture and the functionality of a content adaptation system for mobile e-learning environment. In future, we are going to conduct more usability evaluation. In addition, we may consider an empirical usability study on a specific e-learning tool: Blackboard learning.

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