Mobile Video Transcoding Approaches and Challenges

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INTRODUCTION

Mobile access to multimedia contents requires video transcoding functionality at the edge of the mobile network for interworking with heterogeneous networks and services. Under certain conditions, the bandwidth of a coded video stream needs to be drastically reduced in response to changes in a highly constrained transmission channel, such as mobile.

Therefore, to guarantee quality of service (QoS) delivered to the mobile user, a robust and efficient transcoding scheme should be deployed in a mobile multimedia transporting network. In this article, we review several typical video transcoding architectures and major applications of video transcoding. We identify issues involved in accessing video streams through handheld devices and wireless networks. This article examines the challenges and limitations that face video transcoding schemes in a mobile multimedia transporting network. Then we explore different approaches for video transcoding schemes in a mobile multimedia transporting network.

BACKGROUND AND RELATED WORK

Current advances in mobile communications and portable client devices enable us to access multimedia content universally. However, when multimedia content becomes richer, including video and audio, it is difficult for wireless access because of many restrictions. On one hand, wireless connections usually have a lower bandwidth compared to wired ones and communication conditions change dynamically due to the effect of fading. On the other hand, portable client devices only have limited computing and display capabilities, which are not suitable for high-quality video decoding and displaying.

Concerning the heterogeneity issue, the previous era has seen a variety of developments in the area of multimedia representation and communication. In particular, we are beginning to see delivery of all types of multimedia data for all types of users in all types of conditions. In a diverse and heterogeneous world, the delivery path for multimedia content to a multimedia terminal is not straightforward, especially in the mobile communication environment. Access networks are various in nature, sometimes limited, and differ in performance. The characteristics of end user devices vary increasingly, in terms of storage, processing capabilities, and display qualities, as well as the natural environment (e.g., position, elucidation, temperature, changes). Finally, users are different by nature, showing dissimilar preferences, special usage, disabilities, and so forth.

The advance of multimedia systems has had a major influence in the area of image and video coding. The problem of interactivity and integration of video data with computer, cellular, and television systems is relatively new and subject to a great deal of research worldwide. As the number of networks, types of devices, and content representation formats increase, interoperability between different systems and different networks is becoming more important. Thus, devices such as gateways, multipoint control units, and servers must be developed to provide a seamless interaction between content creation and use.

The transporting of multimedia over wireless channels to mobile users is becoming a research topic of rapidly growing interest (Han et al., 1998; Warabino, Ota, Morikawa, & Ohashi, 2000; Mitchell, Pennebaker, Fogg, Chad, & LeGall, 1996; Shanableh & Ghanbari, 2000; Correia, Faria, & Assuncao, 2001). With the emergence of small wireless handset devices such as PDAs, video mobile, and so forth, it is expected that interactive multimedia will be a major source of traffic to these handset devices. These devices could be carried by users inside buildings when they are connected by a wireless local area network (LAN) or in vehicles when they will be connected to the cellular network, such as GPRS (Eleftheriadis & Anastassiou, 1995; Keesman, 1996). Wideband mobile communication systems such as IMT-2000 have also emerged, and there should be a mechanism to cope with a variety of media such as video provided to a mobile terminal.

Wireless transmissions use radio channels as the transmission media. Generally, radio links connect users to base stations which are connected to routers using wired links. The wireless segment "cells" provide mobility to a user while using the network. In contrast to wireline transmission links where the bandwidth can be easily increased and the channel quality can be guaranteed, the bandwidth of a wireless channel is limited because of spectrum allocation and physical limitations. The transmission quality of radio is easily affected by environments such as buildings, moving

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objects, and atmosphere, as well as shielded obstacles and so forth. Moreover, because of the mobile nature of the users, the access point of a mobile user changes continuously. All these factors in wireless networks give rise to issues such as effective bandwidth allocation, high channel bit error rate, and user handover.

Moreover, because of its high traffic characteristics such as high bit rate, video will be the dominant traffic in multimedia streams and hence needs to be managed efficiently. Obviously for efficient utilization of network resources, video must be compressed to reduce its bandwidth requirement. Although there exist several compression techniques, MPEG [1, 2, and 4] is one of the most widely used compression algorithms for networked video applications. A wireless handset device, for instance a personal data assistant, can integrate voice, video, and data in one device. In contrast to solely text information, multimedia data can tolerate a certain level of error and fading. Therefore, although a wireless network has a high bit error rate when compared to a wireline network, it is possible to cost effectively transmit multimedia over wireless networks with acceptable quality.

For instance, the MPEG-2 compressed digital video content is being used in a number of products, including DVDs, camcorders, digital TVs, and HDTVs. In addition, tons of MPEG2 data have been stored already in different accessible multimedia servers. The ability to access this widely available MPEG-2 content on low-power end user devices such as PDAs and mobile phones depends on effective techniques for transcoding the MPEG-2 content to a more appropriate, low bit rate video.

Therefore mobile access to multimedia contents requires video transcoding functionality at the edge of the mobile network for interworking with heterogeneous networks and services, changing bit rates, and so forth. This transcoding mechanism should tickle the aforementioned issues in transmitting video in a mobile and wireless network.

FUNCTIONS OF TRANSCODING TECHNIQUES

Building a good video transcoding for mobile devices poses many challenges. To meet these challenges, a various kind of transcoding function is provided. This paragraph will describe these functions in detail.

The first function is bit rate adaptation. Bit rate adaptation has been the most significant function of video transcoding techniques. The idea of compressed video bit rate adaptation is initiated by the applications of transmitting pre-encoded video streams over heterogeneous networks. When connecting two transmission media, the channel capacities of the outgoing channel may be less than those of the incoming channel, so that bit rate adaptation is necessary before sending the video bitstream over heterogeneous channels. In applications such as video on demand, where video is off-line encoded for later transmission, the channel characteristics through which the resulting bitstream will be transmitted might be unknown. Through video transcoding, the bit rate of pre-encoded videos can be dynamically adapted to the obtainable bandwidth and variable communication circumstances. In most bit adaptation cases, a pre-encoded video with high bit rate and fine visual quality will be converted into low bit rate video with elegantly degraded visual quality.

The second function is frame size conversion. Video spatial resolution downscaling is significant since most current handheld devices are characterized by limited screen sizes. By inserting a downscaling filter in the transcoder, the resolution of the incoming video can be reduced. For downscaling the video into lower spatial resolution, motion vectors from the incoming video cannot be reused directly, but have to be resampled and downscaled. Based on the updated motion vectors, predictive residues are recalculated and compressed.

The third function is frame rate conversion. To transcode an arriving compressed video bitstream for a low-bandwidth outgoing channel, such as a wireless network, a high transcoding percentage is often necessary. However, high transcoding ratios may result in intolerable video quality when the arriving bitstream is transcoded with the full frame rate as the arriving bitstream. Frame-rate conversion or frame-dropping is often used as an efficient scheme to assign more bits to the remaining frames, so that acceptable quality can be maintained for each frame. In addition, frame-rate conversion is also needed when an end system can only play video at a lower frame rate due to the processing power limit. Frame rate conversion can be simply accomplished by random frame dropping. For instance, dropping every other frame in a sequential order leads to a half rate reduction in the transcoded sequence. When frames are dropped, motion vectors from the arriving video cannot be directly reused because they are pointed to the immediately previous frame. If the previous frame is dropped in the transcoder, the link between two frames is broken and the end decoder will not be able to reconstruct the picture by these motion vectors. Therefore, the transcoder is in charge for calculating new motion vectors that point to the previous un-dropped frames.

TRANSCODING ARCHITECTURES

Generally speaking, transcoding can be defined as the manipulation or conversion of data into another more desirable format. Depending on the particular strategy that is adopted, the transcoder attempts to satisfy network conditions or user requirements in various ways. In the context of video transmission, compression standards are needed to reduce

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