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7th IFIP/IEEE International Conference, MMNS 2004
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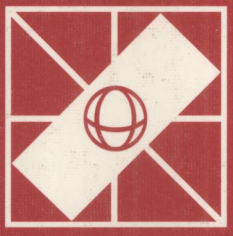

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Preface

We are delighted to present the proceedings of the *7th IFIP/IEEE International Conference on Management of Multimedia Networks & Services (MMNS).*

The MMNS 2004 conference was held in San Diego, California, USA on October 4–6, 2004. As in previous years, the conference brought together an international audience of researchers and scientists from industry and academia who are researching and developing state-of-the-art management systems, while creating a public venue for results dissemination and intellectual collaboration.

This year marked a challenging chapter in the advancement of management systems for the wider management research community, with the growing complexities of the Internet, the proliferation of alternative wireless networks and mobile services, intelligent and high-speed networks, scalable multimedia services, and the convergence of computing and communications for data and voice delivery. Contributions from the research community met this challenge with 84 paper submissions; 26 selected high-quality papers were subsequently selected to form the MMNS 2004 technical program. The diverse topics in this year's program included novel protocols in wireless systems, multimedia over wireless, mobility management, multimedia service control, proactive techniques for QoS management, MPLS traffic engineering and resiliency, distributed systems management, scalable multimedia systems, and adaptive methods for streaming multimedia.

The conference chairs would first like to thank all those authors who contributed to an outstanding MMNS 2004 technical program, second the Program Committee and Organizing Committee chairs for their support throughout the development of the program and conference, third the worldwide experts who assisted in a rigorous review process, and fourth the sponsors Intel Corporation, IFIP and IEEE, without whose support we would not have had such a professional conference. Last and certainly not least, we express grateful thanks to Marie Dudek who was instrumental in helping to ensure a top-quality MMNS 2004.

We truly feel that this year's proceedings mark another significant point in the development of MMNS as a primary venue for the advancement of network and service management, and also novel architectures and designs in technology and network services, to enable multimedia proliferation.

October 2004 David Hutchison and John Vicente

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MPLS: Bandwidth Provisioning and Control

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Proactive Quality of Service

Multimedia Service Control and Management

Mobility: Control and Management

Improving Interactive Video in Wireless Networks Using Path Diversity*

Ahmed Abd El Al[1], Chitra Venkatramani[2], Tarek Saadawi[1], and Myung Lee[1]

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Abstract. The increase in the bandwidth of wireless channels and the computing power of mobile devices increase the interest in video communications over wireless networks. However, the high error rate and the rapidly changing quality of the radio channels can be devastating for the transport of compressed video. In motion compensated coding, errors due to packet losses are propagated from reference frames to dependant frames causing lasting visual effects. In addition, the bounded playout delay for interactive video limits the effectiveness of retransmission-based error control. In this paper, we propose a mechanism that combines retransmission-based error control with path diversity in wireless networks, to provide different levels of protection to packets according to their importance to the reconstructed video quality. We evaluated the effectiveness of the mechanism under different network conditions. Simulation results show that the mechanism is able to maintain the video quality under different loss rates, with less overhead compared to error control techniques that depend on reference frame updates.

1 Introduction

The increase in the bandwidth of wireless channels and the computing power of mobile devices increase the interest in video communications over mobile wireless networks. However, in such networks there is no end-to-end guaranteed Quality of Service (QoS) and packets may be discarded due to bit errors. Wireless channels provide error rates that are typically around 10^{-2}, which range from single bit errors to burst errors or even intermittent loss of the connection. The high error rates are due to multi-path fading, which characterizes radio channels, while the loss of the connection can be due to the mobility in such networks. In addition, designing the wireless communication system to mitigate these effects can be complicated by the rapidly changing quality of the radio channel.

The effect of the high error rates in wireless channels can be devastating for the transport of compressed video. Video standards, such as MPEG and H.263, use mo-

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tion-compensated prediction to exploit the redundancy between successive frames of a video sequence [1]. Although motion-compensated prediction can achieve high compression efficiency, it is not designed for transmission over lossy channels. In this coding scheme the video sequence consists of two types of video frames: *intra-frames* (I-frames) and *inter-frames* (P- or B-frames). I-frame is encoded by only removing spatial redundancy present in the frame. P-frame is encoded through motion estimation using preceding I- or P-frame as a reference frame. B-frame is encoded bi-directionally using the preceding and succeeding reference frames. This poses a severe problem, namely error propagation (or error spread), where errors due to packet loss in a reference frame propagate to all of the dependent frames leading to perceptible visual artifacts that can be long-lasting.

Different approaches have been proposed to tackle the error propagation problem. One approach is to reduce the time between intra-coded frames, in the extreme case to a single frame. Unfortunately, I-frames typically require several times more bits than P- or B-frames. While this is acceptable for high bit-rate applications, or even necessary for broadcasting, where many receivers need to resynchronize at random times, the use of the intra-coding mode should be restricted as much as possible in low bit rate point-to-point transmission, as typical for wireless networks. The widely varying error conditions in wireless channels limit the effectiveness of classic Forward Error Correction (FEC), since a worst-case design would lead to a prohibitive amount of redundancy. Closed-loop error control techniques like retransmission have been shown to be more effective than FEC and successfully applied to wireless video transmission. But for interactive video applications, the playout delay at the receiver is limited, which limits the number of admissible retransmissions [2].

In this paper, we propose a mechanism to provide error resilience to interactive video applications in wireless networks. The mechanism extends retransmission-based error control with redundant retransmissions on diverse paths between the sender and receiver. The mechanism factors in the importance of the packets as well as the end-to-end latency constraints to minimize the overhead and maximize the quality at the receiver. Our simulation results indicate that the proposed mechanism performs significantly better than reference frame update schemes in terms of perceived quality measured at the receiver as well as the transmission overhead.

This paper is organized as follows. Section 2 provides a review for related works. The proposed mechanism is presented in Section 3. Section 4 discusses the mechanism implementation. Section 5 presents experiments that we performed to examine the proposed mechanism and to compare it to reference frame update error control mechanism. Finally, conclusions are outlined in Section 6.

2 Related Work

Analysis for the effects of packet loss on the quality of MPEG-4 video is presented in reference [3], which also proposes a model to explain these effects. The model shows that errors in reference frames are more detrimental than those in dependant frames, due to propagation of errors, and therefore reference frames should be given a higher level of protection.

Forward error correction (FEC) has been proposed to provide error recovery for video packets by adding redundant information to the compressed video bit-stream so that the original video can be reconstructed in presence of packet loss. Reference [4],

presents Priority Encoding Transmission (PET) where different segments of video data are protected with redundant information according to their priority, so that information with higher priority can have a higher chance of correct reception. Typical FEC schemes are stationary and must be implemented to guarantee a certain QoS requirement for the worst-case channel characteristics. Due to the fact that wireless channel is non-stationary, and the channel bit error rate varies over time, FEC techniques are associated with unnecessary overhead that reduces the throughput when the channel is relatively error free.

Unlike FEC, which adds redundancy regardless of correct receipt or loss, reference [5] proposes retransmission-based error control schemes, such as Automatic Repeat Request (ARQ), for real time data. Retransmission-based schemes resend only the packets that are lost, thus they are adaptive to varying loss characteristics, resulting in efficient use of network resources. However, retransmission schemes are limited by the receiver's playout delay, as well as the Round Trip Time (*RTT*). Reference [6] presents Time-Lined TCP (TLTCP), which extends the TCP retransmission to support time-lines. Instead of treating all data as a byte stream TLTCP allows the application to associate data with deadlines.

An overview on different error concealment mechanisms proposed to minimize the visible distortion of the video due to packet loss is presented in [7]. Error concealment techniques depend on the smoothness property of the images as well as that the human eye can tolerate distortion in high frequency components than in low frequency components. Reference [2] shows that detectable artifacts can still exist after the error concealment, and that the degree of these artifacts depends on the amount of lost data, the type of the stream and the effectiveness of the concealment algorithm. High-quality concealment algorithms require substantial additional computation complexity, which is acceptable for decoding still images but not tolerable in decoding real-time video. In addition, the effectiveness of concealment depends on the amount and correct interpretation of received data, thus concealment becomes much harder with the bursty losses in wireless channels.

Error-resilient encoding, such as Multiple Description Coding (MDC) and Layered Coding (LC), are proposed to combat channel-induced impairments. MDC generates multiple equally important, and independent substreams, also called descriptions [8]. Each description can be independently decoded and is of equal importance in terms of quality, i.e. there is no decoding dependency between any two of the descriptions. When the decoder receives more descriptions, the quality can be gradually increased no matter which description is received. LC generates one base-layer bitstream and several enhancement-layer bitstreams [9]. The base-layer can be decoded to provide a basic video quality while the enhancement-layers are mainly used to refine the quality of the video that is reconstructed from the base-layer. If the base-layer is corrupted, the enhancement-layers become useless, even if they are received perfectly.

3 Prioritized Retransmission over Diverse Paths

The ability to successfully decode a compressed bitstream with inter-frame dependencies depends heavily on the receipt of reference frames, and to a lesser degree on dependent frames. Thus, we propose a mechanism to provide adaptive end-to-end unequal error protection for packets belonging to different frames, without sacrificing the timely-delivery requirement for interactive video. We achieve the unequal error