Chapter XII
An H.264/AVC Error Detection Algorithm Based on Syntax Analysis

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ABSTRACT

In this chapter, we present the possibility of detecting errors in H.264/AVC encoded video streams. Standard methods usually discard the damaged received packet. Since they can still contain valid information, the localization of the corrupted information elements prevents discarding of the error-free data. The proposed error detection method exploits the set of entropy coded words as well as range and significance of the H.264/AVC information elements. The performance evaluation of the presented technique is performed for various bit error probabilities. The results are compared to the typical packet discard approach. Particular focus is given on low-rate video sequences.

INTRODUCTION

H.264/AVC (Advanced Video Coding) (H.264/AVC, 2005) is the recent video coding standard, defined by the ITU-T Video Coding Experts Group (VCEG) together with the ISO/IEC Moving Picture Experts Group (MPEG) as the product of a collective partnership effort known as the Joint Video Team (JVT). This standard is especially suitable for low data rate applications as it provides substantially better video quality at the same data rates compared to previous standards (MPEG-2, MPEG-4, H.263), with only

a moderate increase of the complexity. Moreover, H.264/AVC was designed to support a wide variety of applications and operate over several types of networks and systems.

Video telephony and video streaming over Internet Protocol (IP) packet networks are quite challenging applications due to their requirements on delay and data rates. A video stream is encoded and encapsulated in Real Time Protocol (RTP) packets. These packets are typically transported end-to-end within the User Datagram Protocol (UDP). Unlike the Transmission Control Protocol (TCP), UDP does not provide any retransmission control mechanisms. Nevertheless, it has been widely adopted for video streaming and video telephony, since end-to-end retransmissions would cause unacceptable delays. Thus, in such real-time applications, transmission errors cannot be completely avoided.

To allow for applications even in error-prone environments like mobile networks, apart from the improved compression performance, H.264/AVC provides several error resilience features. Therefore, the 3rd Generation Partnership Project (3GPP), standardizing the Universal Mobile Telecommunications Network (UMTS), has approved the inclusion of H.264/AVC as an optional feature in Release 6 of its mobile multimedia telephony and streaming services specifications (TS 26.234, 2005; TS 26.235, 2005).

To facilitate error detection at the receiving entity, each UDP datagram is provided with a simple 16 bits long checksum. The packets with detected errors are typically discarded (TS 26.234, 2005;Wenger, 2003), and missing parts of the video are subsequently concealed. The reason for this handling is the Variable Length Coding (VLC). The H.264/AVC standard supports a Context Adaptive VLC (CAVLC) in all its profiles. After a bit error, CAVLC may easily desynchronize, making the correct distinction between the following codewords impossible. Therefore, without any resynchronization mechanism and/or additional detection/decoding mechanism (Nemethova, Canadas & Rupp, 2005; Chen, He & Lagendijk, 2005; Wiedmann & Nemethova, 2006), the decoding of such stream may result in considerable visual impairments or may become even impossible (due to the nonexisting codewords, too many or too few bits left for decoding). The detection of errors allows utilizing the correctly received parts of the packet for the decoding. Since a packet usually contains a rather large picture area, it may considerably improve the quality of reconstruction at the receiver. The structure of the bit streams (the syntax of its information elements) may also provide some means to detect errors. For H.263 codecs, the performance of a simple syntax check method was evaluated in Barni, Bartolini, and Bianco (2000). However, the structure of the H.264/AVC bitstream and the CAVLC differs considerably from the structure and VLC of the H.263 bitstream.

We investigate the possibility of detecting errors in H.264/AVC encoded video stream. We propose a method for error detection exploiting the codewords, as well as range and significance of the H.264/AVC information elements. We evaluate its performance and compare it to the typical packet discarding approach. The focus of this work is given on the baseline profile (targeting video conferencing, streaming, and especially mobile applications), and thus, we work with CAVLC rather than with context adaptive binary arithmetic coding (CABAC), mainly designed for storage applications. We do not take into account error detection within the RTP/UDP/IP header. Errors within the header could also be detected by other means (e.g., UDP-lite) (IETF RFC 3828, 2004), or using the information from lower layers, depending on the underlying system.

This chapter is organized as follows. After this introduction, we will briefly introduce the architecture of the H.264/AVC codec. Afterwards, the structure of the H.264/AVC RTP bitstream is described and the individual information elements analyzed. After presenting the way in which the syntax information