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JPEG2000 over noisy communication channels thorough evaluation and cost analysis

G. Pavlidis, A. Tsompanopoulos, N. Papamarkos, C. Chamzas*

Cultural and Educational Technology Institute, 58 Tsimiski Street, Xanthi 671 00, Greece

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Abstract

In this paper, we examine the behavior of the JPEG2000 coding scheme over noisy or congested communication channels and highlight a cost policy aspect. Two error schemes are considered, involving bit errors (noisy channel) and packet-dropping (congested channel) effects. Two bit error methods are used, consisting of flipping or eliminating the bits, and various packet sizes are put to the test of packet dropping. Extensive performance results are presented accompanied by an overall cost analysis.

Keywords: JPEG2000; Error resilience; Noisy and congested communication networks; Cost analysis

1. Introduction

The emerging need for multimedia transmission over high-speed communication systems on which several restrictions and transmission policies apply, guide the research to new ways of data handling and algorithm applications, even before the data can be transmitted. One of the problems in engineering a packet switched network carrying both non-bursty delay-sensitive traffic (voice, video) and highly bursty delay-tolerant traffic (computer data, image data) is the congestion problem [1].

Since digital bitmap representations of images require large numbers of bits, data compression techniques are important for efficient transmission. Standard lossless compression methods, such as the lossless JPEG or the JPEG-LS and JBIG coders, provide with compression ratios of about 2:1 on the average. Unfortunately, such algorithms do not have the ability to allow packet dropping by the network. Hence, when a congested facility drops a packet containing compressed image data, the rest of the image is destroyed, unless the end-user is employing an end-to-end receive—acknowledge transmission—repeat mechanism. Such a protocol saves the transmitted information, but ultimately makes matters worse for the already congested network as it further increases traffic, not to mention the additional disadvantage of increasing transmission delay. Thus, to be effective as a congestion relieving mechanism, packet dropping must be allowed with the knowledge and blessing of the end-user. Presumably such a user would be given pricing advantages for the packets that he/she marks as droppable, since this

*Corresponding author. Tel.: +30-2541-078787x112 or 079571; fax: +30-2541-063656.
E-mail address: chamzas@ceti.gr (C. Chamzas).

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information is delivered only when the network is idle. Similar problems appear when noisy communication channels carrying delay-sensitive image data change or drop bits.

JPEG2000, the new coding standard, comes to fulfill such requirements of progressive coding while providing with error control mechanisms. Several papers and publications consider the performance of this coder in noisy environments in order to compare the scheme with the existing ones [2–5]. In this work, we present the results of using the JPEG2000 coder in error resilient mode with Layer–Resolution–Component–Position (LRCP) priority, considering the overall effect of different error models. Preliminary results have been reported in [6]. The outcome of our tests is an overall communication channel cost policy analysis that can be used by providers to impose fees policies and users to evaluate provided services.

2. JPEG2000

The JPEG2000 standard provides with a set of features that are of importance to many high-end and emerging applications by taking advantage of new technologies. It addresses areas where current standards fail to produce the best quality or performance and provides capabilities to markets that currently do not use compression [2].

In Fig. 1 the general block diagram of a JPEG2000 encoder and decoder is depicted. The encoding scheme comprises of a forward wavelet transform, followed by quantization and bitplane entropy coding with rate allocation capabilities. The encoder is able to produce a fully embedded codestream, which is optimal in a rate-distortion aspect. The decoder reconstructs the image by inverting the steps of the encoder. Fig. 2 shows the basic JPEG2000 encoder blocks graphically.

Some of the most important features, relevant to this work, that this standard possesses are the following [7,8]:

- superior low bit-rate performance,
- lossless and lossy compression,
- progressive transmission by pixel accuracy and resolution,
- region-of-interest coding (ROI),
- random codestream access and processing,
- robustness to bit errors,
- open architecture,
- side channel spatial information (transparency),
- protective image security,
- continuous-tone and bi-level compression.

For an in-depth analysis of the JPEG200 coding scheme the reader could refer to an excellent textbook by Taubman and Marcellin [9] and the JPEG2000 Special Issue on Image Communication Journal published by Elsevier [10].

In this work, we consider the behavior of JPEG2000 over noisy or congested communication channels and measure the error resilient coding efficiency and performance. We like to make clear that we address here the general case of any theoretic communication network and do not restrict ourselves to real-life networks of any specific kind or implementation. As known, the most important and widespread networks are

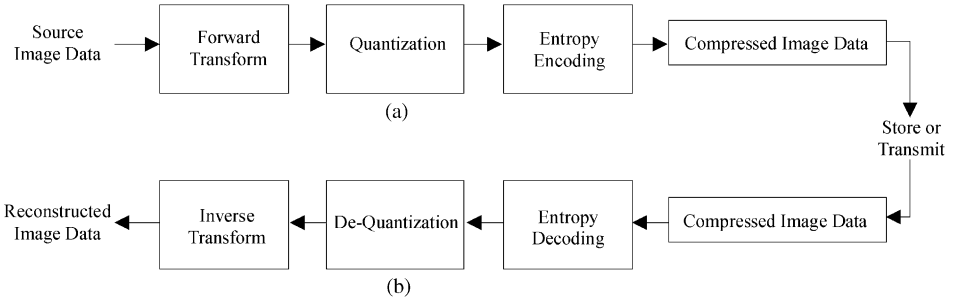

Fig. 1. JPEG2000 encoder (a) and decoder (b).