Comparison of JPEG and JPEG 2000 in Low-Power Confidential Image Transmission

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Outline

- Introduction
- Principles of Confidential Transmission of Visual Data
- Basic Building Blocks
  - Compression
  - Encryption
  - Transmission
- Cost optimal configuration: how to ?
- Cost optimal configuration: Results
- Conclusions

Introduction

- Visual content is exchanged over networks for many different application areas: e.g., distributed medical image databases, surveillance, . . . for many of these applications, confidentiality is important.
- Visual data require a large processing capacity or transmission bandwidth – imaging applications involving weak hardware (mobile !) or low bandwidth network links need to be carefully optimized.
- Processing chain: compression – encryption – transmission
- Minimize bandwidth consumption: max. compression (high comput. cost)
- Here: Minimize energy consumption/Minimize processing time (battery life !)
- In particular: is JPEG or JPEG 2000 the optimal lossy compression scheme for this application area ??

Principles of Confidential Transmission of Visual Data

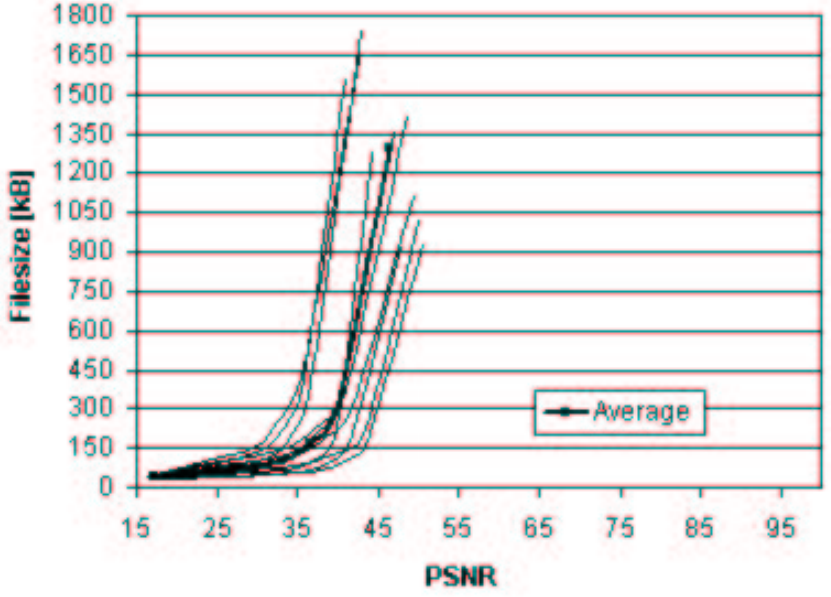
There are two ways to provide confidentiality to a transmission application:

1. Confidentiality is based on mechanisms provided by the underlying computational infrastructure
   - e.g., in case of TCP/IP connections this can be achieved using IPSec
   - PRO: applications do not have to be adapted, complete transparancy
   - CON: overhead since all data is encrypted (news feed), application specific properties can not be exploited

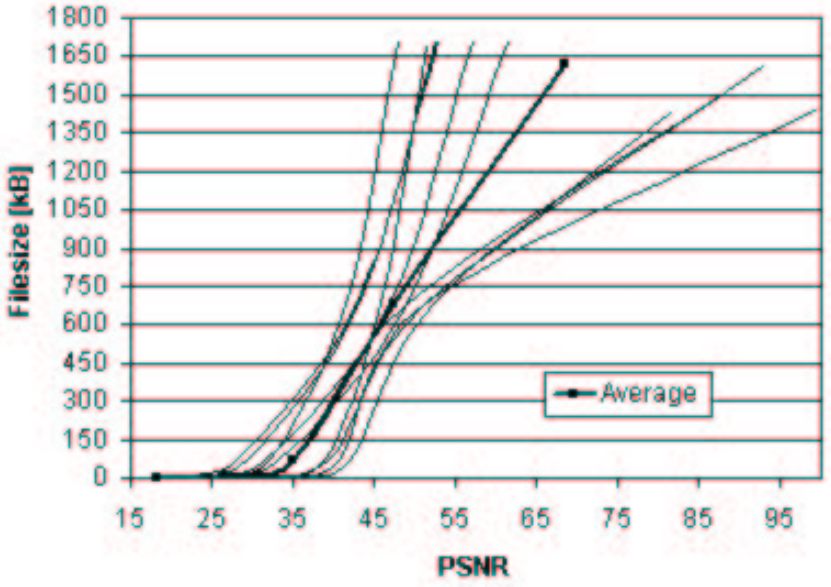
2. Confidentiality is based on mechanisms provided by the application
   - e.g., shttp, encrypted video conferencing
   - PRO: application specific properties can be exploited, applied only for sensitive data
   - CON: each application has to take care about security

Basic Building Blocks: Compression

- Ten 1780×1308 pixels 24bpp color testimages, IJG JPEG C implementation (0.51 sec) vs. Jasper JPEG 2000 (6.12 sec)
- Intel Pentium III with 1GHz and 256MB SDRAM

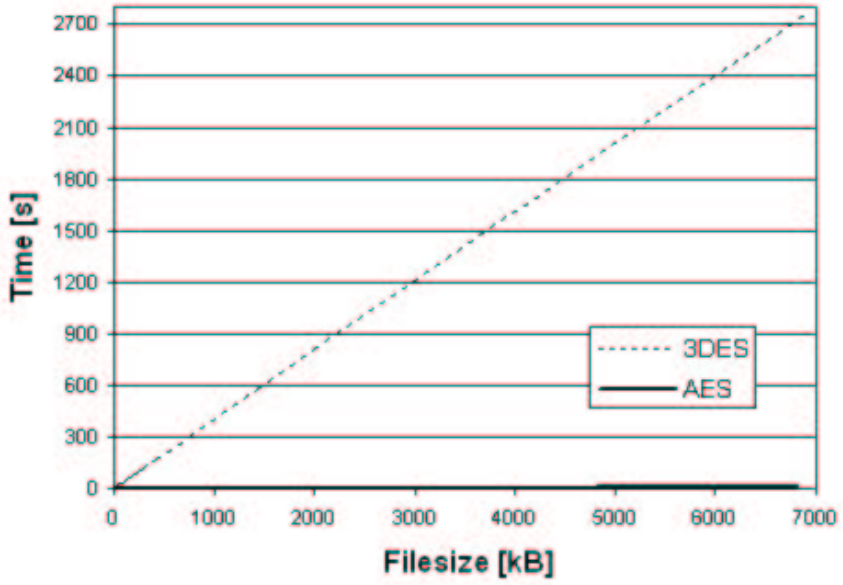


JPEG



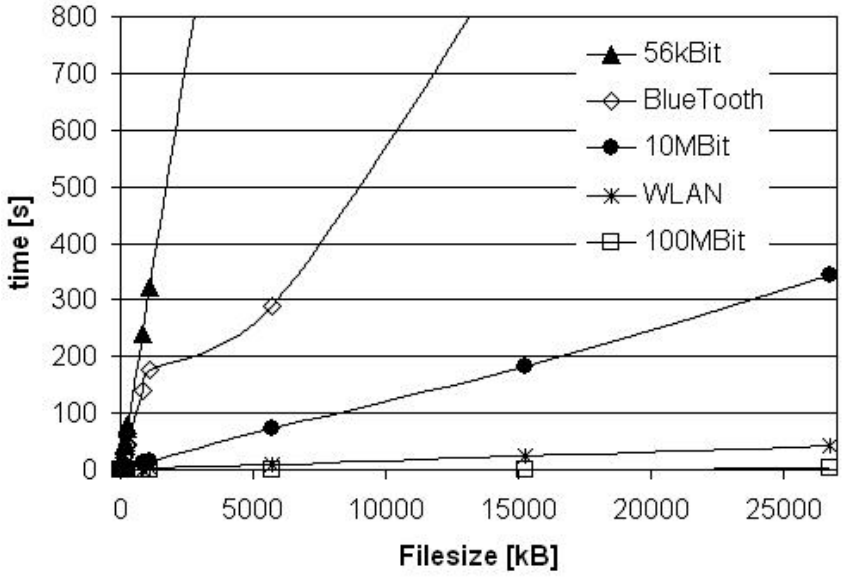
JPEG 2000

Basic Building Blocks: Encryption



- C++ implementations of AES and tripleDES
- tripleDES is much slower as compared to AES
- correct trend but amount of AES superiority due to implementation

Basic Building Blocks: Transmission



- 56kBit modem, 1MBit Bluetooth, 10MBit ethernet, 11MBit IEEE802.11b WLAN, and 100MBit ethernet. A client server application transmits data, the client measures elapsed time after the connection has been established.
- Actual tranmission rates are much lower as claimed by specifications but the "theoretical" ranking among the different media is maintained in the experiments.

Cost Optimal Configuration: How To ?

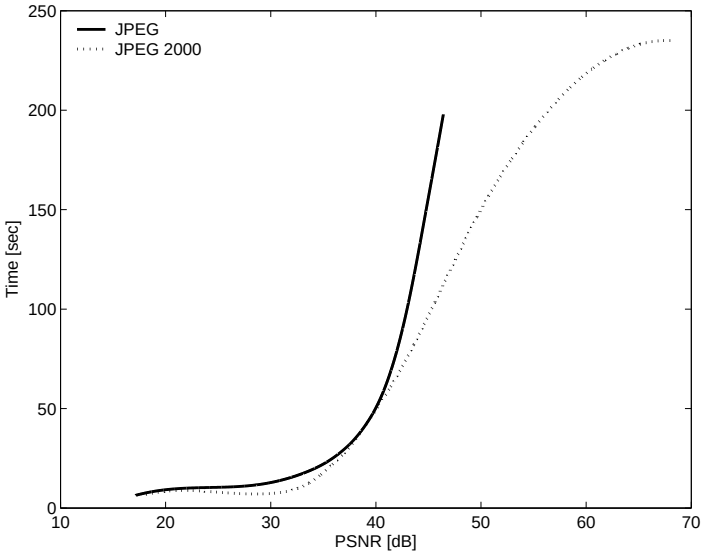
KEY QUESTION: Given a fixed target quality, does the lower amount of data as produced by JPEG 2000 (which causes the subsequent encryption and transmission stages to be executed with lower computational demand) justify the higher computational cost as compared to JPEG ?

We model the basic building blocks as functions (use spline approximations to the exp. data):

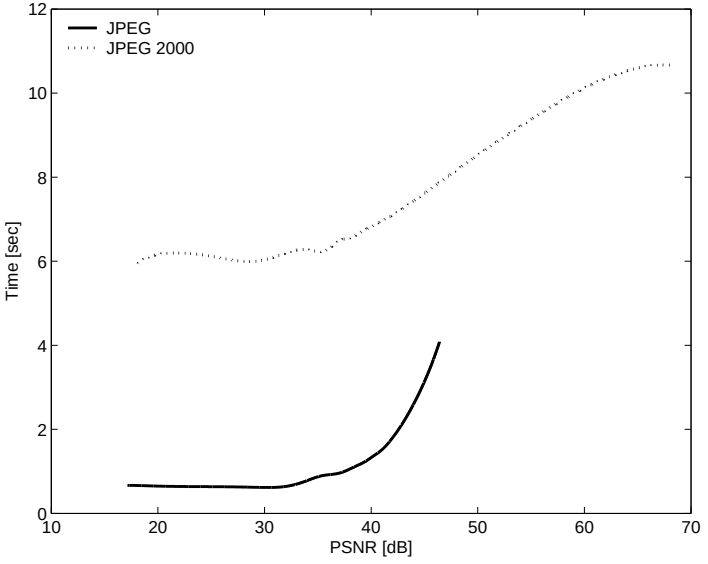
1. Compression: Input–PSNR (dB), Output–data size (kB), fixed time demand (0.51 sec vs. 6.12 sec)
2. Encryption: Input–data size (kB), Output–time demand (sec)
3. Transmission: Input–data size (kB), Output–time demand (sec)

Combine three stages into one by inserting Encryption and Transmission into Compression which results in a function with Input–PSNR (dB) and Output–time demand (sec). Considering the two modes for compression, two modes for encryption, and five modes for transmission we result in 20 different functions.

Cost Optimal Configuration: Results I



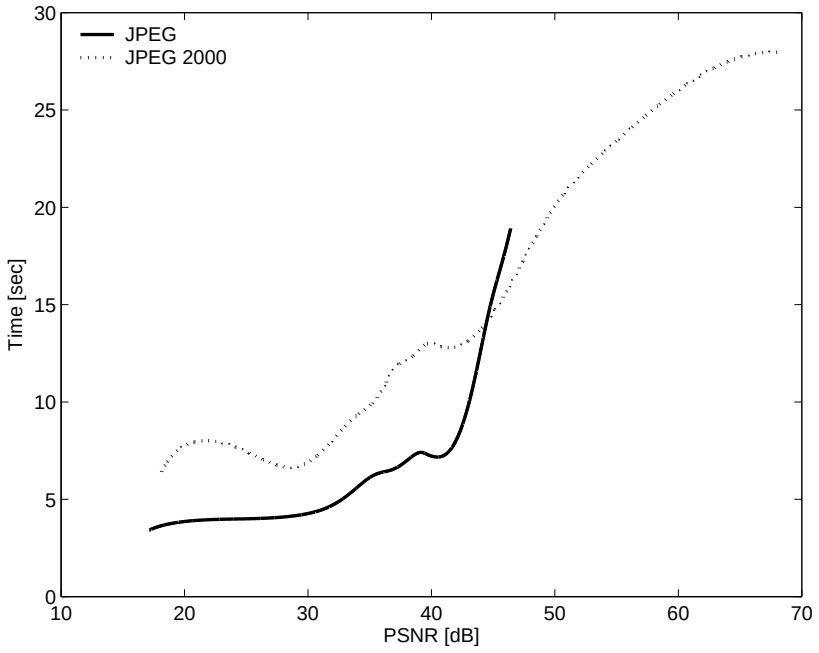
Bluetooth + AES



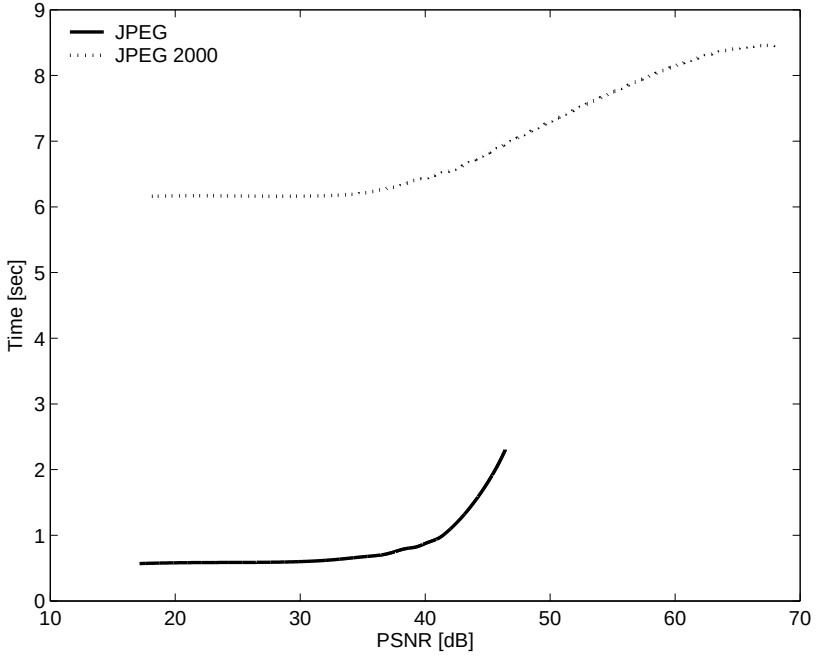
WLAN + AES

Note: If the time demand of encryption plus transmission is very high (as it is of course the case if tripleDES encryption or modem transmission is used) results are similar to Bluetooth + AES. In these cases, the final result only reflects the difference in the output bitrate as produced by JPEG and JPEG 2000.

Cost Optimal Configuration: Results II



10 MBit + AES



100 MBit + AES

Conclusions

1. Only in case of very slow encryption (tripleDES) and/or slow transmission (modem & Bluetooth) JPEG 2000 outperforms JPEG in terms of time demand

2. Only in such environments the data rate reduction of JPEG 2000 as compared to JPEG is significant enough to compensate for the higher time demand of JPEG 2000 compression.

3. Note: JPEG is superior for AES encryption and WLAN transmission for example (recent mobile environment) !!

4. Future work: GSM and UMTS wireless transmission and generalization to variably sized images.