Video Quality Optimization Algorithm for Video-Telephony over IP Networks

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Outline

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- Evaluation and Simulation results
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Introduction

• This work aims at improving the subjective video quality of video-telephony services.
  • Bandwidth and delay bound
  • Retransmission (TCP) introduce unacceptable delays

• Subjective video quality is very sensitive to packet losses, therefore a dynamic length parity FEC is implemented to protect against single packet errors.
• Subjective video quality metric
  – estimates QoE for video-telephony services;
  – based on quality design/management parameters in terminals and networks;
  – More accurate than PSNR when evaluating network losses.
• Maximum video quality at each bit rate is obtained encoding at the optimal frame rate.
• Limitations:
  – Video bit rate < 1282 kbps
  – Packet losses < 10%
  – MPEG-4 (There are no H.264 coefficients available)
Video quality vs. bit rate and packet loss rate

- **Using the optimal frame rate as given by G.1070.**

![Graph showing Video quality (Vq) vs. Video Bit rate (kbps) with different packet loss rates.](image-url)
Dynamic length FEC scheme (1)

- Simple packet-level parity FEC:
  - Only protects against single packet losses
  - Much simpler than interleaving and/or Reed Solomon based schemes, which can protect against burst errors.
- Uses a fixed gross bit rate
- Optimizes the video quality ($V_q$) based on packet loss rate and video bit rate
- $V_q$ is a convex function:
  - there is one video data rate that maximizes the video quality.
Fixed versus dynamic FEC length

- Example of inter-frame delays due to fixed FEC block length.

- Example of dynamic FEC length eliminating inter-frame delays.
Optimizing for the best $V_q$ at very low PLR ($P_{plv} \ll 1\%$) will lead to large values for $k$.

Does not span different video frames, i.e., no significant additional delays.

- This introduces a slight overhead (transmitting more packets than needed for the targeted packet loss rate). In bad conditions the overhead is below 5%.
• Search algorithm for optimal value for $k$ and $V_q$. 

\[ V_{q0} = 0 ; k = 0 \]

\[ k = k + 1 \]

Calculate $V_{qk}$

\[ V_{qk-1} > V_{qk} \]

\[ k_{\text{optimal}} = k - 1 ; V_{q\text{optimal}} = V_{qk} \]
Video quality for 1024 kbps with uniformly distributed packet losses

![Graph showing video quality versus video bit rate for different packet loss rates and FEC options. The graph compares video quality metrics for various bit rates and packet loss percentages, highlighting the impact of FEC on video quality at different packet loss levels.]
Video quality for 256 kbps with uniformly distributed packet losses

![Graph showing video quality for 256 kbps with packet losses.](image-url)
Improvements in video quality

- Maximum quality improvement is 119% for 1024 kbps, when PLR is 5%.
Simulation scenario

- Fixed packet loss rate
- Constant bit rate stream
- Error Model: Uniform and simplified Gilbert.
Video quality for a gross bit rate of 1024 kbps and 1% packet loss (uniform)
Video quality for a gross bit rate of 1024 kbps and 10% packet loss (simplified Gilbert model with ABEL of 1)
Video quality and burst error distribution for Simplified Gilbert model with packet loss rate of 1%

**Diagram Description:**
- **Y-axis:** Number of occurrences
- **X-axis:** Average Burst Error Length (ABEL)
- **Graph Elements:**
  - Green bar chart: Corrected errors
  - Red bar chart: Persistent errors
  - Blue line: sim VQ FEC
  - Green line: MIN Vq teórico S/FEC

**Key Points:**
- The graph illustrates the distribution of video quality and burst errors.
- The x-axis represents the average burst error length in units of (ABEL).
- The y-axis shows the number of occurrences.
- Different line styles and colors represent various error correction methods and their performance.

**Legend:**
- Corrected errors
- Persistent errors
- sim VQ FEC
- MIN Vq teórico S/FEC
Conclusions

- A Dynamic FEC length can optimize the subjective video quality based on the G.1070
- FEC length is dynamic in order to not span different video frames, i.e., no additional delays
- Each video frame ends with a FEC packet:
  - Overheads less than 5%.
- Improvements for a packet loss rate of approx:
  - 5%, the video quality can be doubled,
  - 1%, more than 20% improvement for high data rates (1024 kbps) and almost 10% for lower data rates (256 kbps).
- FEC scheme achieves good protection even for ABEL > 1