Robust Video Transmission Based on Distributed Multiple Description Coding

Olivier Crave[1,2] Christine Guillemot[1]
Béatrice Pesquet-Popescu[2] Christophe Tillier[2]

[1]IRISA / INRIA RENNES
Campus Universitaire de Beaulieu, 35042 Rennes Cedex, FRANCE

[2]GET / ENST, Signal and Image Proc. Dept.
46, rue Barrault, 75634 Paris Cedex 13, FRANCE

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Outline

Introduction

UDP and RTP protocols used for video transmission do not guarantee the robustness over error-prone channels. Several techniques have been proposed to provide a solution to this problem:

- Automatic Repeat reQuest (ARQ): Retransmit unreceived frames
  - \+ Offer the application level a guaranteed data transport service
  - \- Delay induced by the retransmission of lost packets
- Forward Error Correction (FEC): Send redundant information along with the original information
  - \+ No need for a feedback channel
  - \- Cliff effect
- Multiple description coding (MDC)
  1. Decompose the source into multiple correlated bitstreams
  2. Quality remains acceptable and improves with the number of bitstreams received
  - \+ No cliff effect

Introduction

Wyner-Ziv (WZ) coding can also be used as a FEC mechanism:

- In [1] for analog transmission enhanced with WZ-encoded digital information
- Followed by [2] and [3] where:
  - The video sequence is first conventionally encoded (MPEG),
  - And in parallel WZ-encoded with a coarser quantizer
  - WZ bitstream can be seen as an extra coarser description of the sequence

  Problem: Error-propagation in the MPEG stream may degrades the RD performance

[1] S. Shamai, S. Verdu, and R. Zamir, 'Systematic lossy source/channel coding', 1998

[2] S. Rane, A. Aaron, and B. Girod, 'Systematic Lossy Forward Error Protection for Error Resilient Digital Video Broadcasting', 2004

[3] A. Sehgal, A. Jagmohan, and N. Ahuja, 'Wyner-Ziv coding of video: An error-resilient compression framework', 2004

Introduction

Objectives:

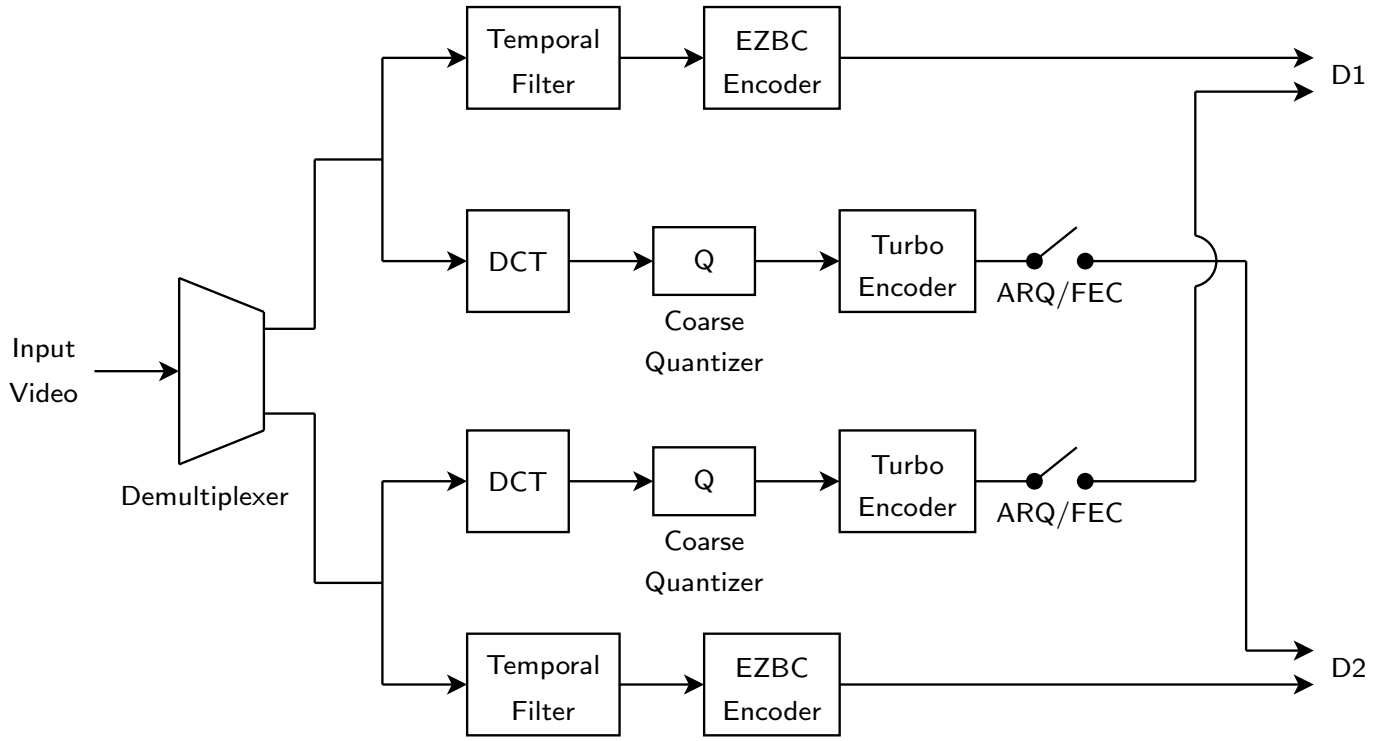
- Create a robust balanced two-description coding scheme where the error-propagation is handled with a MDC scheme and where the quality at the side decoders is tuned by controlling the quality with Wyner-Ziv
- The redundancy should be flexible (ARQ or FEC mechanism):
  If there is a feedback channel, the WZ bistream can be sent on demand, otherwise it is systematically sent

Two MDC schemes:

- Systematic lossy description coding in pixel domain
- Systematic lossy description coding in MCTF domain

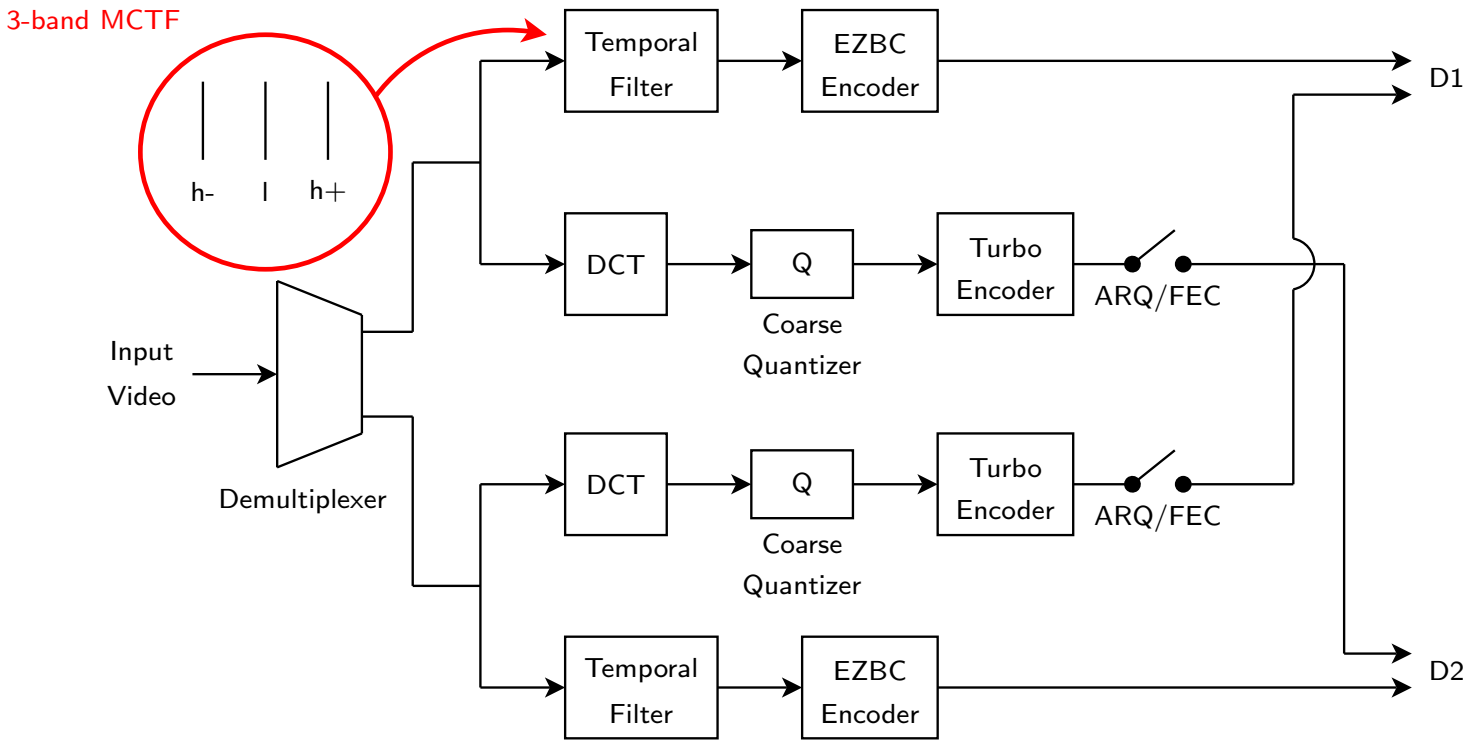
Systematic lossy description encoder in pixel domain:

Scheme 1 - Encoder



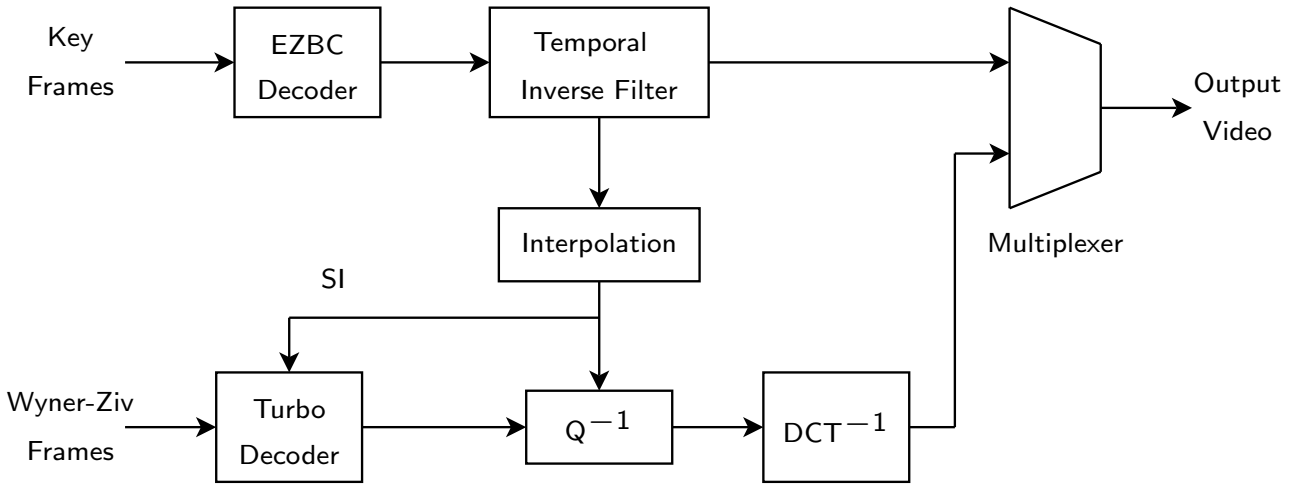
Systematic lossy description encoder in pixel domain:

Scheme 1 - Encoder



Systematic lossy description decoder in pixel domain:

Scheme 1 - Decoder



Scheme 1 - Frames synchronization

Original sequence	0	1	2	3	4	5	6	7	8	9
Description 1	HF	WZ	LF	WZ	HF	WZ	HF	WZ	LF	WZ
Description 2	WZ	HF	WZ	HF	WZ	LF	WZ	HF	WZ	HF

- Should work well if there is a feedback channel (ARQ)
- Otherwise, quite redundant (FEC)

Therefore, we propose another scheme in the MCTF domain:

Scheme 2 - Frames synchronization

Original sequence	0	1	2	3	4	5	6	7	8	9
Non-redundant	HF	LF	HF	WZ	WZ	WZ	HF	LF	HF	WZ
Description 1	HF	LF	HF		WZ		HF	LF	HF	
Description 2		WZ		HF	LF	HF		WZ		HF

This time, only the low-frequency subbands are WZ-encoded

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Description 1	HF	LF	HF		WZ		HF	LF	HF	
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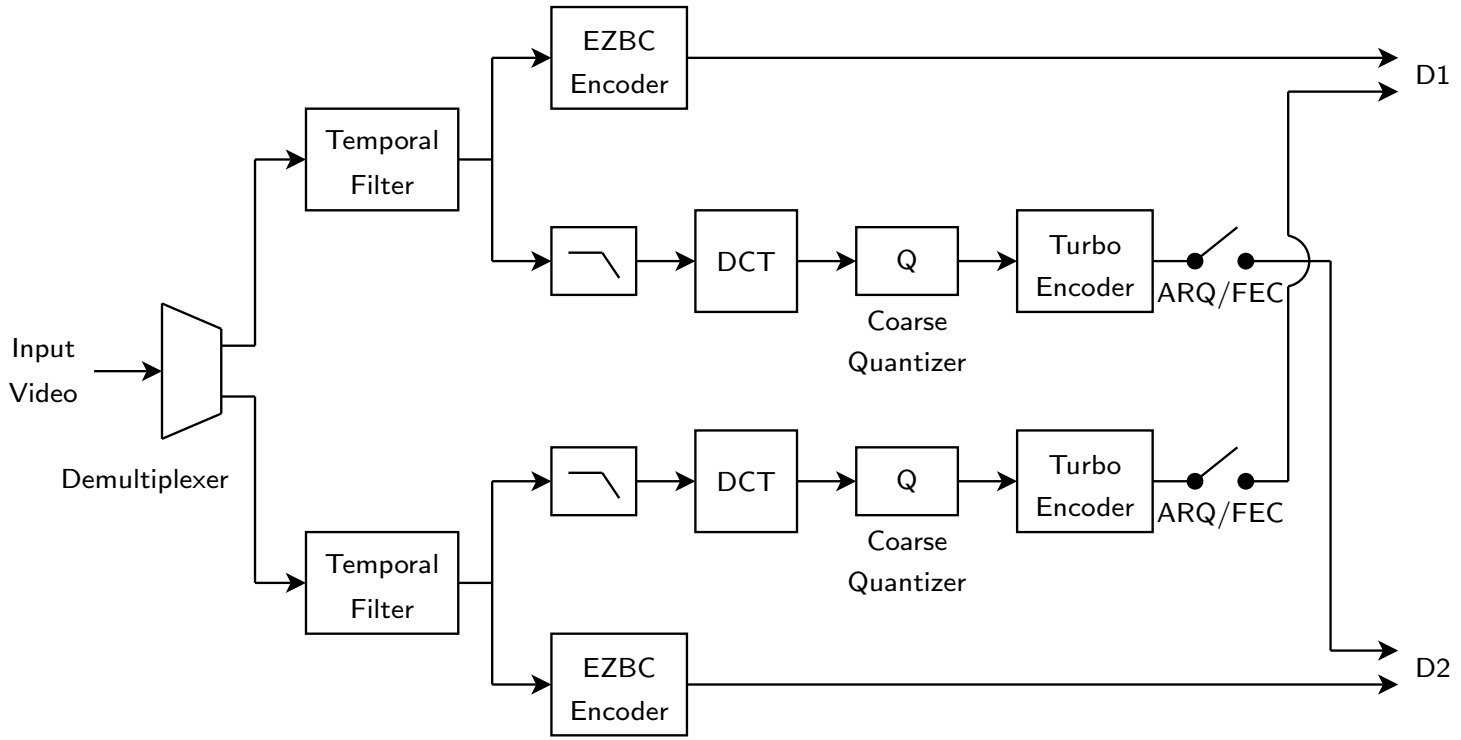
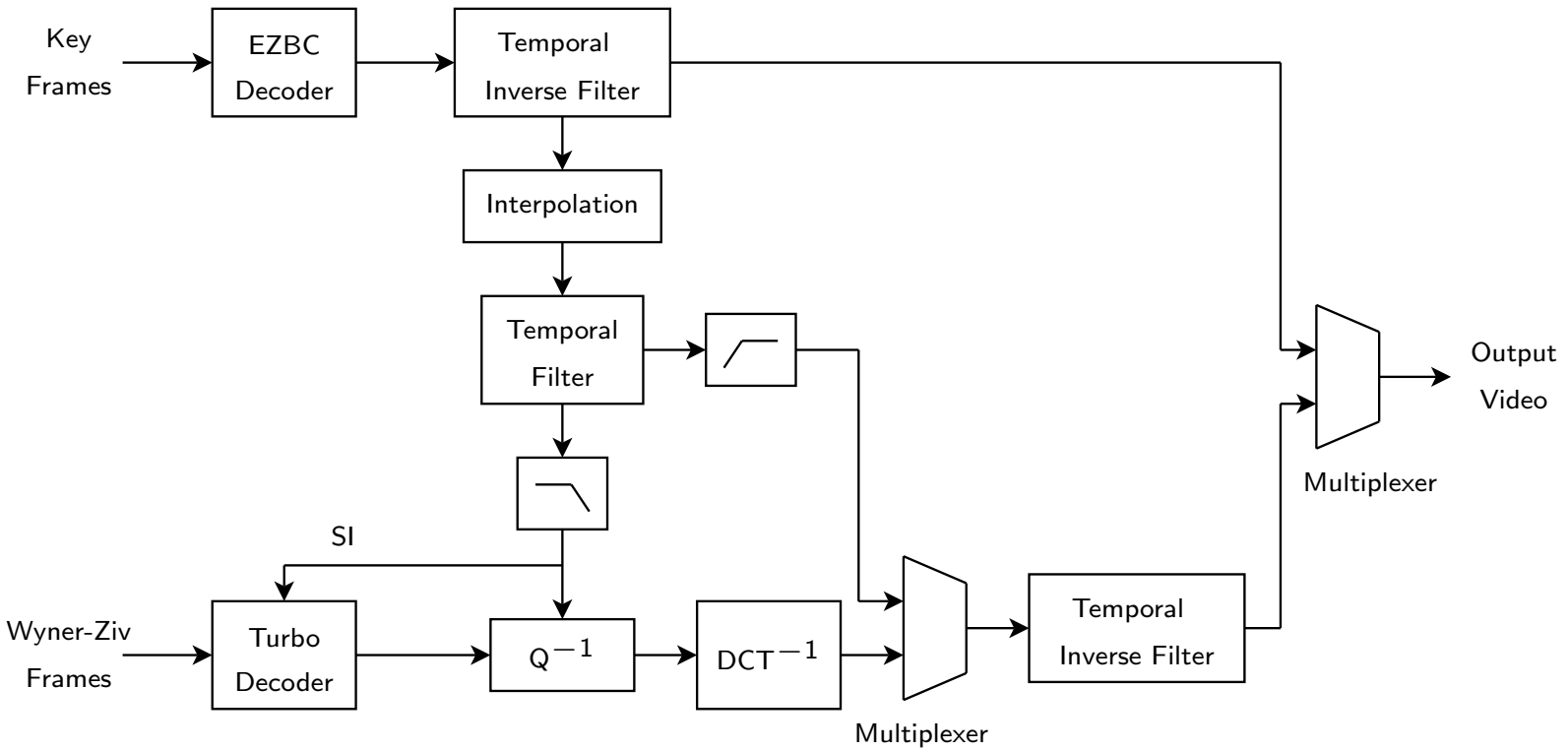
Systematic lossy description encoder in MCTF domain:

Scheme 2 - Encoder



Systematic lossy description decoder in MCTF domain:

Scheme 2 - Decoder



Tests conditions

Three-band temporal MDC scheme

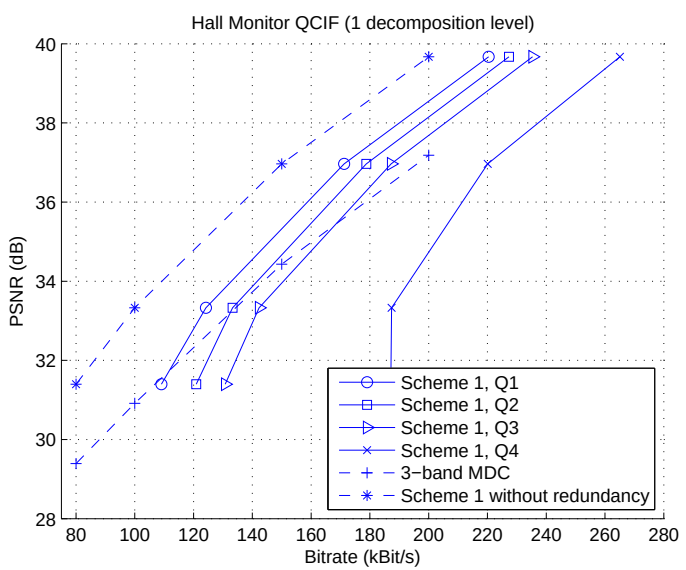
Original sequence	0	1	2	3	4	5	6	7	8
Description 1	h_1^{1-}	l_1^1	h_1^{1+}		h_3^{1-}	l_3^1	h_3^{1+}		
Description 2			h_2^{2-}	l_2^2	h_2^{2+}		h_4^{2-}	l_4^2	h_4^{2+}

- One level of temporal subband decomposition
- MCTF performed with 1/8th pel accuracy
- Four rate-distortion points for the Wyner-Ziv bitrate: Q_1, Q_2, Q_3, Q_4
- Two sequences:
  - Hall Monitor (QCIF, 15 Hz)
  - Foreman (CIF, 30 Hz)

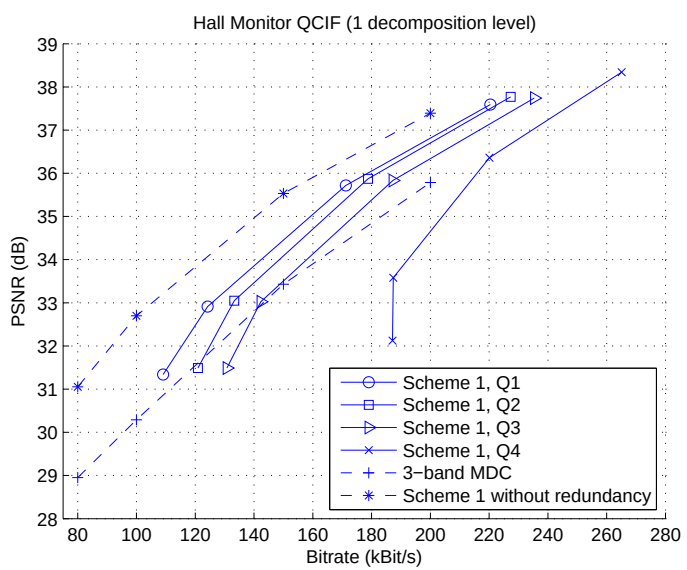
Systematic lossy description coding in pixel domain

Hall Monitor, QCIF, 15 Hz

Central decoder



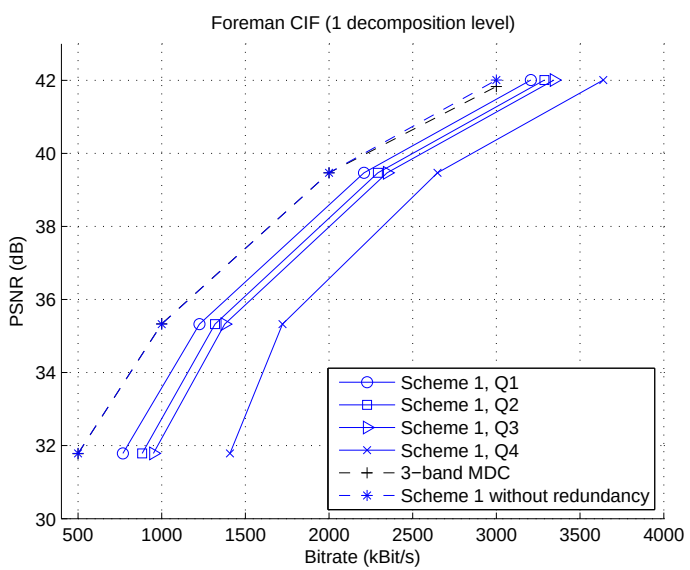
Side decoders



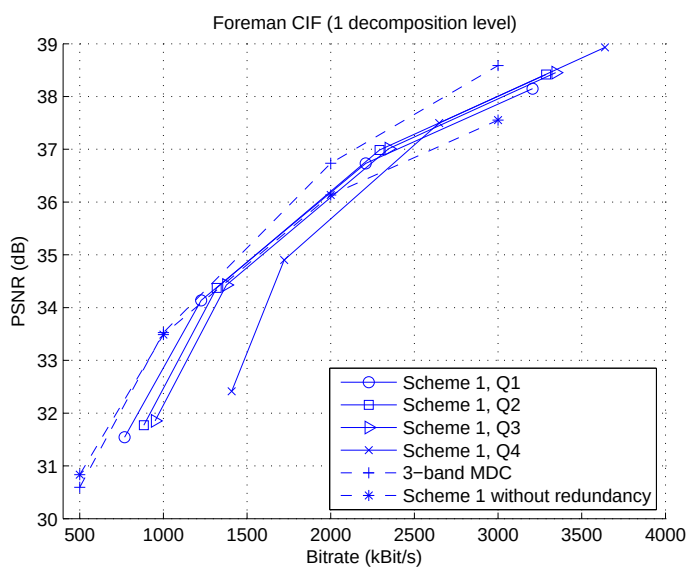
Systematic lossy description coding in pixel domain

Foreman, CIF, 30 Hz

Central decoder



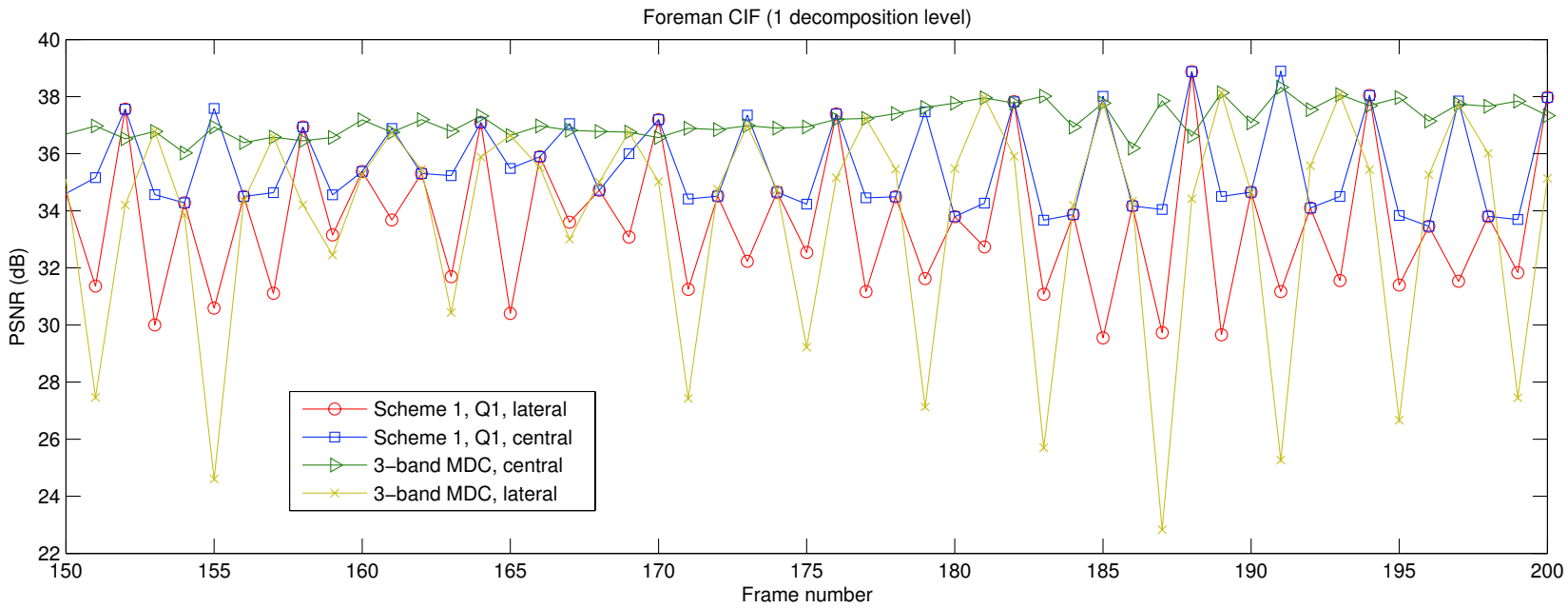
Side decoders



Systematic lossy description coding in pixel domain

Foreman, CIF, 30 Hz at 1225 kBit/s

PSNR variation from the 150th to the 200th frame

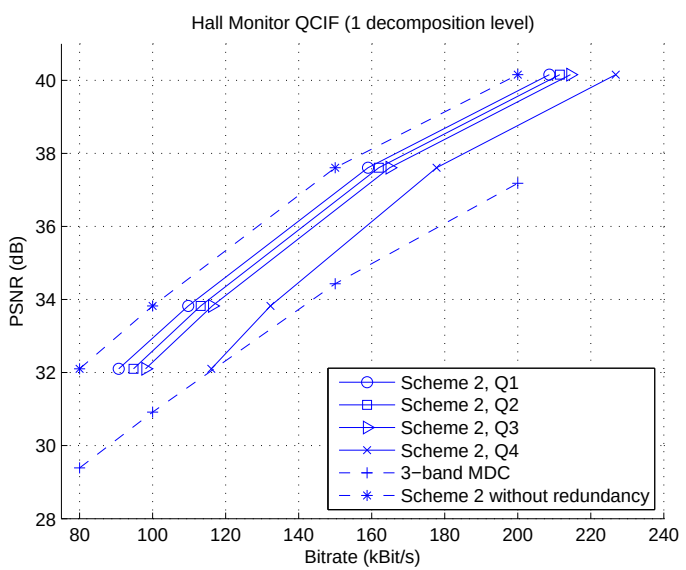


Wyner-Ziv information leads to more stable PSNR at the side decoders

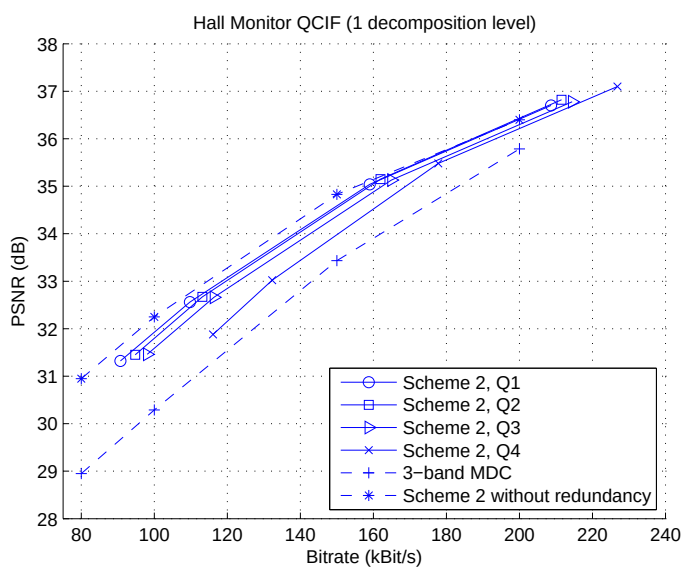
Systematic lossy description coding in MCTF domain

Hall Monitor, QCIF, 15 Hz

Central decoder



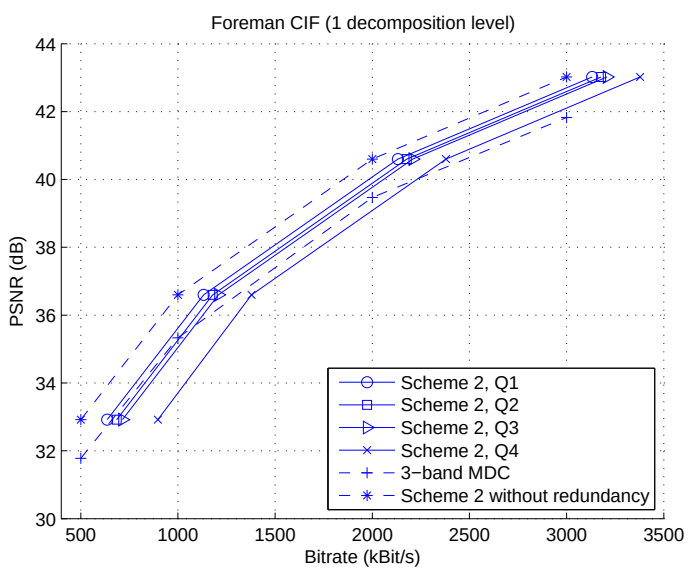
Side decoders



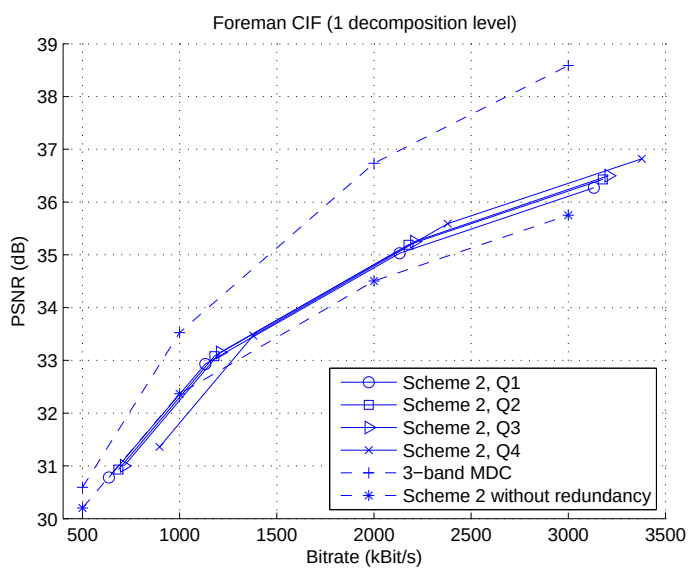
Systematic lossy description coding in MCTF domain

Foreman, CIF, 30 Hz

Central decoder



Side decoders



Conclusion

Conclusion:

+ Balanced MDC schemes with reduced error propagation which can be used as an alternative to ARQ or FEC
+ Average RD performances versus three-band MDC highly depend on the sequence type
+ But Wyner-Ziv information leads to more stable quality over time
- Wyner-Ziv information does not contribute to any improvement at the central decoder

Future work:

- Find a way to use Wyner-Ziv information at the central decoder

THANK YOU