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Transform Domain Distributed Video Coding Using Larger Transform Blocks

Asif Mahmood, Laurence S Dooley and Patrick Wong

School of Computing & Communications
The Open University, Milton Keynes, UK

Contents

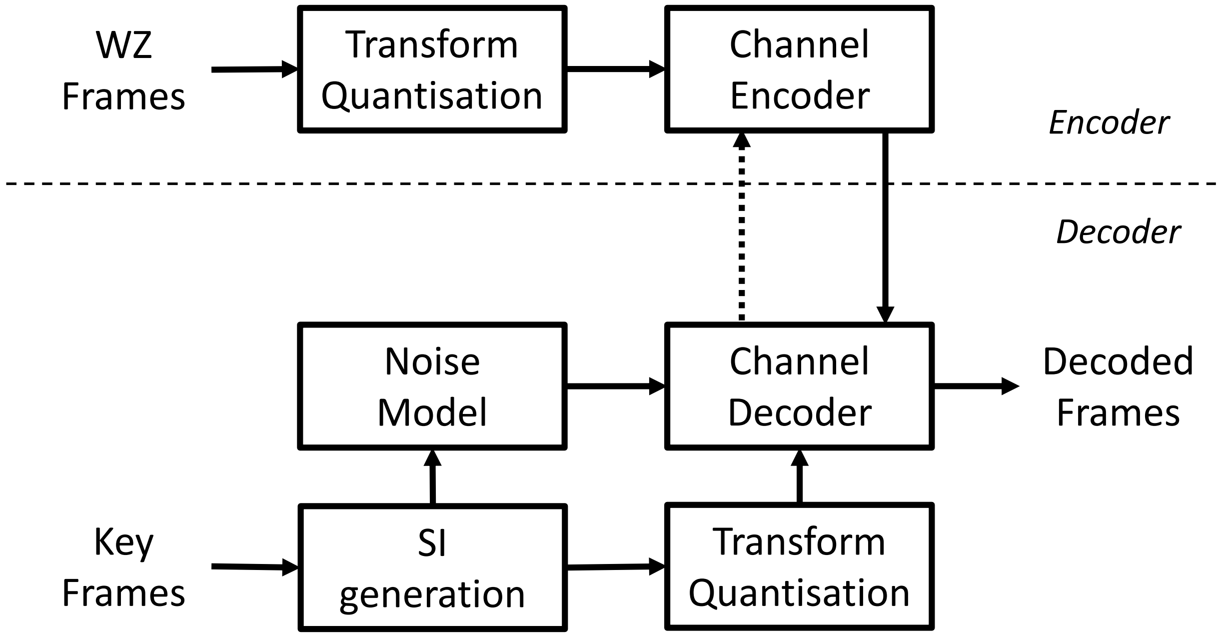
- Transform domain *Distributed Video Coding* (DVC)
- Objectives and contributions
- Results analysis
- Conclusions and future work

Distributed Video Coding (DVC)

- An alternate video coding paradigm
- Simple encoder, complex decoder
- Attractive for
  - Low power surveillance network
  - Wireless video camera
  - Drones
  - Internet of Things

Transform domain DVC

- *Group of pictures* (GOP)
  - Key Frame
  - Wyner-Ziv frame
- *Discrete Cosine Transform* (DCT)
- *Side information* (SI)
  - Motion estimation
- Error correction
- Feedback channel



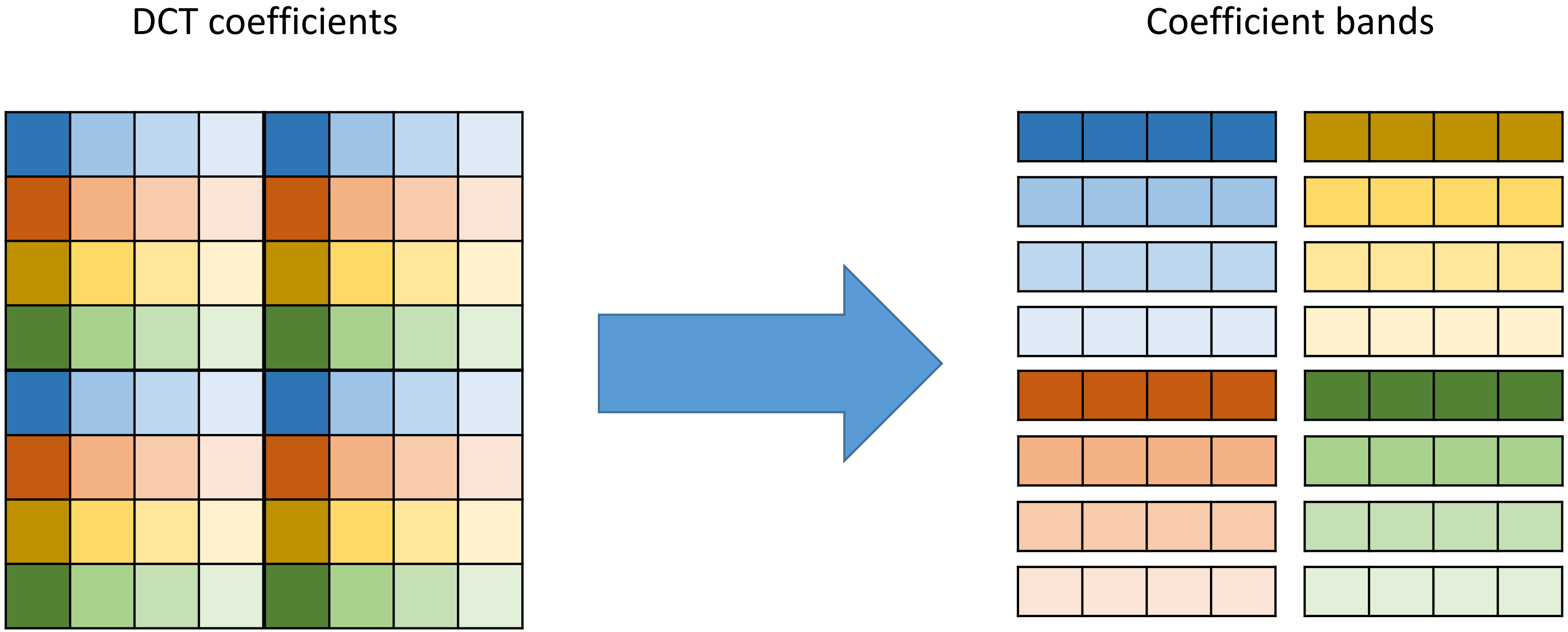
Objectives

- Issue: Poor performance at higher resolutions
- Hypothesis
  - 4x4 DCT block size less effective at higher resolutions
    - JPEG – 8x8
    - H.264/AVC FRExt – 8x8
    - H.264/HEVC – up to 32x32
- Proposed Solution
  - Implement larger DCT block-sizes
  - Challenge
    - *Quantisation Matrix* (QM) available for only 4x4 blocks

Contributions

- Content-Aware Quantisation (CAQ) algorithm
  - Dynamically derives QM for a given block size
- DVC results for 8x8 and 16x16 block sizes
- DVC results for higher resolutions

Transform & Quantisation

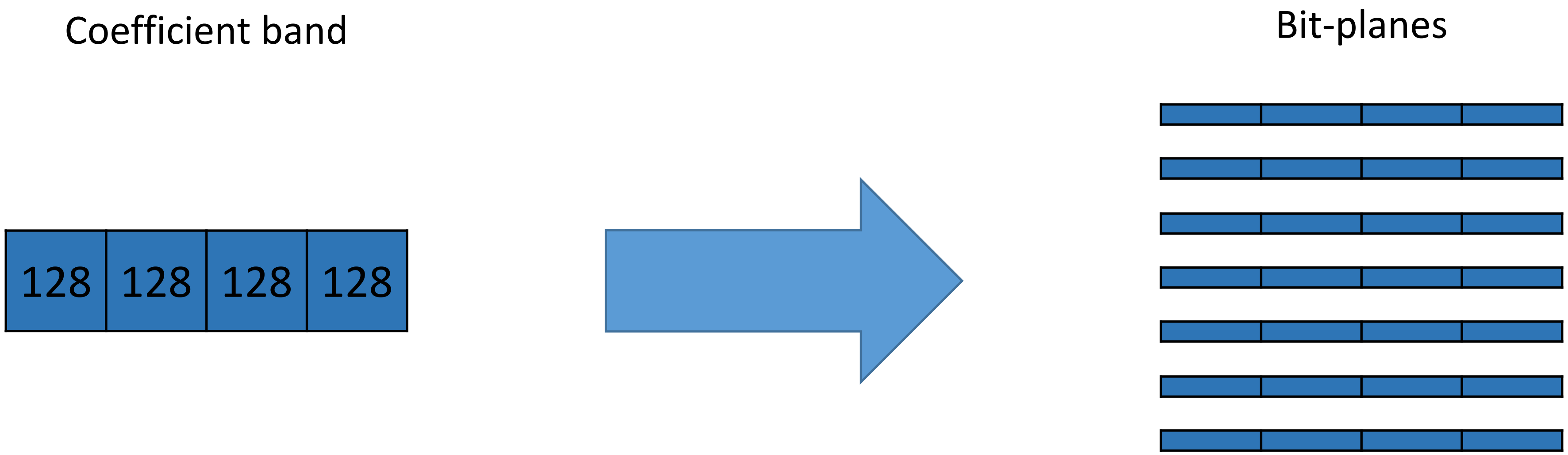


Transform & Quantisation

Quantisation Matrix
(QM)

128	64	32	16
64	32	16	8
32	16	8	4
16	8	4	0

Transform & Quantisation



Quantisation Matrix

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Quantisation steps

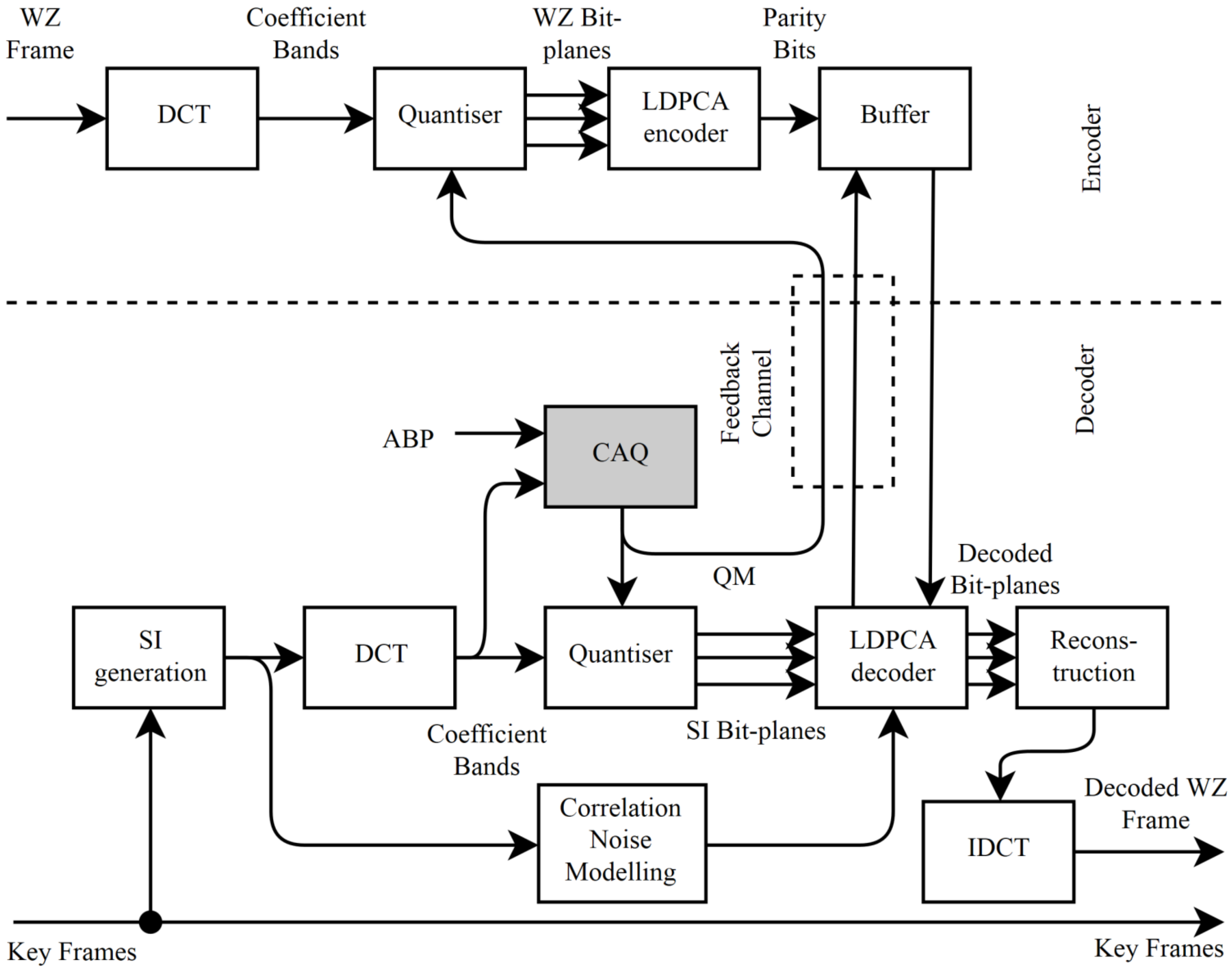
128	64	32	16
64	32	16	8
32	16	8	4
16	8	4	0

No. of bit-planes

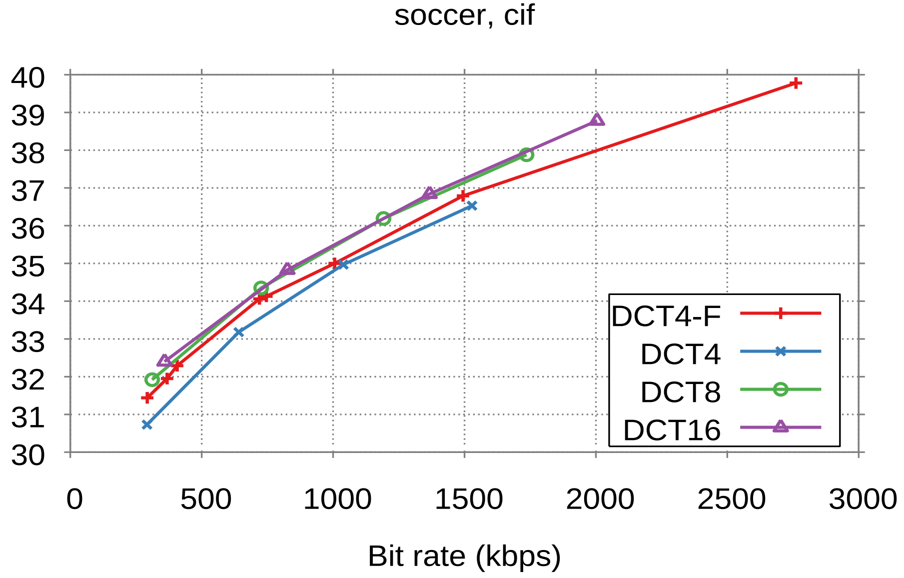
7	6	5	4
6	5	4	3
5	4	3	2
4	3	2	0

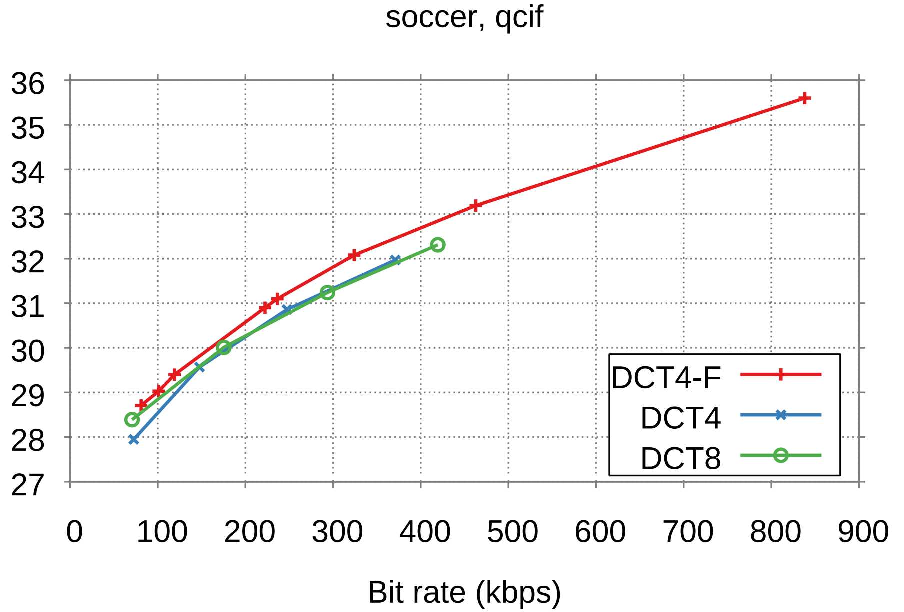
CAQ module

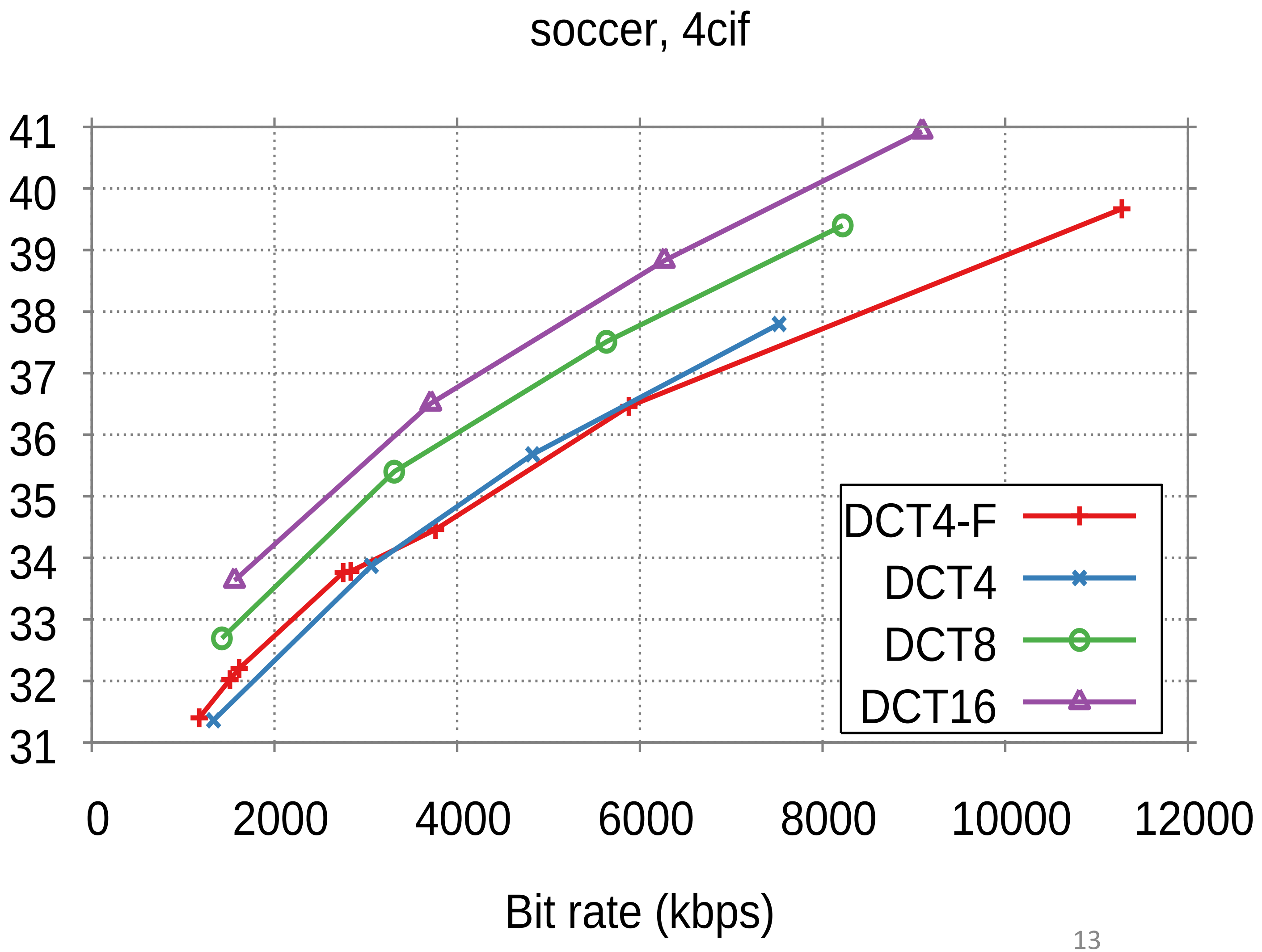
- Idea: Allocate bit-planes to coefficient bands so as to reduce quantisation errors
- Implemented at the decoder
- Determines QM for every WZ frame
- QM transmitted to encoder via feedback channel


WZ Frame
DCT
Coefficient Bands
Quantiser
WZ Bit-planes
LDPCA encoder
Parity Bits
Buffer
Encoder
Feedback Channel
Decoder
ABP
CAQ
QM
Decoded Bit-planes
SI generation
DCT
Quantiser
LDPCA decoder
Recons-truction
Coefficient Bands
SI Bit-planes
Correlation Noise Modelling
IDCT
Decoded WZ Frame
Key Frames
Key Frames

Results


soccer, cif
40
39
38
37
36
35
34
33
32
31
30
0
500
1000
1500
2000
2500
3000
Bit rate (kbps)
DCT4-F
DCT4
DCT8
DCT16


soccer, qcif
36
35
34
33
32
31
30
29
28
27
0
100
200
300
400
500
600
700
800
900
Bit rate (kbps)
DCT4-F
DCT4
DCT8


soccer, 4cif
41
40
39
38
37
36
35
34
33
32
31
0
2000
4000
6000
8000
10000
12000
Bit rate (kbps)
DCT4-F
DCT4
DCT8
DCT16

Results

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Average performance improvement compared to 4x4 DCT with fixed QM

CIF sequences	8x8	
	BD-PSNR (dB) (higher is better)	BD-Rate (%) (lower is better)
Bus	0.16	–4.57
Coastguard	–0.10	–2.27
Crew	0.48	–18.91
Football	0.35	–7.26
Foreman	0.33	–23.97
Hall	0.05	–1.16
Mother & Daughter	0.21	–28.58
Soccer	0.33	–9.19
Stefan	0.67	–16.75

Results

Average performance improvement compared to 4x4 DCT with fixed QM

CIF sequences	16x16	
	BD-PSNR (dB) (higher is better)	BD-Rate (%) (lower is better)
Bus	–0.48	16.75
Coastguard	–1.02	66.42
Crew	0.16	–8.81
Football	0.38	–7.72
Foreman	–0.83	62.38
Hall	–2.23	637.07
Mother & Daughter	–1.96	867.25
Soccer	0.39	–10.58
Stefan	0.45	–10.95

Performance analysis

- Bit-plane lengths for different resolutions and DCT block sizes

	4x4	8x8	16x16
QCIF	1584	396	
CIF	6336	1584	396
4CIF	25344	6336	1584

- Trade-off

Large DCT block + short bit-planes

vs

Small DCT block + long bit-planes

Parallel processing benefit

- Larger DCT block sizes better for parallel processing

  Coefficient bands are linearly independent

  Each band can be concurrently processed

Larger DCT block → More bands → More parallel processing

Constraints and future work

- Feedback channel requirement
- Feedback channel overhead
  - Transmission
  - Delay
- CAQ performance at 4x4 block size
  - SI improvement

Summary

- Larger DCT block sizes are better suited for:

    Higher resolution sequences

    Larger GOP

    Parallel processing

- Best block size for different resolutions

    QCIF – 4x4

    CIF – 8x8

    4CIF – 16x16

- CAQ constraints

    Requires a feedback channel

    Minimal performance gain at 4x4 block sizes