Video Compression in the Studio

Simon Gauntlett

22nd November 2005

Compression is all around us

- In production all cameras and recording devices use compression of some variety
- Typical production workflow goes through many stages
- Concatenation of single codec is a problem
- Concatenation of multiple codecs could be disastrous
- Where is the metadata to help codec concatenation?
  - e.g. The Mole

- Each compression system has different parameters

Typical HD compressions

Codec	Resolution	Bit-depth	Chroma Sampling	Bitrate
HDCAM	1440x1080	8-bit	3:1:1	135 Mbps
HDCAM SR	1920x1080	10-bit	4:2:2 or 4:4:4	440 Mbps
DVCPRO HD	1440x1080	8-bit	4:2:2	100 Mbps
HD D5	1920x1080	10-bit or 8-bit	4:2:2	235 Mbps
Avid DnxHD 145	1920x1080	8-bit	4:2:2	145 Mbps
Avid DnxHD 220	1920x1080	10-bit or 8-bit	4:2:2	220 Mbps
HDV	1440x1080	8-bit	4:2:0	25 Mbps

1080i v 720p debate is over (in the studio)

- Studio and location based production want the highest quality HD
- 1920 x 1080 progressive is the best we can currently achieve in television world
- Various frame-rates available for different “looks”
- European frame-rates:
  - 24P and 25P for the “film look”
  - 50P for content with high motion

1080p50 is an ideal acquisition format

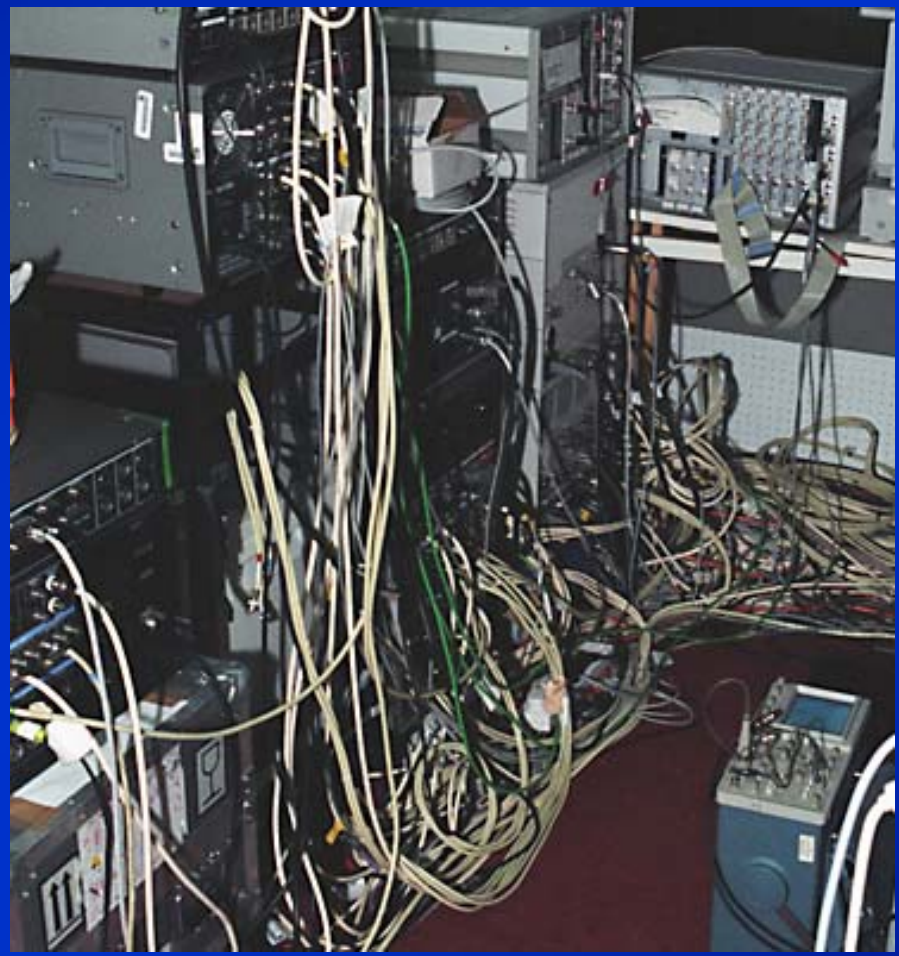
- Easily converted to either 1080i or 720p for delivery
- Future-proof broadcasters' archives

However

- High data rate around 3 Gbps
- How can we move that around the studio?

TV studios

- Large installed base of coaxial cable interconnections



1080p/50 needs 3 Gbit/s

Option 1:

- Dual link HD-SDI:
  - Inconvenient
  - Halves installed cabling capacity

1080p/50 needs 3 Gbit/s

Option 2:

- 3 Gbit/s over coax:
  - Uncertainty over distance achievable
  - Incompatible with existing routers

1080p/50 needs 3 Gbit/s

Options 3:

- Twisted pair:
  - Requires entire infrastructure replacement

1080p/50 needs 3 Gbit/s

Option 4:

- Optical:
  - Expensive
  - Limited routing capability.

Mild compression

‘Only’ 2:1 compression is needed to fit 1080p/50 into HD-SDI – the but requirements are tough:

- Perceptually lossless or very low loss
- Negligible additional loss on multi-generation compression
- Low delay
- Simple and cheap to implement in hardware.

BBC's algorithm has the following properties:

- Total delay through codec of 8 lines at 1080p/50
- Compressed signal conforms to 1080i bit stream
- Small, intra-coded, picture blocks (16 pixels x 4 lines).

Picture split into macroblocks for coding

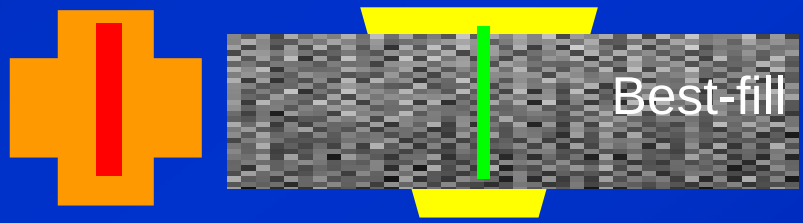
Macroblocks divided into 4x4 blocks

H.264 transform applied to each block

$$\begin{bmatrix} r_{00} & r_{01} & r_{02} & r_{03} \\ r_{10} & r_{11} & r_{12} & r_{13} \\ r_{20} & r_{21} & r_{22} & r_{23} \\ r_{30} & r_{31} & r_{32} & r_{33} \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 & 1 \\ 2 & 1 & -1 & -2 \\ 1 & -1 & -1 & 2 \\ 1 & -2 & 2 & -1 \end{bmatrix} \begin{bmatrix} x_{00} & x_{01} & x_{02} & x_{03} \\ x_{10} & x_{11} & x_{12} & x_{13} \\ x_{20} & x_{21} & x_{22} & x_{23} \\ x_{30} & x_{31} & x_{32} & x_{33} \end{bmatrix} \begin{bmatrix} 1 & 2 & 1 & 1 \\ 1 & 1 & -1 & -2 \\ 1 & -1 & -1 & 2 \\ 1 & -2 & 1 & -1 \end{bmatrix}$$

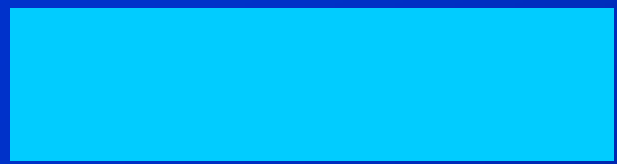
Quantising and variable-length coding

Hadamard transform for DC coefficients



Best-fill algorithm

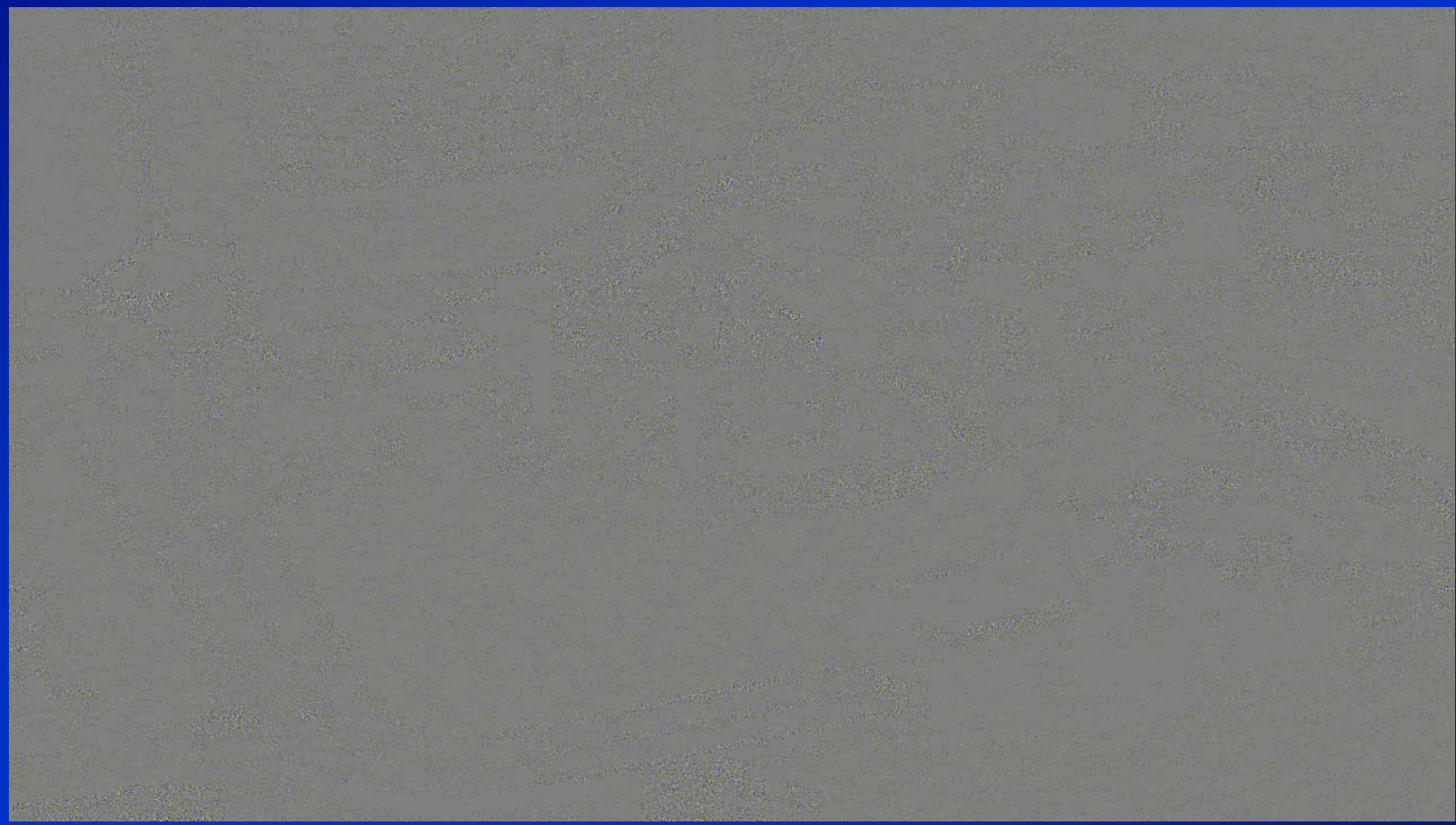
5-bit quantisation parameter



512 bits available

Decoded picture

Difference picture (gain x16)



Compressed data formatted as a 1080i signal

- Compressed data transported in the least significant 8-bits of each pixel
- Most significant 2-bits of each pixel contain ‘compatible’ interlaced version of original video
- Most significant 2-bits modified if necessary to eliminate forbidden TRS codes.

‘Compatible’ coded picture

Effect of halftone dither

- Original linear ramp

Effect of halftone dither

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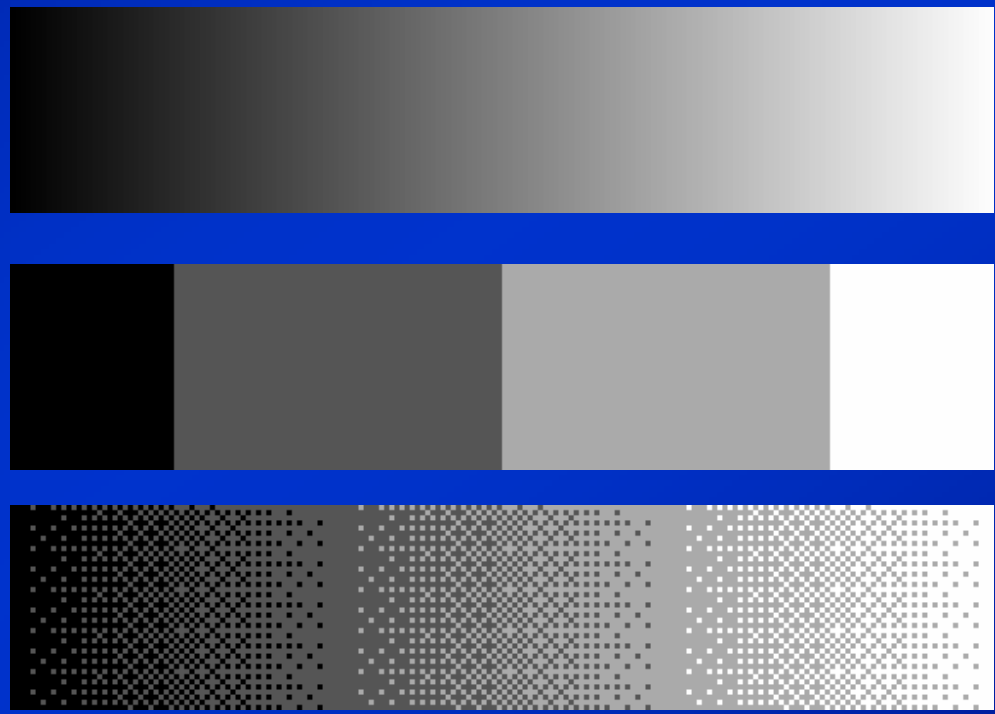
- Quantise to 2 bits

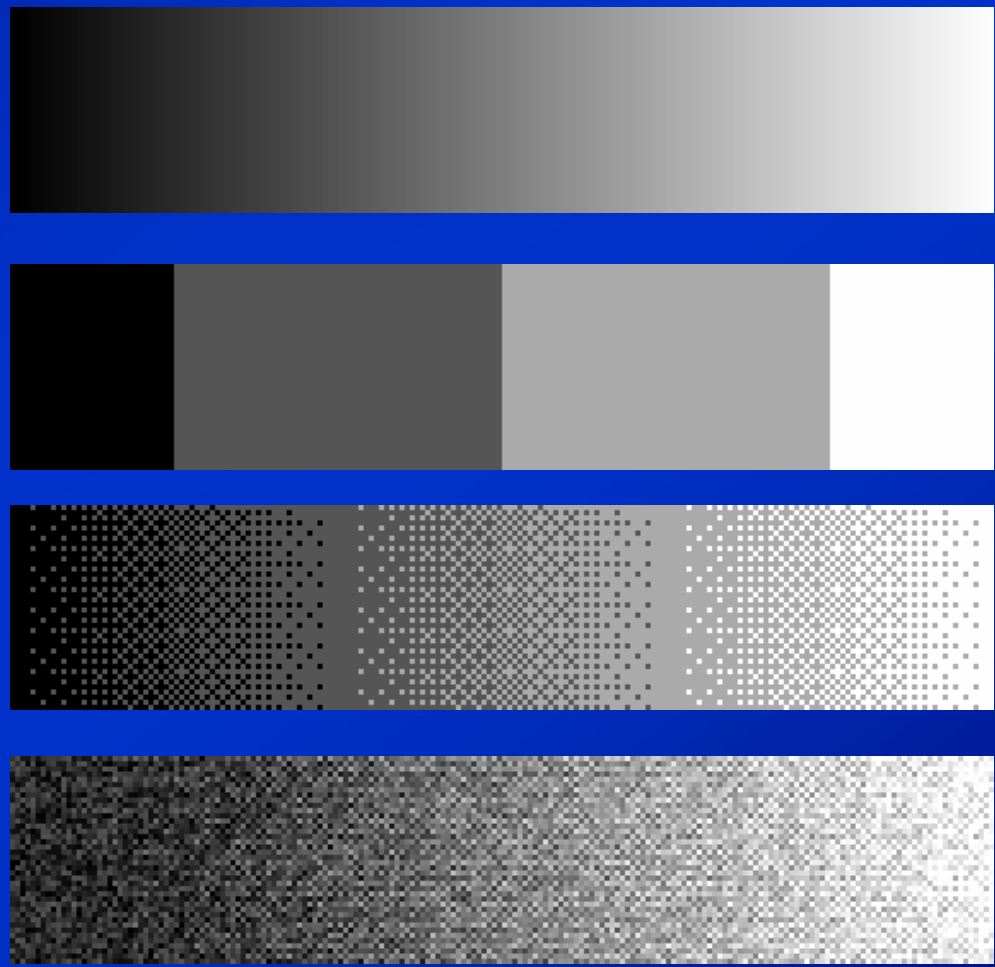
Effect of halftone dither

- Original linear ramp
- Quantise to 2 bits
- 2D halftone dither



Effect of halftone dither

- Original linear ramp
- Quantise to 2 bits
- 2D halftone dither
- Random data in LSBs



‘Compatible’ coded picture

Multihop routing

- Programme making involves routing the signal several times round a site:

camera

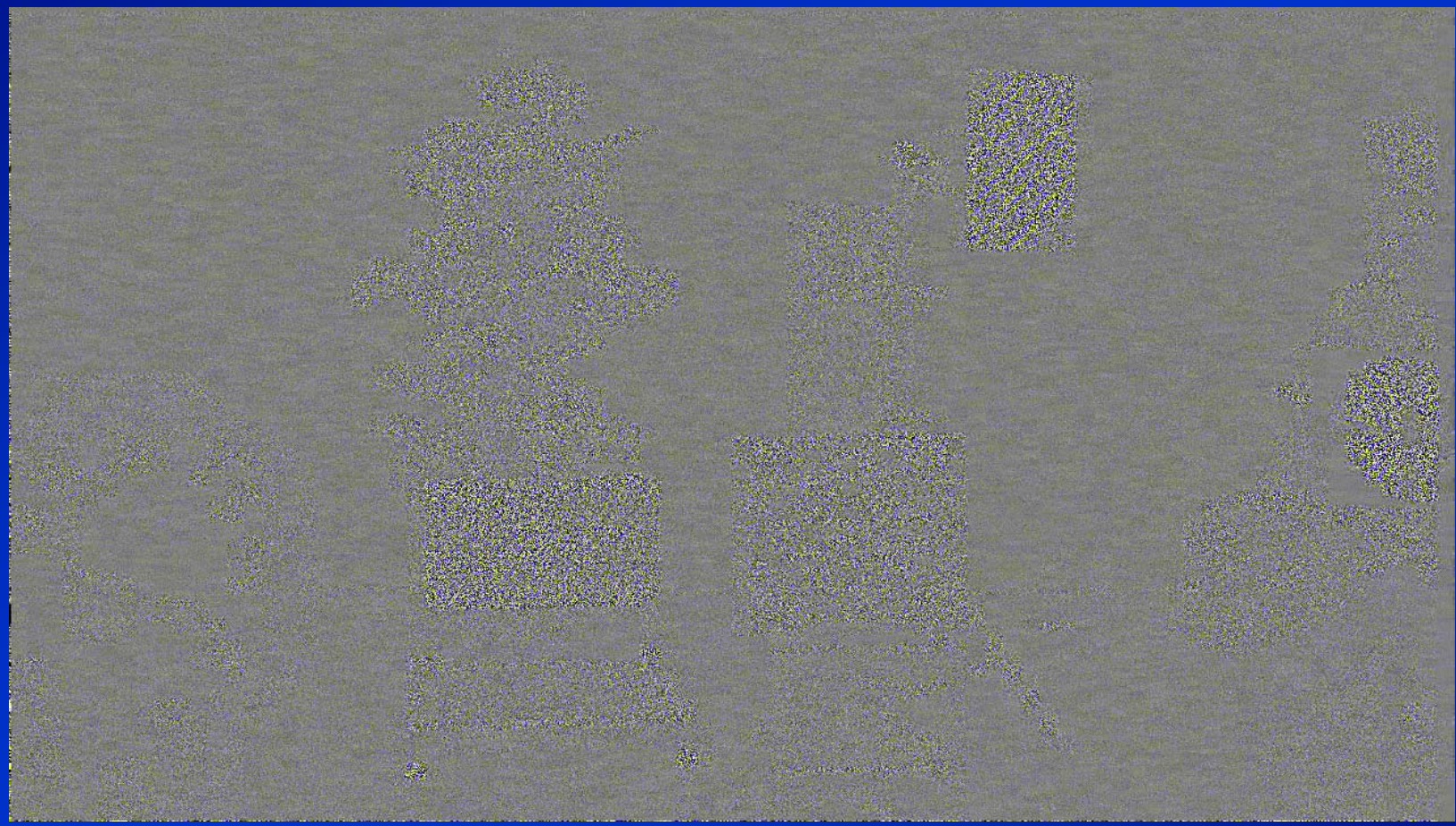
DVE

mixer

VTR

7th generation decoded picture with pixel shifts

7th generation difference picture (gain x16)



With pixel shifts between each generation

Summary

- Compression is inevitable with HD
- Mezzanine coding system to carry 1080p in 1080i
- Low delay, simple to implement in hardware
- Existing 1.5 Gb/s routing infrastructure can be used
- Compatible picture for viewing on 1080i equipment
- Being considered by SMPTE Ad-Hoc group (C24-Mezz)
- Should we keep content in native formats or common studio format??

Thank You