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USING H.264 AND H.265 EXPERTISE TO BOOST MPEG-2 EFFICIENCY

Anais Painchault

Field Application Engineer

ATEME

Agenda

- Video codecs history
- the 6-in-6 concept
- Preliminary considerations
- Enhanced Motion Estimation
- Rate-Distortion Optimization
- Smart use of SKIP mode
- Backtracking

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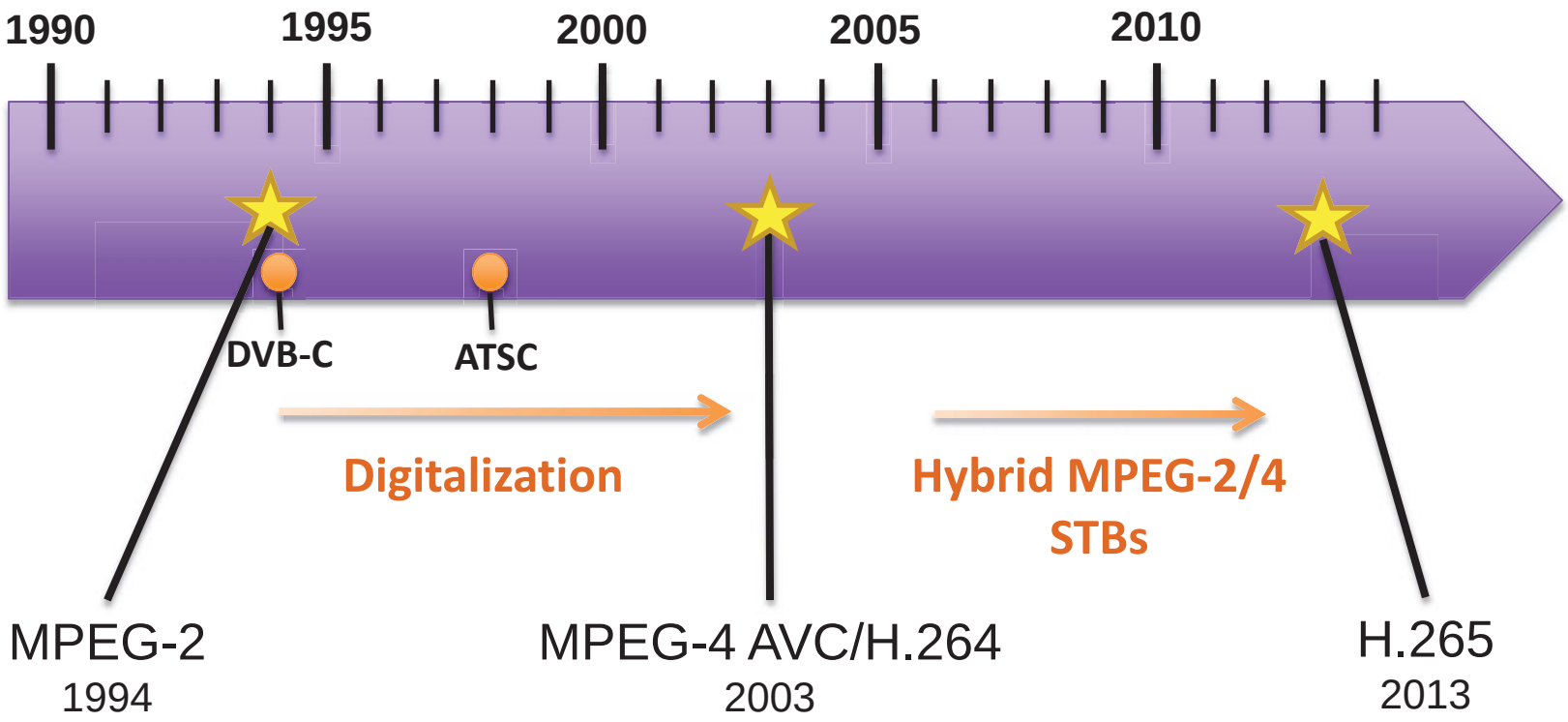
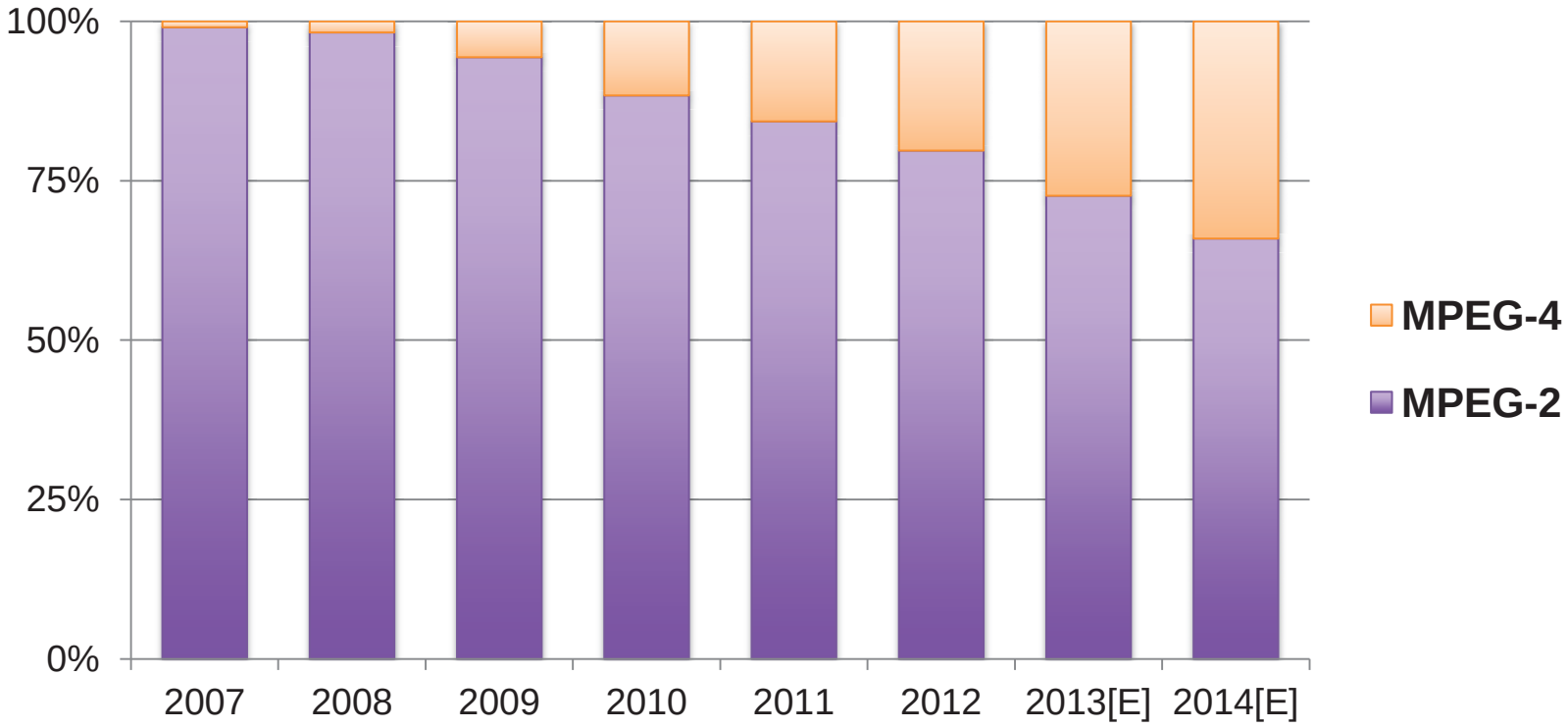
Video codecs history



Today's situation



Video Encoders for Cable TV Head-ends in Americas

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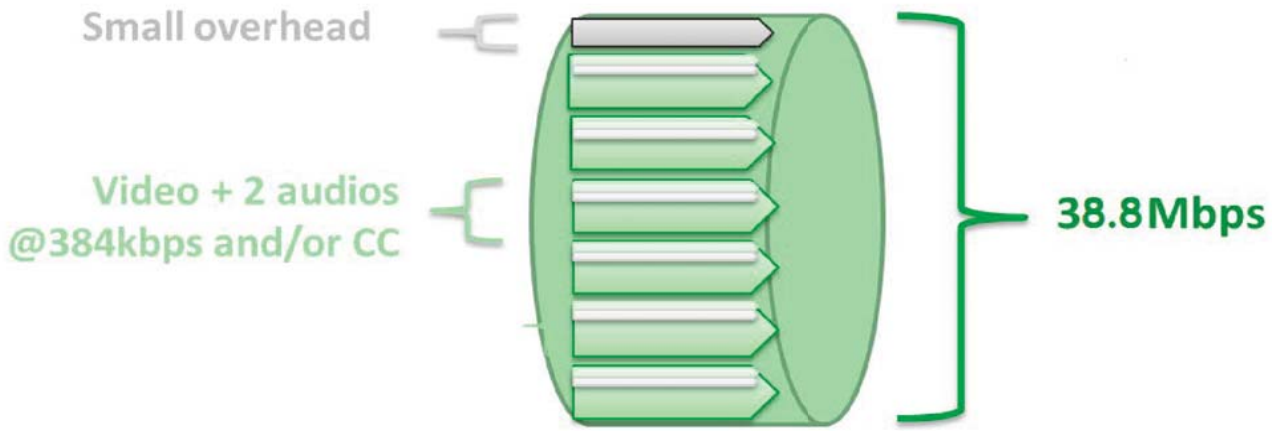
6-in-6 concept

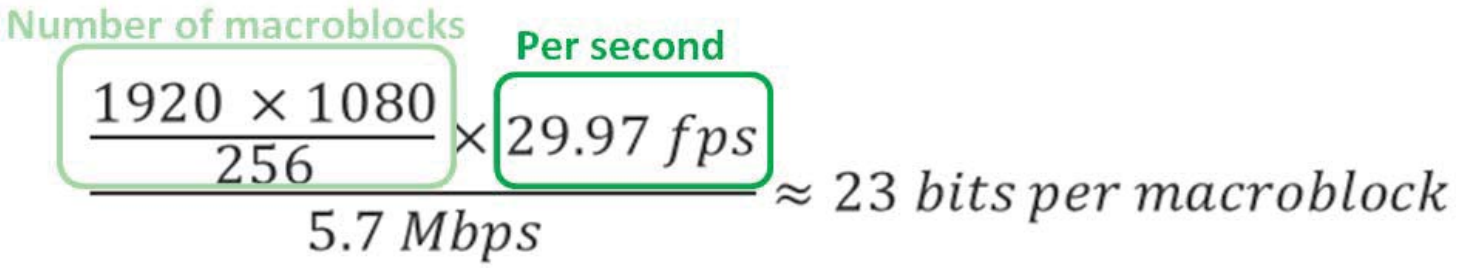
6 HD Channels (1080i59.94 in MPEG-2) **…**

… IN 6 MHZ = 1 QAM = 38.8 Mbps



- 5.7 Mbps per video
- Today: mainly 3-in-6 → 12 Mbps per video

6-in-6 challenge



- 1 macro-block in 4:2:0 = 384 bytes
  - 3 bytes to transmit 384 bytes : **Divide by 130!**
  - **Every bit counts!**
  - Encoded image **will** differ from source (low PSNR)
  - What needs to be improved is the **visual image coherence**
- **Unusual scenario for video compression**

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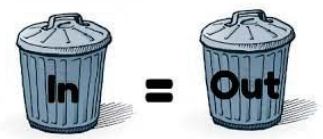
Preliminary considerations

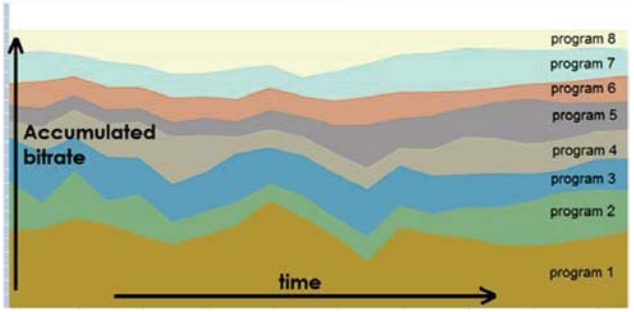
- Enable all tools (what's allowed?)

CableLabs

- Pristine quality sources



- Statistical multiplexing
  - 30% quality improvement!



- Resolution: what about 1440x1080 ?
  - No visual difference
  - HDCAM + some live events

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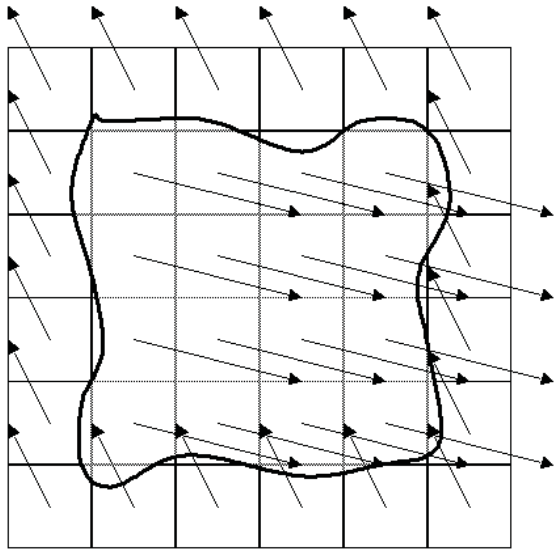
Enhanced Motion Estimation

- Goal: predict the movement of a macroblock

Ideal Motion Vectors to be predicted

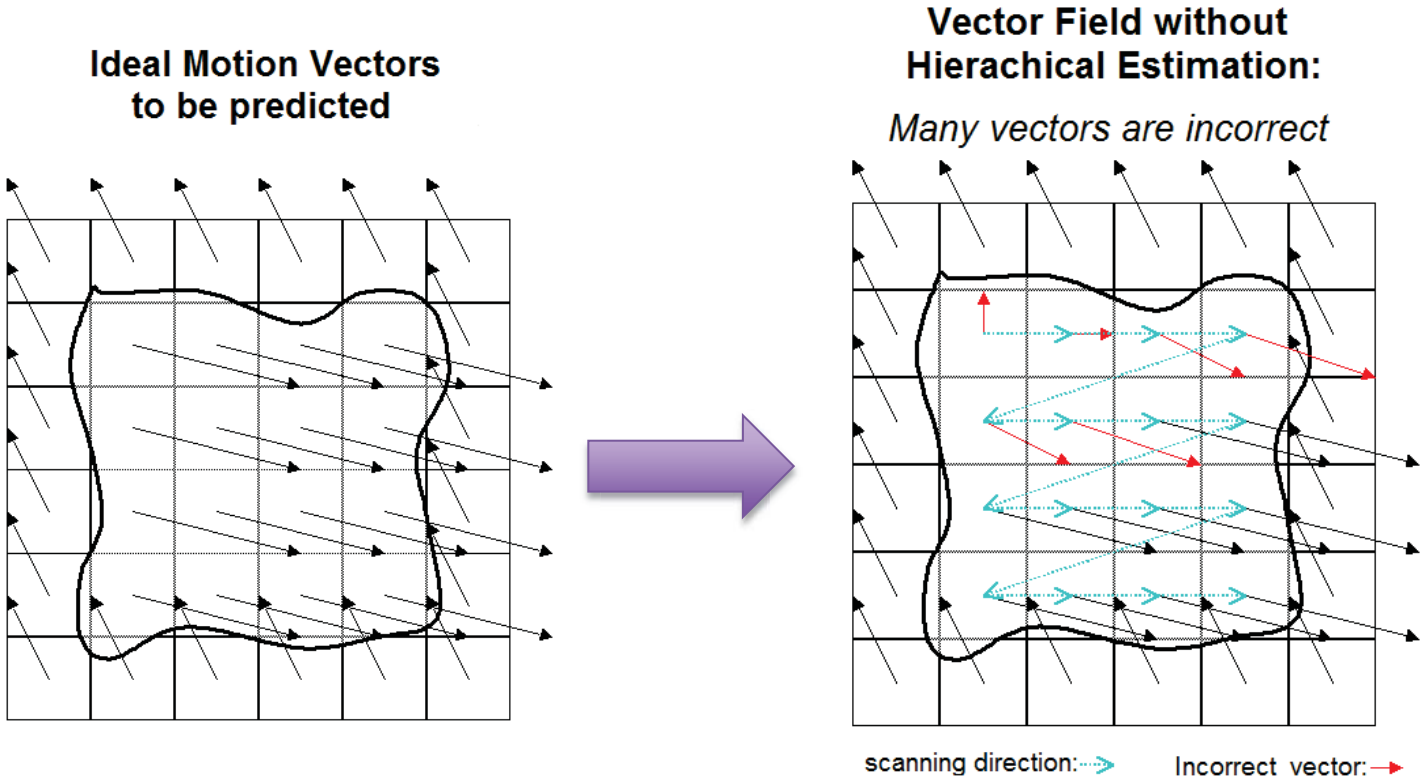


Enhanced Motion Estimation

- Goal: predict the movement of a macroblock
- To reduce the search window → focus on the most probable motion vectors
  - Vectors from neighboring blocks
  - Vectors of the same block in the previous images

Enhanced Motion Estimation

- Goal: predict the movement of a macroblock

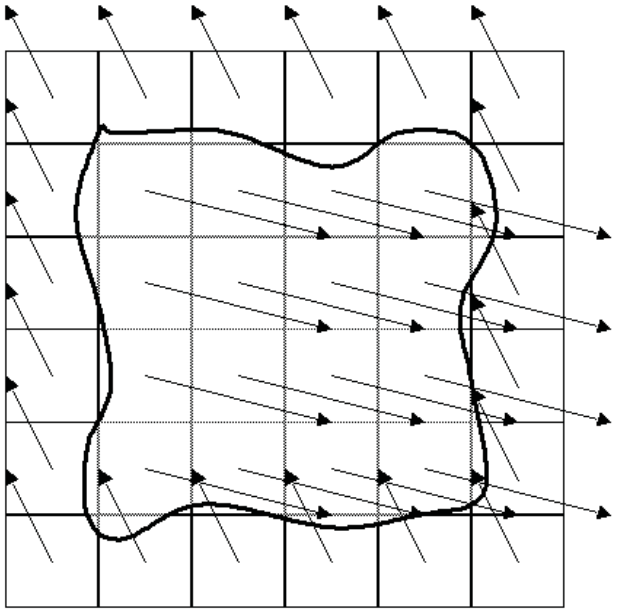


Enhanced Motion Estimation

- Hierarchical Motion Estimation → Look at the vectors from sub-partitions
- The smallest sub-partition level is estimated first, and the vectors found for this sub-partition can then be re-used as candidates for the lower level
  - Better but the raster scanning of the blocks induces some asymmetry in the motion estimation

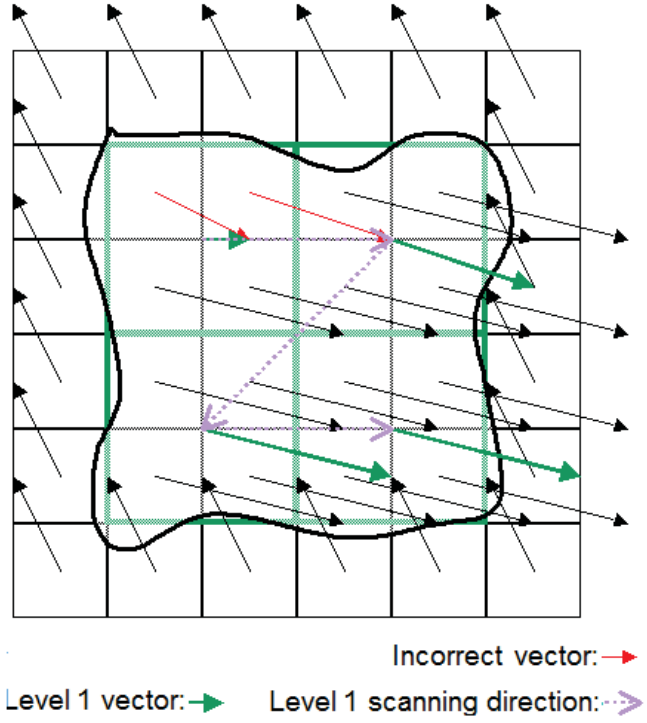
Enhanced Motion Estimation

Ideal Motion Vectors to be predicted



Vector Field With Standard Hierarchical Estimation:

Better but some vectors are still incorrect



Enhanced Motion Estimation

- ATEME patented technique developed for MPEG-4:

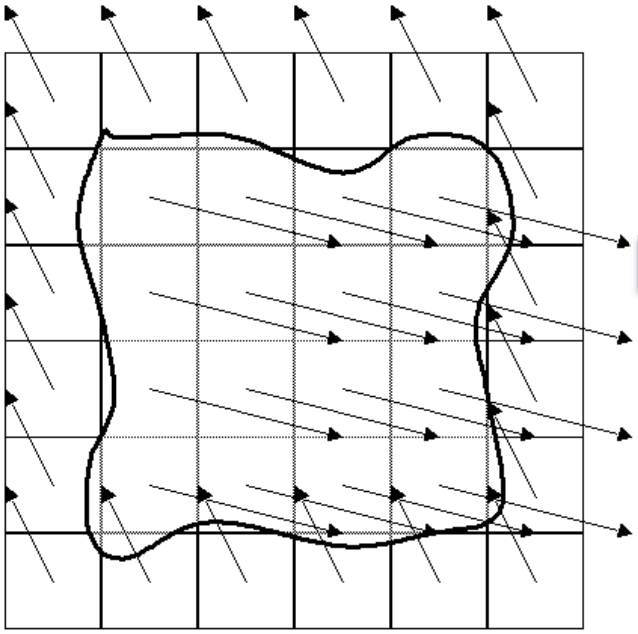
  “Bilinear Hierarchical Motion Estimation”

  – Change scanning direction at each level

  – Better accuracy in the prediction

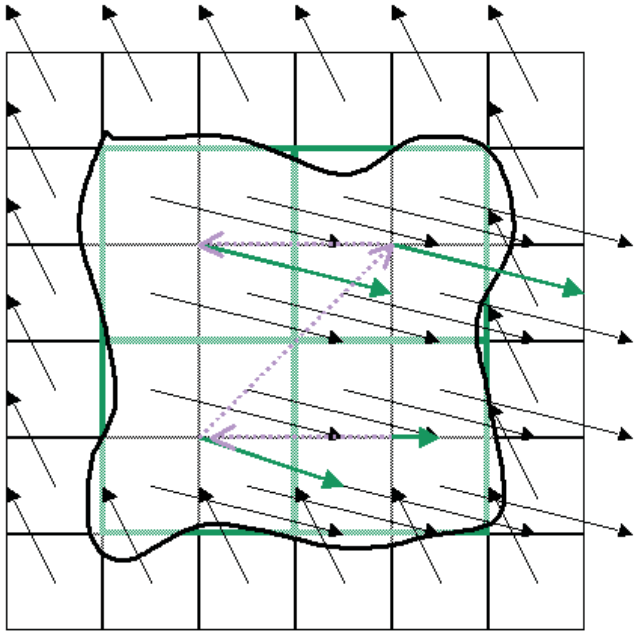
Enhanced Motion Estimation

Ideal Motion Vectors to be predicted



Vector Field with ATEME Bilinear Hierachical Estimation:

All estimated vectors are correct



Incorrect vector:

Level 1 vector: Level 1 scanning direction:

Enhanced Motion Estimation

- Approach developed for MPEG-4 because of heavy partitioning
- Used in H.265 as well (quad-tree)
- Great results in MPEG-2
  - Better motion estimation → better visual homogeneity

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Rate Distortion Optimization

- Rate distortion optimization:

  → Test all encoding modes possible for each macro-block to choose the best one

Rate Distortion Optimization

1 Macro-block

Optimization

Choose mode 1:
-INTRA/INTER/SKIP
-Partitioning
-Motion vector
-…

Residual image

Get rate needed to transmit residual + info

Re-create Prediction image

T → Q → Q^{-1} → T^{-1} → Rate and Distortion

Prediction info: mode, motion vector

Compute quality Distortion (MSE)

mode 2: T → Q → Q^{-1} → T^{-1} → Rate and Distortion

mode *N*: T → Q → Q^{-1} → T^{-1} → Rate and Distortion

S E L E C T

Rate Distortion Optimization

- Rate distortion optimization:

  → Test all encoding modes possible for each macro-block to choose the best one

- Method introduced in 1998 (G. Sullivan)

- Widely used with h.264 (used by reference encoder)

- Not applied to MPEG-2 until recently

  E/// “Revolutionary Optimized Mpeg2” in 2009, Thomson 2010

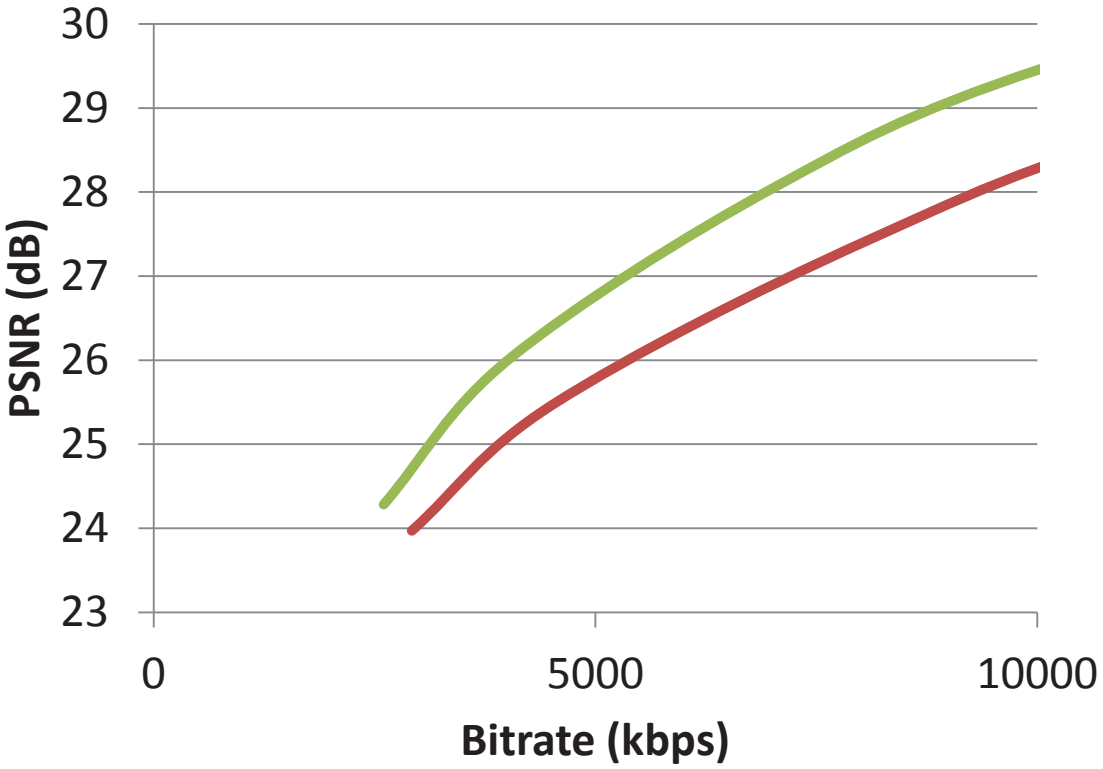
Rate Distortion Optimization

- Re-use the testing method of H.264:
  - Taking advantage of computing power available today
  - On very powerful machine developed for H.264
  - MPEG-2 more simple than H.264

- **Massive** RDO tests: around 90 per macro-block (compared to 33 in 2009)

- It’s possible to test all modes

Rate Distortion Optimization



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Smart Use of SKIP Mode

- 23 bits per macro-block: every bit counts!
- Try to use as much as possible modes with low data rate:
  - where we don't have to sent vectors and/or residual
- SKIP block: no information is sent
  - copy previous block
- Performs very good in RDO

BUT…

- Too much SKIP blocks → bad visual rendering

Smart Use of SKIP Mode

- SKIP mode needs to be chosen carefully
- While working on H.264 optimization, new techniques have been developed to validate the use of SKIP modes
  - SKIP must be chosen based on other criteria than RDO
  - The motion vector needs to be coherent with the neighboring blocks vectors
  - Allowed an important visual quality gain

→ Can be re-applied to MPEG-2

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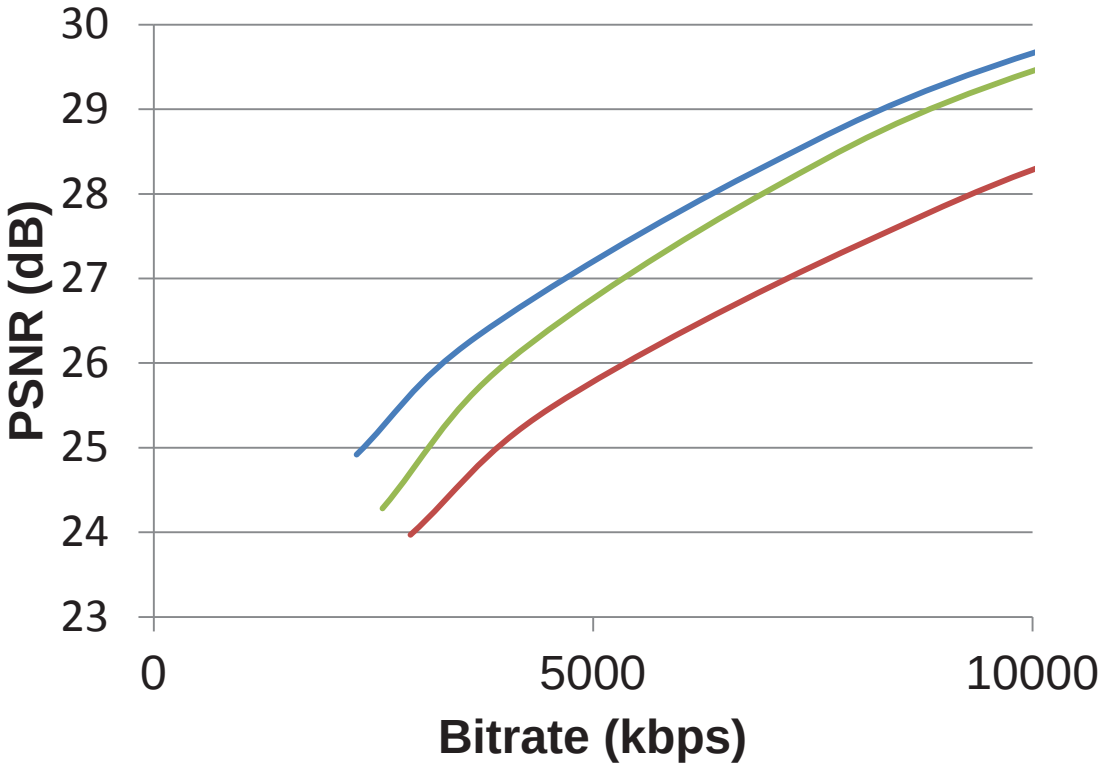
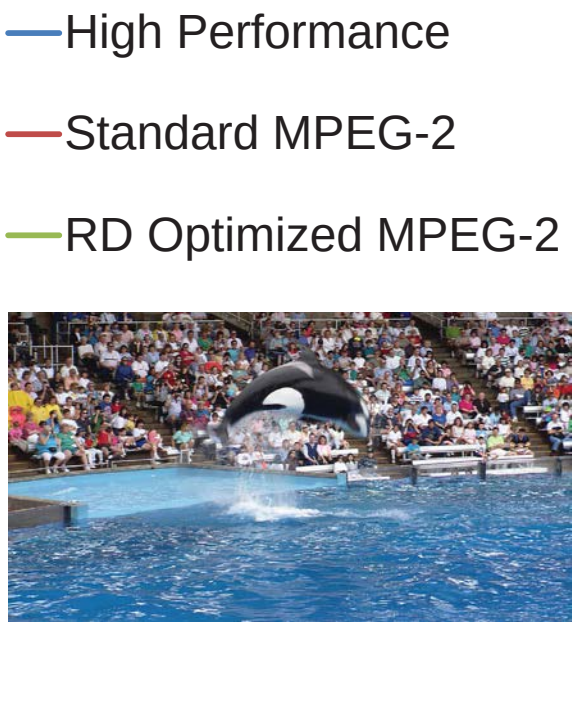
Backtracking

- Optimization approaches (RDO) consider decisions are independent
  - Not true… one block affects the others
- H.265: Treillis quantization
  - quantized coefficients considering context of the whole block
  - Quality gain up to 10%
  - Can be extrapolated: quantizer, macroblock, picture type...
- Too demanding (CPU) for H.264 live
- MPEG-2 is much simpler!

Backtracking





High Performance MPEG-2 including backtracking (the 6-in-6 enabler)

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- **Conclusion**

Conclusion

- H.264 and H.265 introduced new approaches and improvements
- Re-injected to MPEG-2: great quality gains
- All combined: improve quality up to 6-in-6
- Otherwise:
  - 6-in-6 only on “easy” content ?
  - 5-in-6 for challenging ones ?
- We can hope future improvements to come while H.265 is being optimized over the years

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ATEME

a.painchault@ateme.com

(305) 433 4244

ateme