Συστήματα και Αλγόριθμοι Πολυμέσων

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Ομιλία #11: Διεθνές στάνταρ συμπίεσης βίντεο H.264

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Πανεπιστήμιο Θεσσαλίας
Τμήμα Μηχ. Η/Υ, Τηλεπ. & Δικτύων

Επανάληψη

- Ανθεκτικότητα στο θόρυβο κατά τη μετάδοση ψηφιακού βίντεο MPEG4
  - *Πακετοποίηση δεδομένων (RM)*
  - *Επανάληψη επικεφαλίδας (HEC)*
  - *Χωρισμός δεδομένων (DP)*
  - *Αναστρέψιμοι κωδικοί μεταβλητού μήκους (RVLC)*
  - *Κυκλική ενδο-ανανέωση (CIR)*
  - *Προσαρμοσμένη ενδο-ανανέωση (AIR)*

Επανάληψη (2)

- Αρχιτεκτονική μικροεπεξεργαστή Xtensa (Tensilica)
  - Πυρήνας μικροεπεξεργαστή που μπορεί να προσαρμοστεί ή να επεκταθεί ανάλογα με τις εφαρμογές
  - TIE: καινούργιες εντολές γλώσσας μηχανής που καθορίζονται από το σχεδιαστή
  - Όλες οι παράμετροι του μικροεπεξεργαστή μπορούν να καθοριστούν και συνεπώς να βελτιστοποιηθούν ανάλογα με την εφαρμογή.

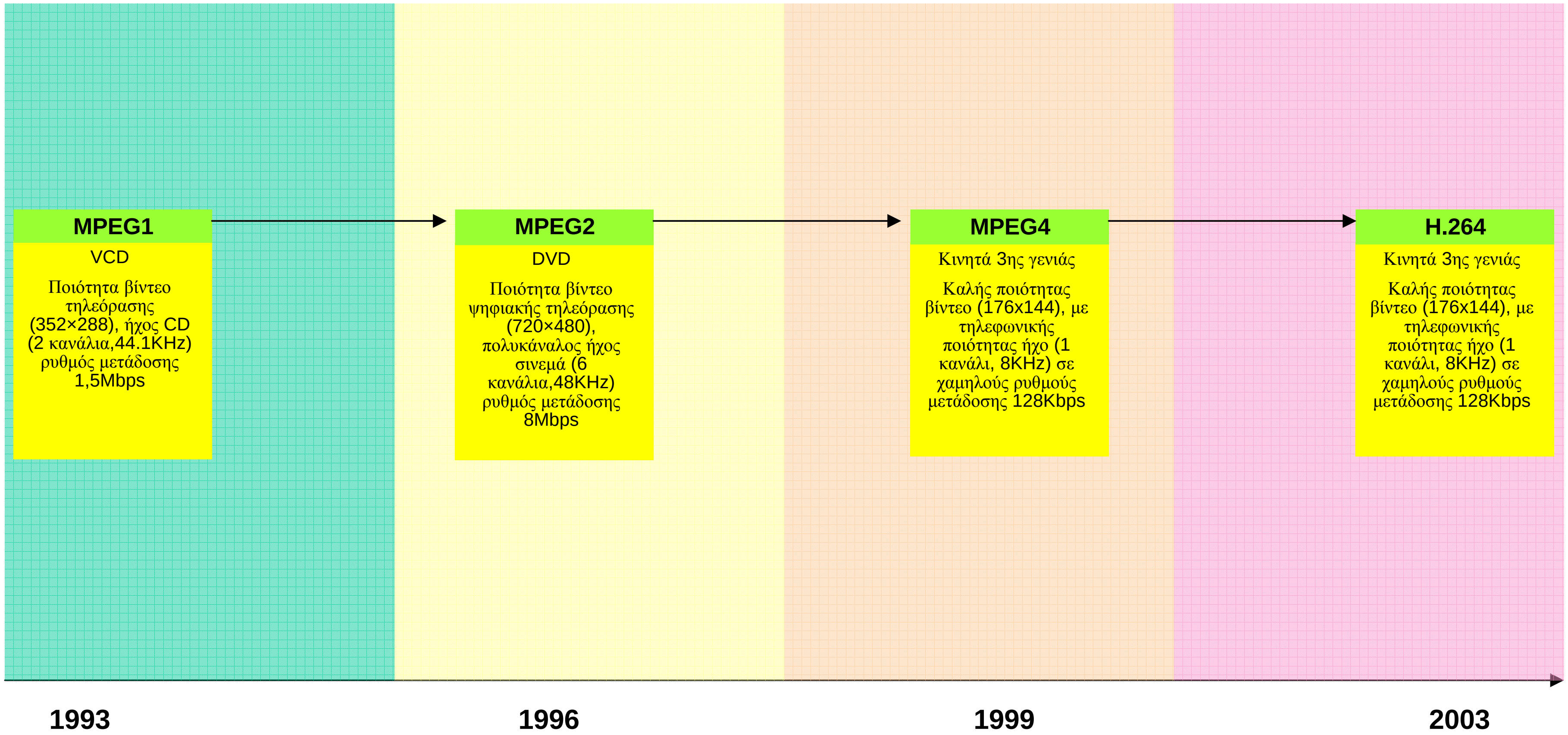
Άσκηση #10

- Να υλοποιήσετε τον αλγόριθμο εύρεσης διανύσματος κίνησης χρησιμοποιώντας το κριτήριο της ελαχιστοποίησης του αθροίσματος των απολύτων τιμών των διαφορών (minSAD)
- Να εφαρμόσετε τον αλγόριθμο εύρεσης διανύσματος κίνησης σε μπλοκ 16x16 φωτεινότητας του βίντεο src19 και να σχεδιάσετε το ιστόγραμμα των διανυσμάτων κίνησης οριζοντίως και καθέτως για κάθε καρέ

Άσκηση #10 (συνέχεια)

- Να μεταφέρετε το πρόγραμμα από αρχιτεκτονική PC (Windows/Intel/AMD) σε αρχιτεκτονική Tensilica-Xtensa.

Χρονοδιάγραμμα MPEG



MPEG4 part 10: H.264

- Originally called H.26L (“Long term”), H.264 is an effort within ITU-T to establish a high efficiency video compression standard
- Core experiments demonstrate 40-50% bit-rate savings over H.263
- H.26L & MPEG4 groups joined to form JVT (Joint Video Team) in order to contribute part 10 to MPEG4 version 2: Advanced Video Coding; H.264 standard drafted May 2003

MPEG4 part 10: H.264

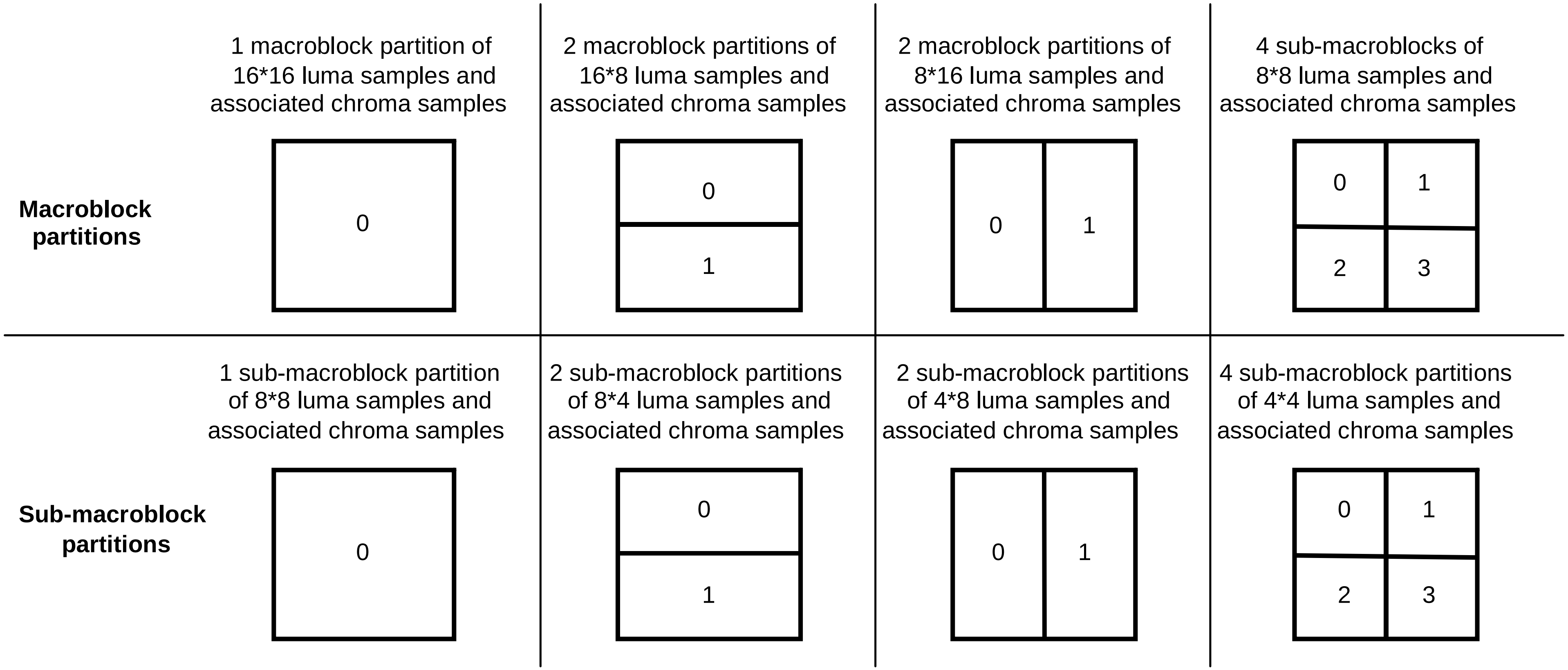
- H.264 unique technology:
  - Only one regular VLC is used for symbol coding
  - Alternatively, context-adaptive arithmetic or Huffman entropy coding is used
  - 1/4 pixel positions are used for motion prediction, with 6x6 separable interpolation filter.
  - A number of different block-sizes are used for motion prediction: 4x4, 4x8, 8x4, 8x8, 8x16, 16x8, 16x16
  - In-loop de-blocking filter is normative for the decoder

MPEG4 part 10: H.264

- More H.264 unique technology:
  - Residual coding is based on 4x4 blocks and an exact integer transform (DCT-like) is used
  - Non-linear quantization scale is used, different for luma and chroma
  - Multiple reference frames may be used for prediction and this is considered to replace any use of B-frames
  - Multiple intra coding modes that allow for prediction from blocks from the same frame (almost same coding efficiency as JPEG2000)

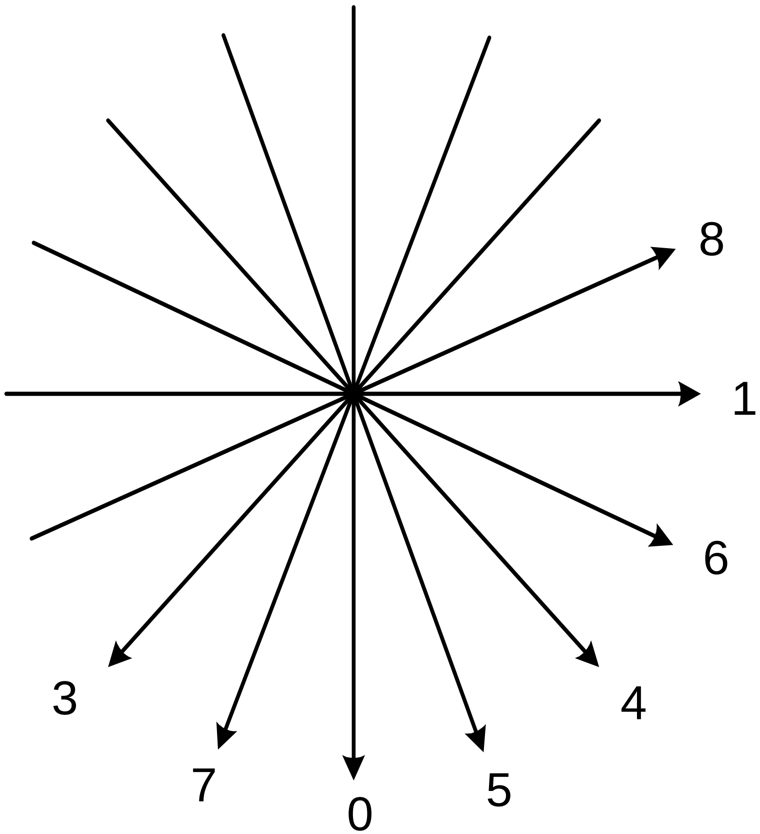
H.264 technology

- Variable macroblock partitions



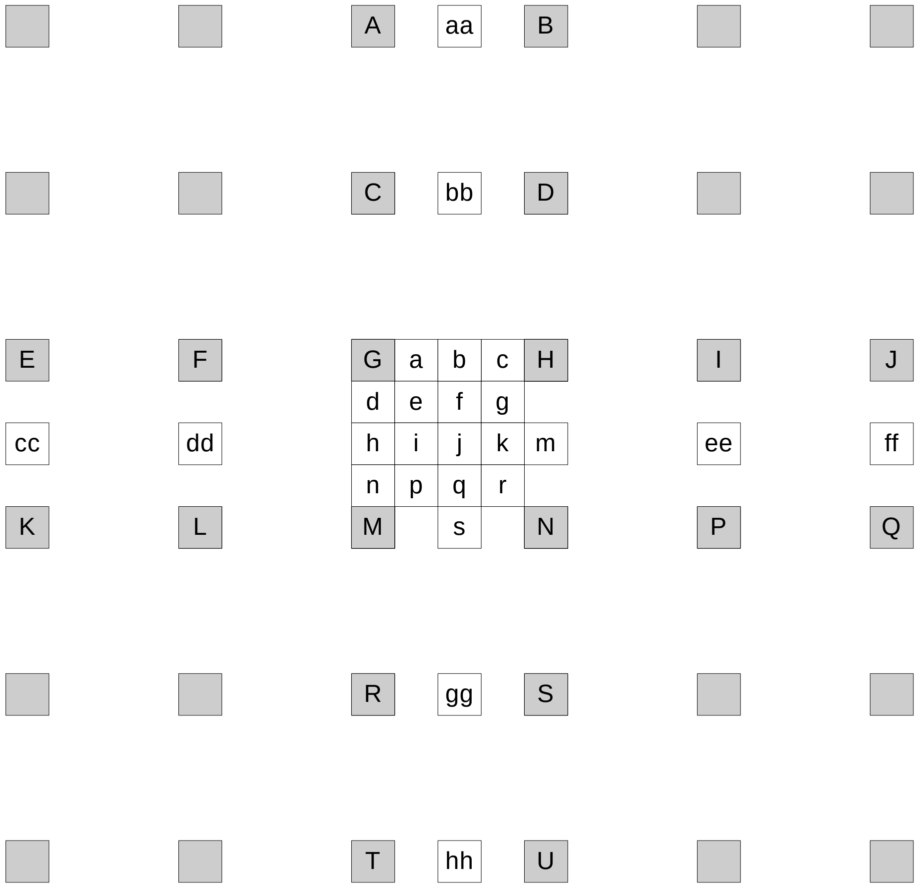
H.264 technology

- Intra prediction modes



H.264 technology

- ½ and ¼-pixel motion compensation



H.264 technology

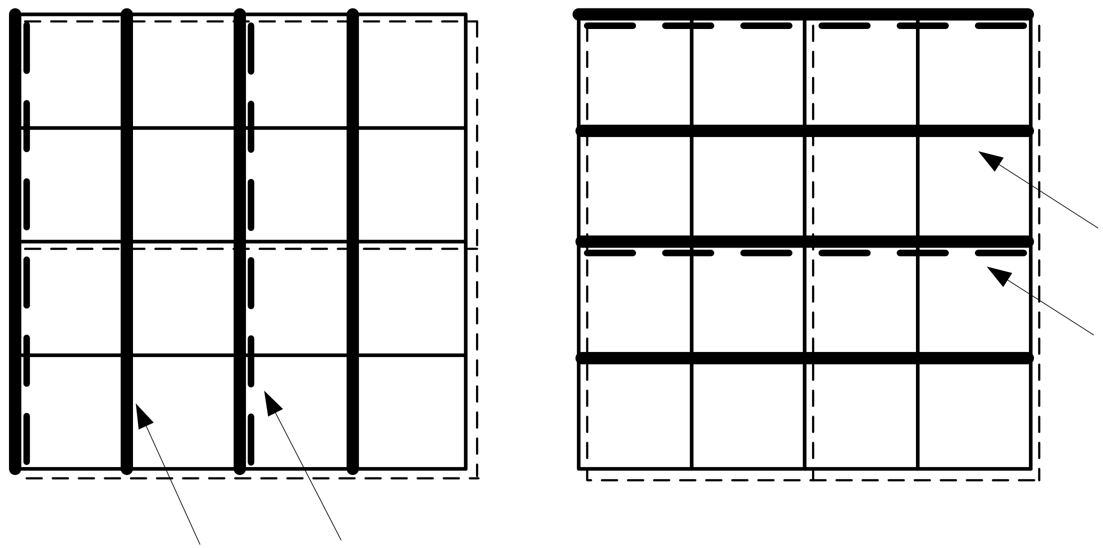
- Integer inverse transform

$$v = \begin{bmatrix} 10 & 16 & 13 \\ 11 & 18 & 14 \\ 13 & 20 & 16 \\ 14 & 23 & 18 \\ 16 & 25 & 20 \\ 18 & 29 & 23 \end{bmatrix}$$

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

H.264 technology

- In-loop de-blocking filter



H.264 technology

- UVLC

Bit string form	Range of codeNum
1	0
0 1 x_0	1-2
0 0 1 x_1 x_0	3-6
0 0 0 1 x_2 x_1 x_0	7-14
0 0 0 0 1 x_3 x_2 x_1 x_0	15-30
0 0 0 0 0 1 x_4 x_3 x_2 x_1 x_0	31-62
…	…

codeNum	syntax element value
0	0
1	1
2	–1
3	2
4	–2
5	3
6	–3
k	$(-1)^{k+1}$ Ceil(k÷2)

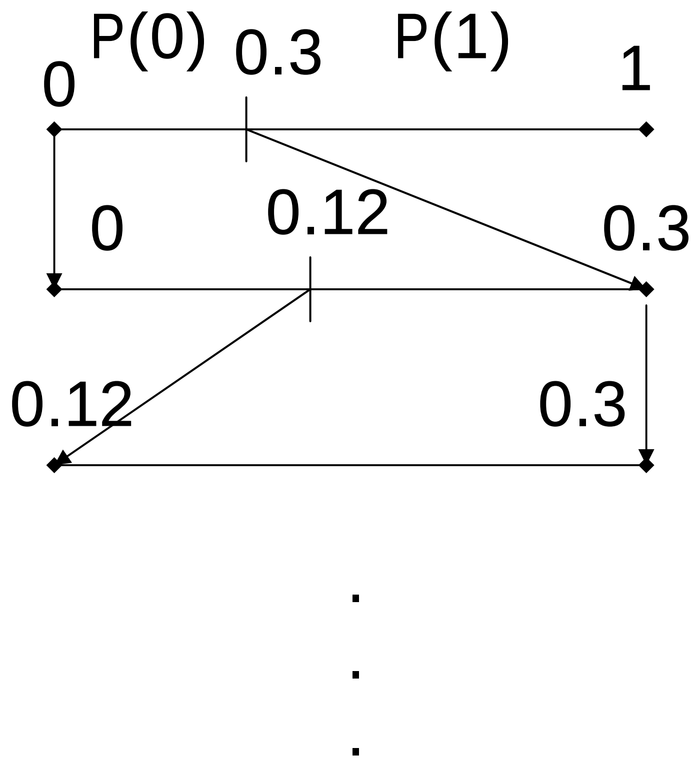
H.264 technology

- CAVLC
  - Total number of non-zero coefficients is coded
  - Both trailing zeroes (“run”) and trailing ones are coded, context-adaptive
  - Level is coded, context-adaptive

H.264 technology

- CABAC

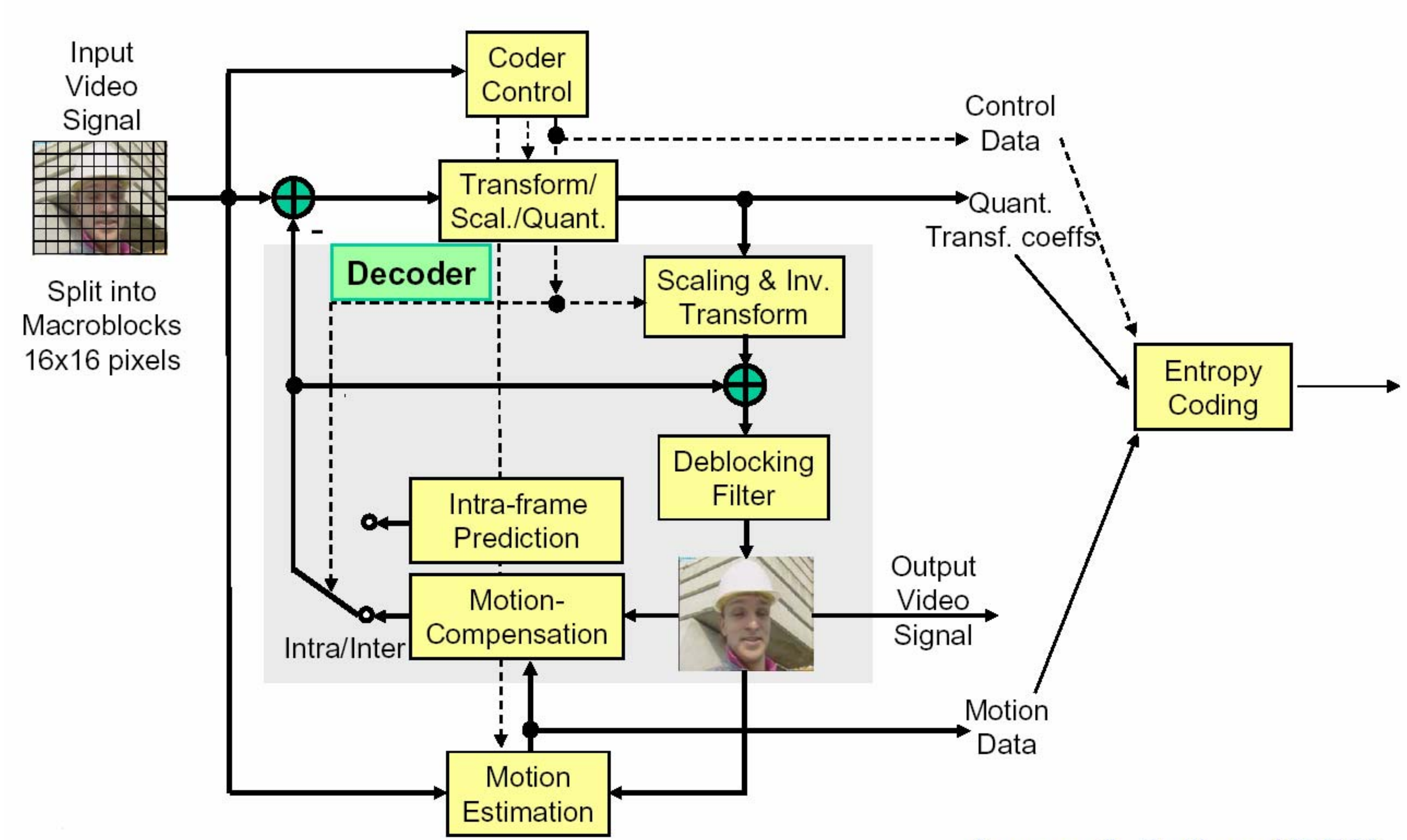
Value of syntax element	Bin string					
0	0					
1	1	0				
2	1	1	0			
3	1	1	1	0		
4	1	1	1	1	0	
5	1	1	1	1	1	0
…						
binIdx	0	1	2	3	4	5



H.264 Technology

- Amendments to the 05/2003 standard led to the current 03/2005 version that introduced new tools and profiles
  - Fidelity Range Extensions (FRE), including
    - 8x8 integer transform (Hadamard-like)
    - 8x8 intra-prediction mode
    - RGB-like color representation
    - More than 8-bit video
    - YUV400 (monochrome), YUV422 and YUV444 color formats
    - Loseless Region Coding

Διάγραμμα συστήματος κωδικοποιητή βίντεο H.264



[source: G. Sullivan, VCEG]

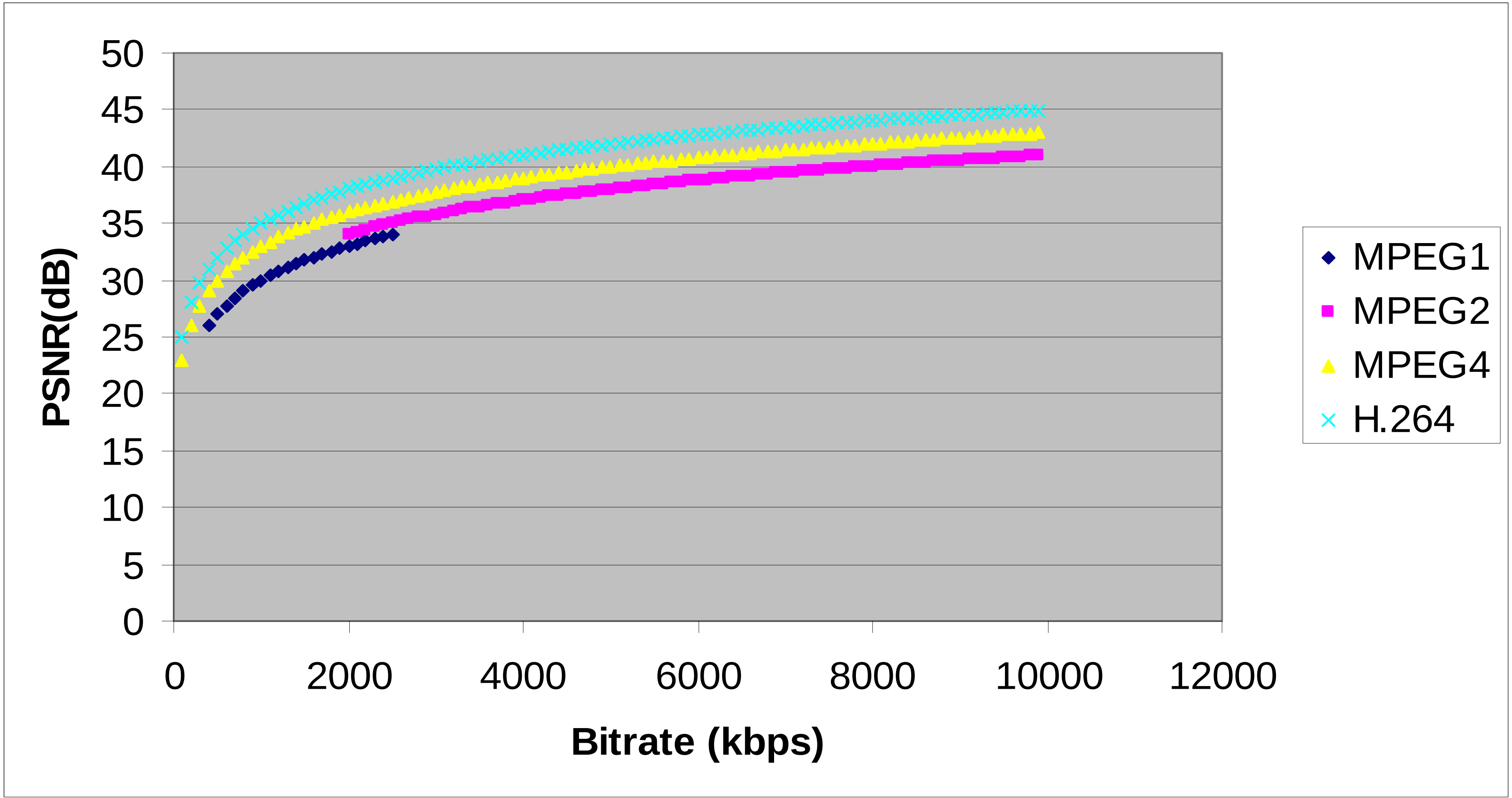
MPEG4 part 10: H.264

- More work is needed to make successful products out of H.264:
  - Encoding complexity is ~100x that of MPEG2
  - Decoding complexity is ~3x that of MPEG2
  - Interlaced tools, error resilience
  - Rate control

MPEG 1/2/4 comparison

- How much better is MPEG4 over MPEG2 ?
  - Depends highly on the encoder
  - MPEG (1/2/4) only define the decoder, not the encoder; there is no “standard” MPEG encoder
  - MPEG2 encoders in 1993 were using 50% more bit-rate than MPEG2 encoders in 2000; the same decoder can be used to decode all such streams
  - Under the same level of sophistication for the encoder, MPEG4 has 10-15% better efficiency due to additional coding tools over MPEG2 for high bit-rate content

MPEG efficiency comparison



MPEG4 vs. H.264 comparison

- Same caveats as for MPEG2 vs. MPEG4 comparison apply
- H.264 requires significantly higher complexity and any error resilience tools reduce its coding efficiency
- Under same level of sophistication, H.264 has 15-20% better efficiency due to additional coding tools over MPEG4 for low bit-rate content

MPEG1/2 summary

- MPEG1 and MPEG2 are well established and widely used standards for medium and high bit-rate compression of video signals for digital storage media (DVD) and digital TV broadcasting

MPEG4 summary

- MPEG4 is an emerging standard that extends video compression to a variety of multimedia content, addresses the whole range of bit-rates and gives the flexibility to offer multimedia content through every communication channel

H.264 summary

- H.264 is a new video compression standard that can potentially improve over MPEG1/2/4 by a significant factor and further enhance the capabilities of MPEG4