H.264 Overview

Video Team

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Contents

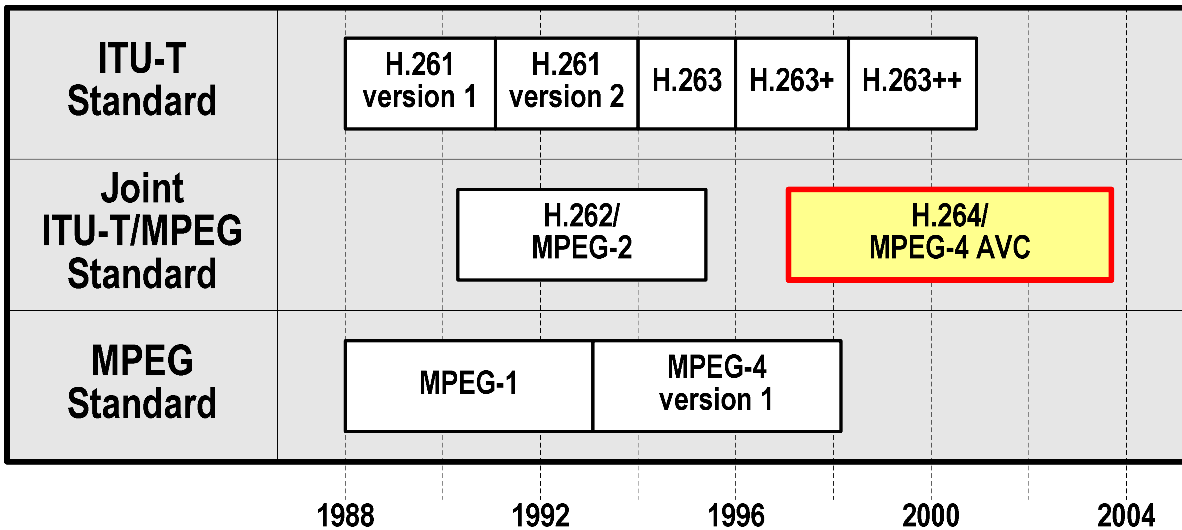
Video Codec Applications

Codec (Encoder & Decoder)

Digital Video Applications

Set-top box	Satellite network Broadband network (Cable, xDSL) ATM network
V2oIP Gateway	Voice & Video over IP products
IP Video Phone & Video Conferencing	H.320, H.323, SIP based products
Mobile Multimedia Terminal	Cellular/ mobile phone, PDA, DMB terminal
Video Monitoring System	Video monitoring and recording system Web camera Network camera PVR: Personal Video Recorder(PVR: Personal Video Recorder)

History of Video Standards



- **ITU VCEG**
  - H.26L → H.264
- **ISO MPEG**
  - MPEG-4 AVC (advanced video coding) or MPEG-4 Part 10
- **VCEG-MPEG**
  - JVT (joint video team)
  - JMx.x (joint model: reference software)

H.264 Features

High compression performance

- Many advanced compression techniques are adopted.
  - ✓ Advanced Intra-Prediction
  - ✓ Strong Motion Isolation (4x4, ¼-pel resolution)
  - ✓ Multiple Reference Frames
  - ✓ Weighted Bi-Prediction
  - ✓ Context-adaptive VLC/BAC

  } Very High Complexity!
- Average bit rate reduction of 50% given fixed fidelity compared to any other video standard

Exact match decoding

- Integer Transform

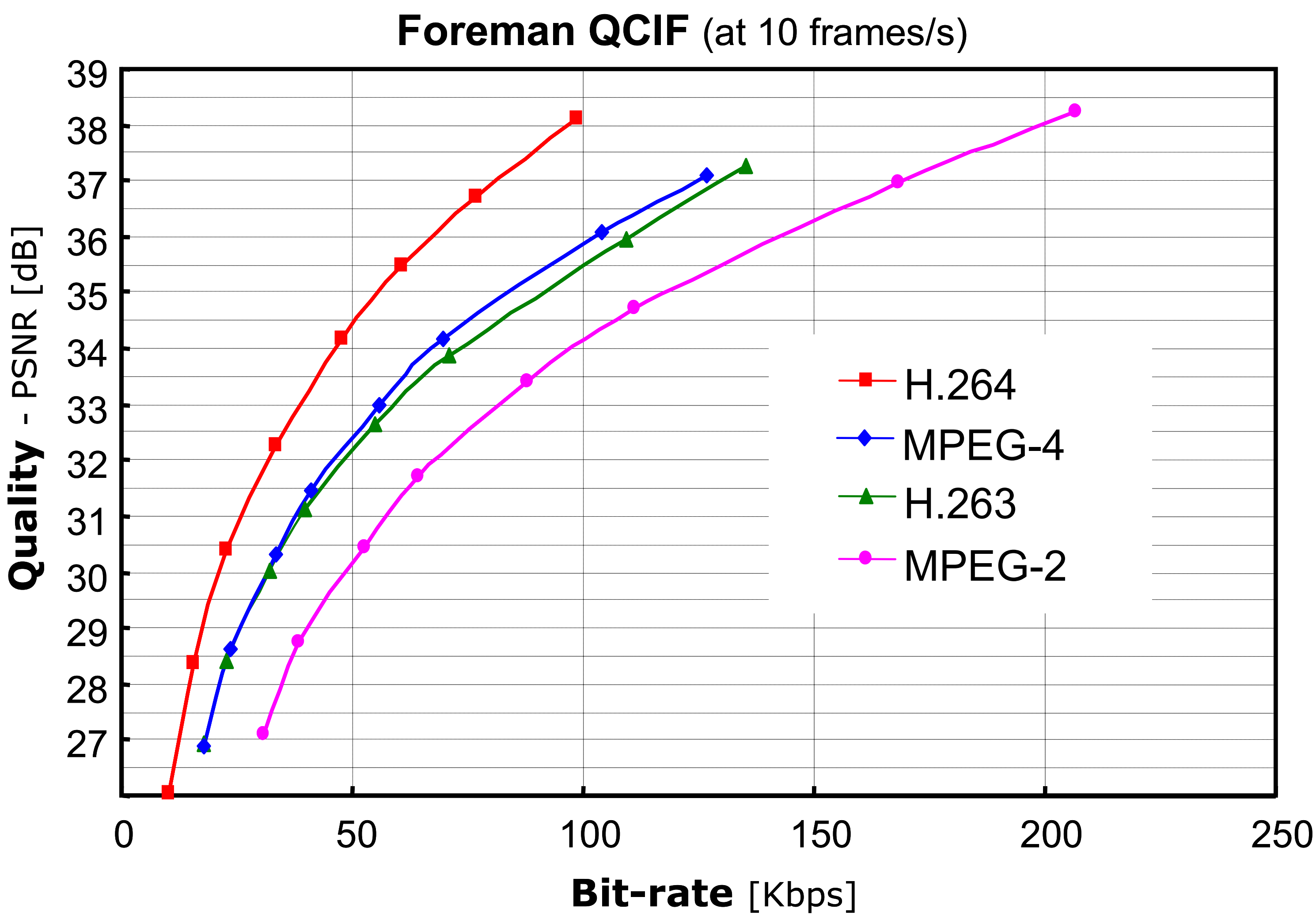
Improved Perceptual Quality

- In-Loop Deblocking Filter

Network friendliness

- NAL (Network abstraction layer)
- Enhanced Error Resilience

Comparison to Other Standards



Comparison to MPEG-4

Environment

- Matrix 20sec
- 320x240
- 30fps
- 128Kbps (Low Bit-rate)

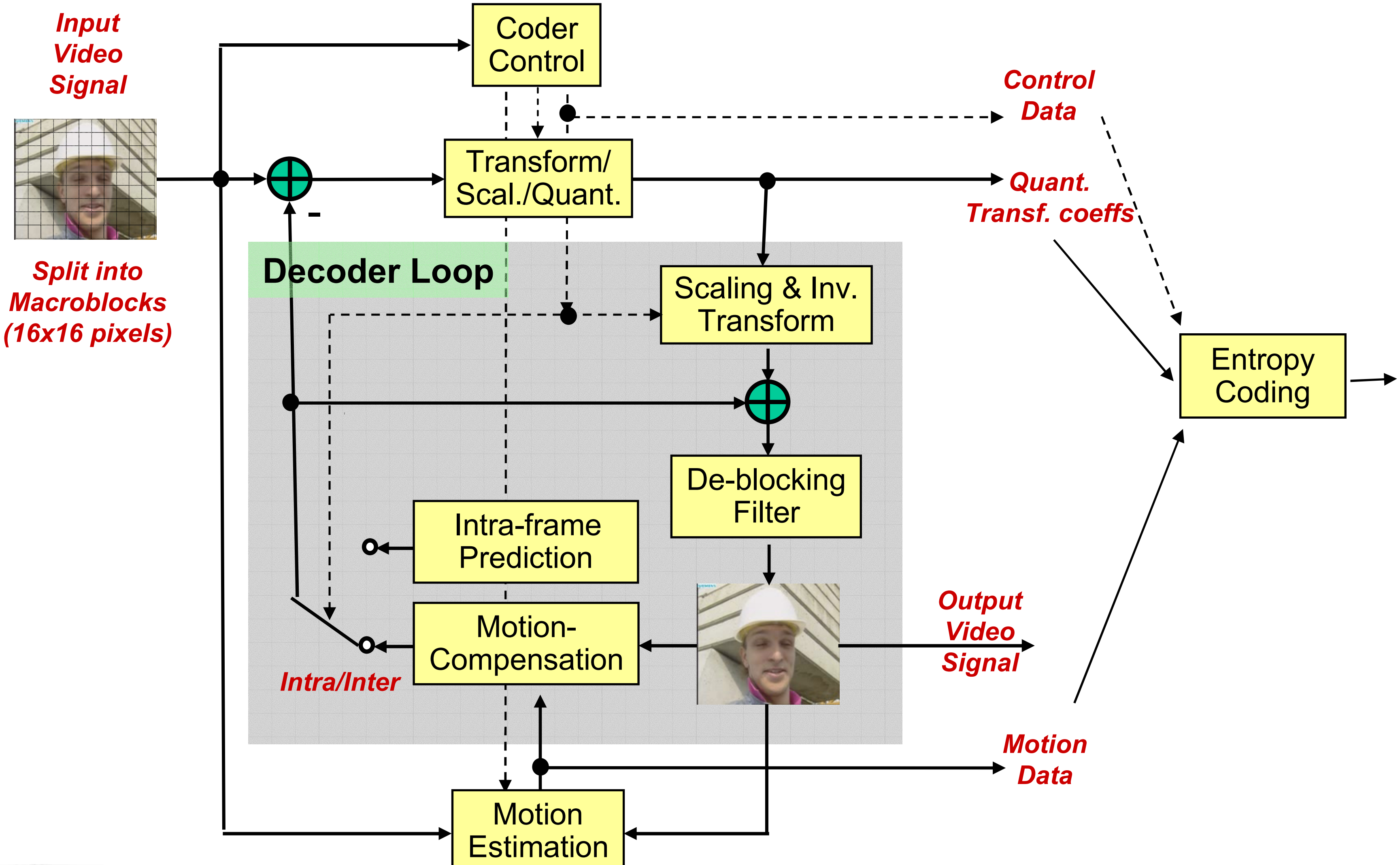
H.264 - Technical Tools

- Sequence→GOP→Picture→Slice→MB→Block
- Chroma format – 4:2:0
- Picture type – I, P, B, SI, SP
- Frame structure – Interlaced, Progressive
- Adaptive frame/field – per picture, per MB
- Deblocking filter – in-loop
- MV resolution – ¼ pixel
- Tree-like motion segmentation – 16x16 to 4x4
- Entropy coding – EG and CAVLC/CABAC
- Data partitioning – NAL_unit, priority
- ASO (arbitrary slice order) – independently decodable
- FMO (flexible macroblock order) – map
- Redundant slice
- ABP (adaptive bi-prediction) – adaptive weighting

H.264 Profiles

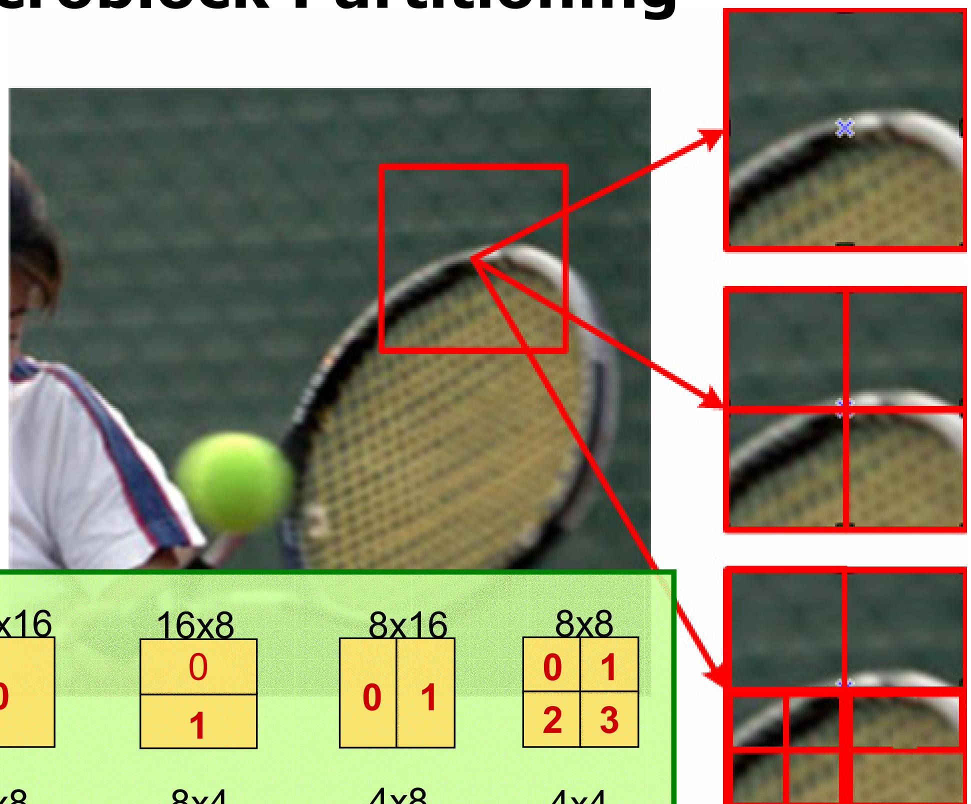
- **Baseline (Videoconferencing & Wireless)**
  - I and P picture types (not B)
  - Interlace
  - Per-picture adaptive frame/field
  - In-loop deblocking filter
  - 1/4-sample motion compensation
  - Tree-structured motion segmentation down to 4x4 block size
  - VLC-based entropy coding (CAVLC)
  - Some enhanced error resilience features: FMO, ASO, Redundant slices
- **Main Profile (esp. Broadcast)**
  - All Baseline features except enhanced error resilience features
  - B pictures
  - CABAC (context-adaptive binary arithmetic coding)
  - MB-level frame/field switching
  - Adaptive weighting for B and P picture prediction
  - Interlace
- **Profile X (esp. Streaming)**
  - All Baseline features
  - B pictures
  - More error resilience: Data partitioning
  - SP/SI switching pictures

H.264: Encoder Structure



H.264: Motion Compensation Accuracy

■ Macroblock Partitioning



MPEG-2
- 16x16 block size
- Square shape
- ½ pel motion vector

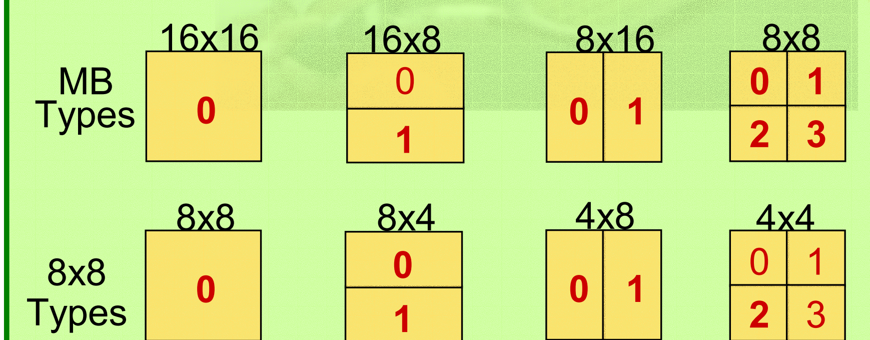
➔ Weak Motion Isolation !

MPEG-4
- 8x8 block size
- Square shapes
- ½ pel motion vector

➔ Moderate Motion Isolation !!

H.264
- 4x4 block size
- Arbitrary shapes
- ¼ pel motion vector

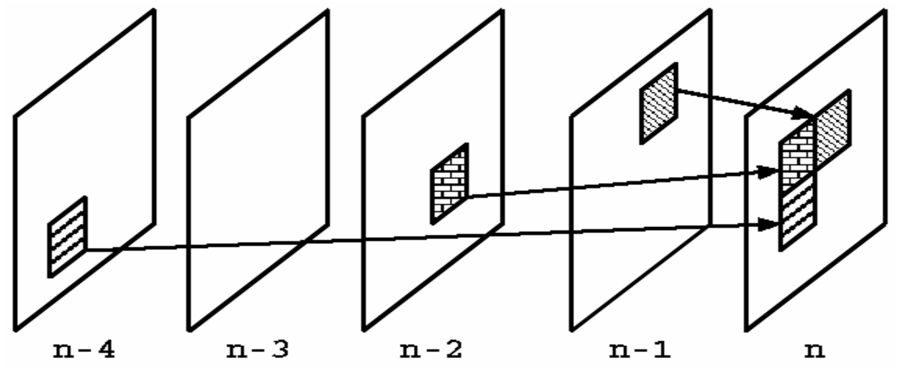
➔ Strong Motion Isolation !!!



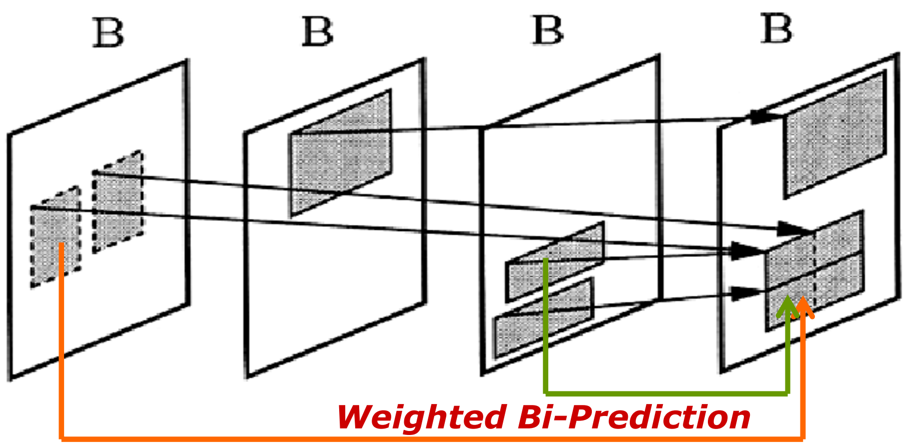
Motion vector accuracy ¼ pixel

H.264: Multiple Reference Frames

- **Per-MB reference control**

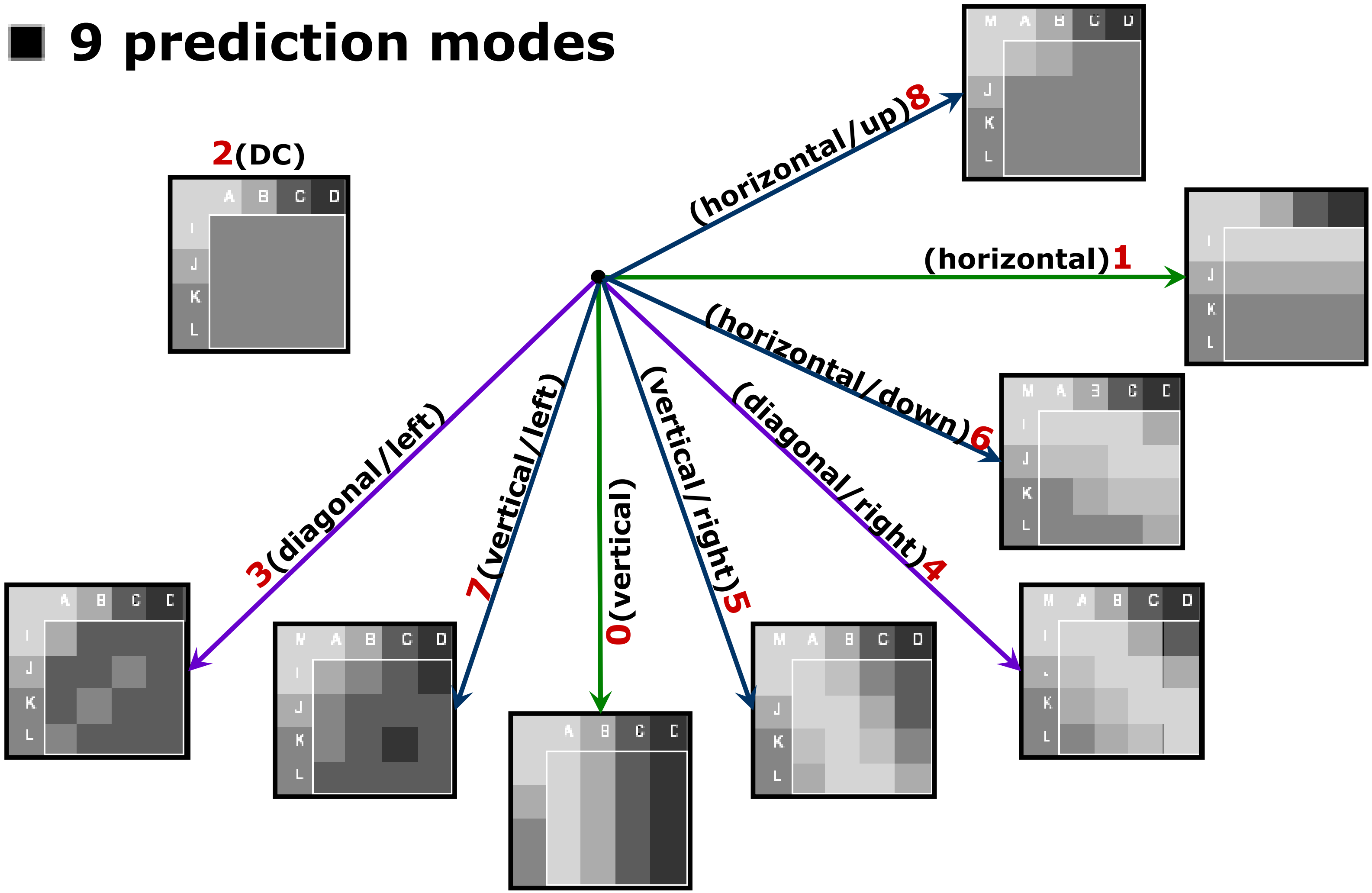


- **Generalized B(bi-predictive) picture**



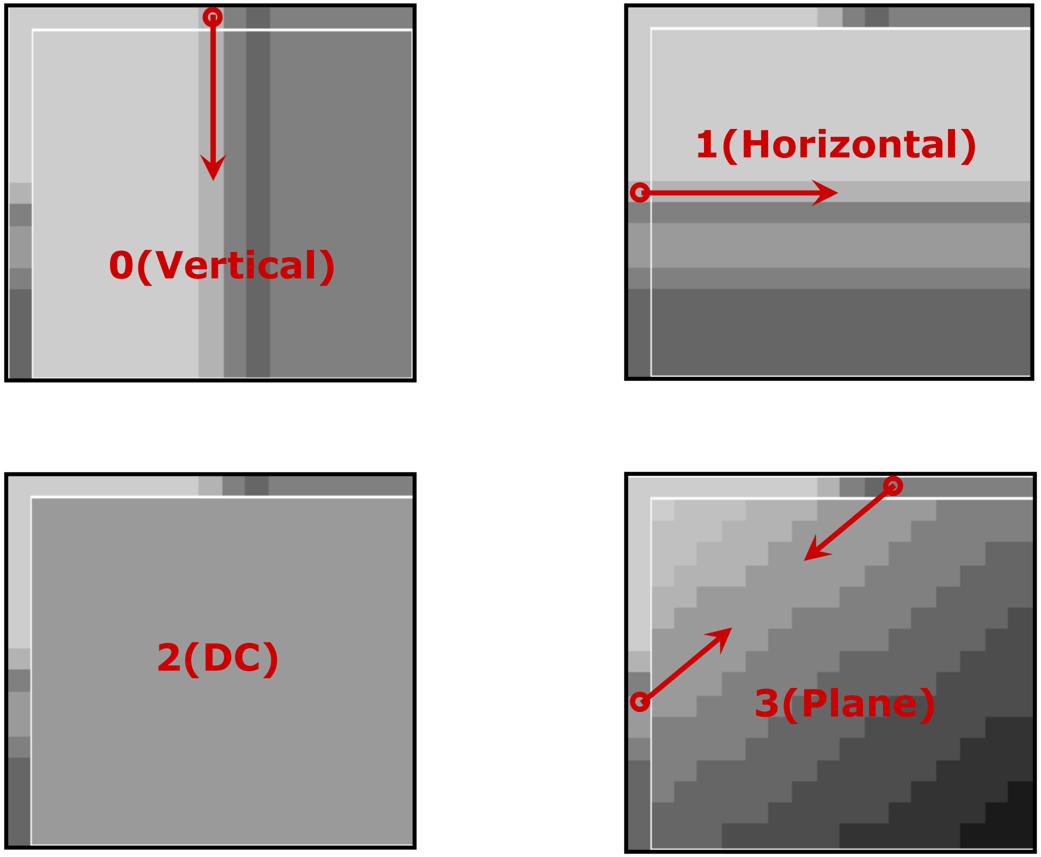
H.264: 4x4 Intra-Prediction

- 9 prediction modes



H.264: 16x16 Intra-Prediction

- 4 prediction modes



H.264: Transform

- EXACT MATCH Simplified Transform
  - **Based primarily on 4x4 transform**

4x4 DCT

$$H = \begin{bmatrix} a & a & a & a \\ b & c & -c & -b \\ a & -a & -a & a \\ c & -b & b & -c \end{bmatrix}$$

H.264

$$H = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 2 & 1 & -1 & -2 \\ 1 & -1 & -1 & 1 \\ 1 & -2 & 2 & -1 \end{bmatrix}$$

where $a = 1/2$, $b = \sqrt{1/2} \times \cos(\pi / 8)$,

and $c = \sqrt{1/2} \times \cos(3\pi / 8)$.

  - **Requires only 16 bit arithmetic (including intermediate values)**
  - **Expanded to 8x8 for chroma by 2x2 transform of the DC values**

AddPac Video Solution

H.264: Quantization

- Quantization of transform coefficients
  - **Logarithmic step size control**
  - **Extended range of step sizes**
  - **Smaller step size for chroma (cf. H.263 Annex T)**
  - **Table-driven (12.5%-increase in QStep per 1-QP increase) → 2-times in QStep for every 6th increment in QP**

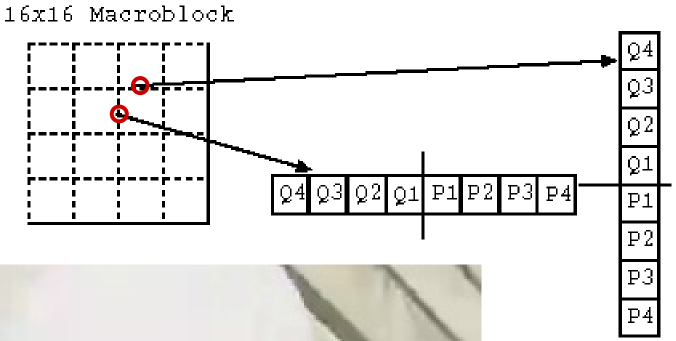
QP	0	1	2	3	4	5	6	7	8	9	10	11	12	…
qStep	*0.625*	*0.6875*	*0.8125*	*0.875*	*1*	*1.125*	*1.25*	*1.675*	*1.625*	*1.75*	*2*	*2.25*	*2.5*	*…*
QP	…	18	…	24	…	30	…	36	…	42	…	48	…	51
qStep	*…*	*5*	*…*	*10*	*…*	*20*	*…*	*40*	*…*	*80*	*…*	*160*	*…*	*224*

- ***Reconstruction is 16-bit multiply, add, shift***

- Actual definition is very complicated due to
  - **The non-orthonormality of the integer transform → position dependent scaling**
  - **Reconstruction simplicity**

H.264: In-loop Deblocking Filter

- Improves subjective visual quality
- Much better than post filtering
- Highly context adaptive



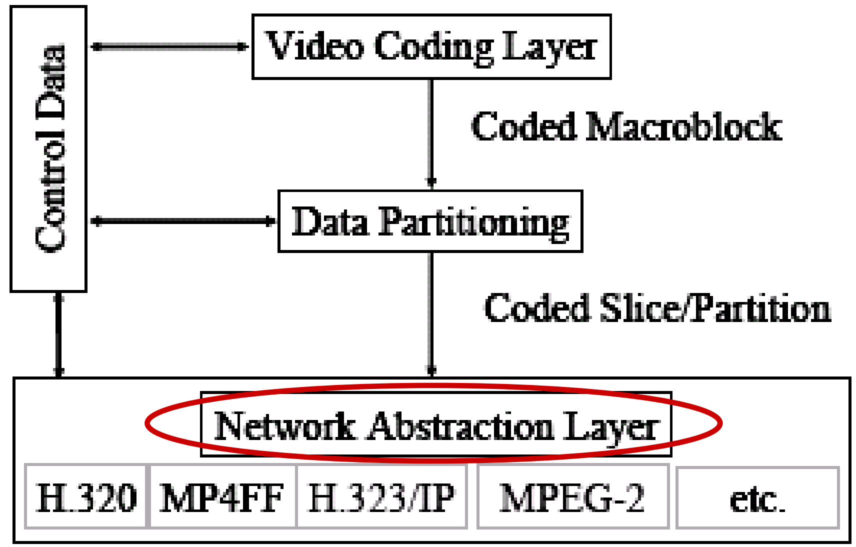
1) Without Filter

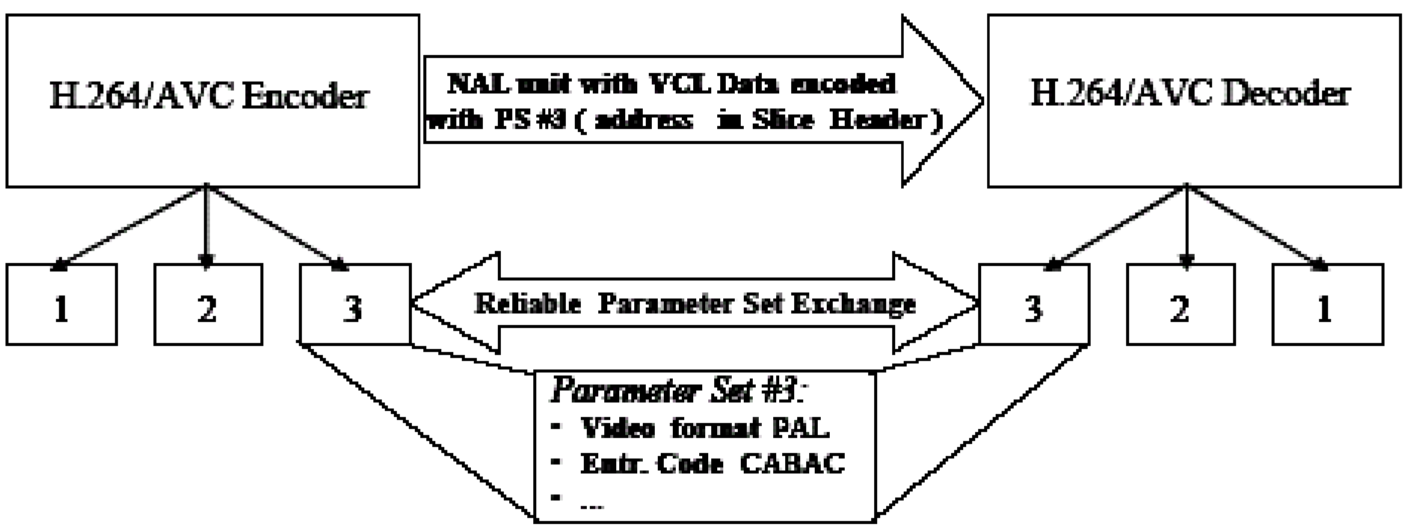
2) With H264/AVC Deblocking

H.264: Entropy Coding

- **Exp-Golomb Code**
  - Universally for all symbols except for transform coefficients
- **CAVLC** (Context adaptive VLC)
  - For transform coefficients
  - No end-of-block, but number of coefficients is decoded
  - Coefficients are scanned backwards
  - Contexts are built dependent on transform coefficients
- **CABAC** (Context-based binary arithmetic coding)
  - For transform coefficients
  - Usage of adaptive probability models for most symbols
  - Exploiting symbol correlations by using contexts
  - Average bit-rate saving over CAVLC 10-15%

H.264: Network Abstraction Layer (1)





H.264: Network Abstraction Layer (2)

- NAL unit: transport entity, e.g., contain one slice
- H.264/AVC standard defines a byte-stream format to transmit a sequence of NAL units as an ordered stream of bytes
- NAL unit boundaries need to be identified to obtain NAL units with correct size to guarantee integrity
- A byte-oriented HDLC-like framing including start codes (1or 2 bytes) and emulation prevention is specified
- For simplified gateway operation, the emulation prevention on byte basis is applied to all raw byte sequence payloads (RBSPs).
- MPEG-2 systems support!

Thank You !

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