Wireless Communication Systems
@CS.NCTU

Lecture 10: H.263 and H.263+

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Chap. 10.4 of "Fundamentals of Multimedia"
http://media.ee.ntu.edu.tw/courses/dvt/15F/

Outline

- **Introduction**
- Motion Compensation
- Optional modes
- H.263+

ITU-T Very Low Bit Rate Video Coding

- Developed for video conferencing on Public Switched Telephone Networks (**PSRN**)
- ITU-T SG15/LBC Near Term:
  - Started in Nov. 1993
  - Near-term: H.263: PSTN, 10 to 24 kb/s
  - Long-term: Joint work with MPEG-4, H.26L
- Optimized at bitrate < 22 kb/s (overall < 28.8 kb/s)
- Technical elements finalized in March 1995
- TMN5 (Test Model Near-term)
  - 3-4 dB higher PSNR than H.261 at < 64kb/s for all ITU test sequences
  - 30% saving compared with MPEG1 SM3 at 512 kb/s for "football" at CIF resolution

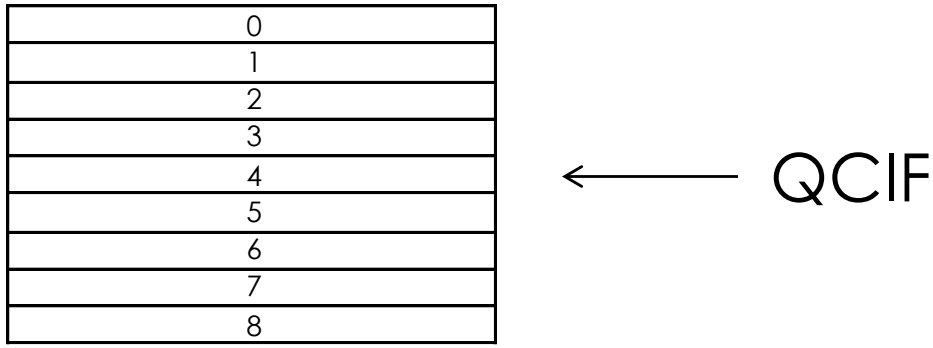
Video Formats in H.263

Video format	Luminance image resolution	Chroma image resolution	Bitrate (Mbps) for 30fps (uncompressed)	Bitrate (Kbps) for 30fps (compressed)
Sub-QCIF	128 x 96	64 x 48	4.4	64
QCIF	176 x 144	88 x 72	9.1	64
CIF	352 x 288	176 x 144	36.5	256
4CIF	704 x 576	352 x 288	146	512
16CIF	1408 x 1152	704 x 576	583.9	1024

- H.261 only supports QCIF and CIF

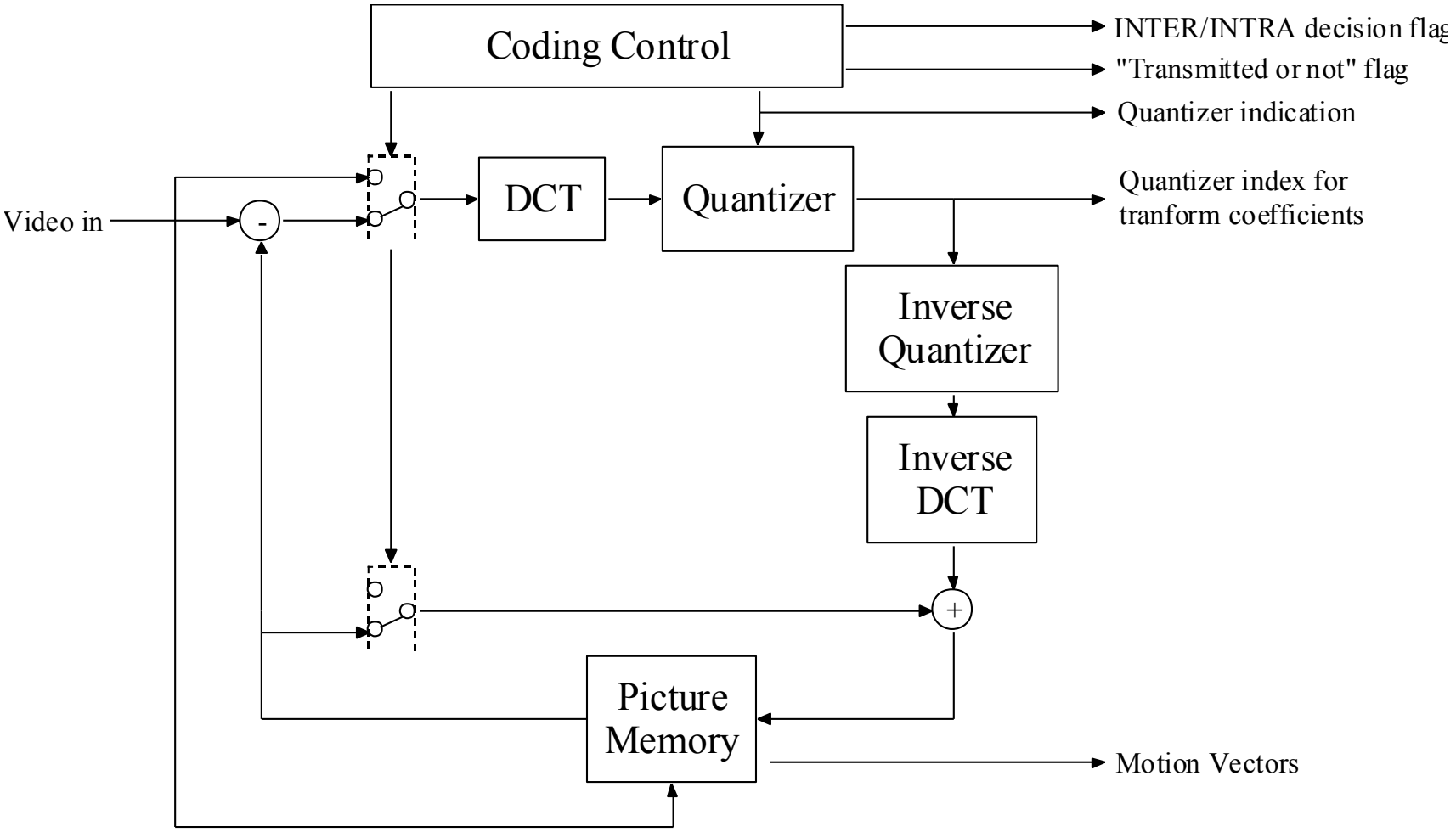
H.263: Syntax Structure

- Picture Layer
- Group-of-Block (GOB) Layer
  - A GOB comprises k*16 lines (k=1 for sub-QCIF, QCIF, and CIF; k=2 for 4CIF; k=4 for 16CIF)



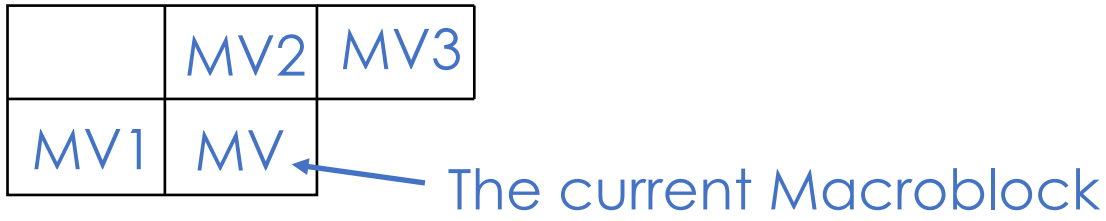
- Macroblock Layer:
  - A macroblock covers 16x16 luminance pixels area
  - Usually contains 6 blocks except for PB-frame mode (12 blocks instead)
- Block Layer: Each block contains 8x8 pixels

H.263 Video Encoder



Differences Between H.261 and H.263

- **Source Formats**: H.263 supports 5 while H.261 supports 2
- **Motion Compensation Accuracy**: Half-pixel accuracy (range -16 to 15.5) for H.263
- **Loop Filter**: None in H.263 while optional in H.261
- **Motion Vector Predictor**:
  - H.263 : Median value of the three candidate motion vectors (MV1-3)
  - H.261 : Motion vector of the preceding macroblock (MV1)



Differences Between H.261 and H.263

- Entropy Coding of DCT Coefficients:
  - H.263: (LAST, RUN, LEVEL)
  - H.261: (RUN, LEVEL) and EOB

- Four negotiable options:
  - Unrestricted Motion Vector
  - Advanced Prediction Mode
  - Syntax-based Arithmetic coding
  - PB-frame mode

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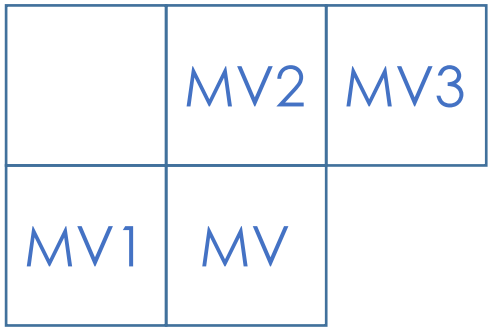
Motion Vector Prediction



- MV: current motion vector
- MV1: Previous motion vector
- MV2: Above motion vector
- MV3: Above right motion vector

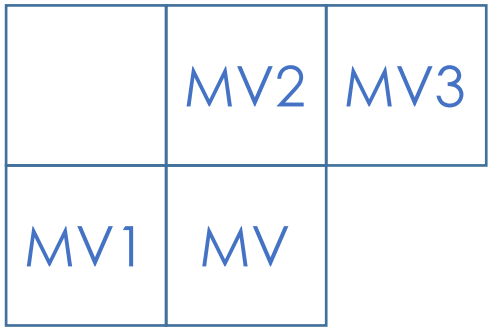
- Find difference motion vectors from the neighboring predictions
- Instead of coding the MV (u, v), the error vector (δu, δv) is coded
- How to find the error vector?

$$u_p = \text{median}(u_1, u_2, u_3)$$

$$v_p = \text{median}(v_1, v_2, v_3)$$

$$\Rightarrow (\delta u, \delta v) = (u - u_p, v - v_p)$$

Motion Vector Prediction



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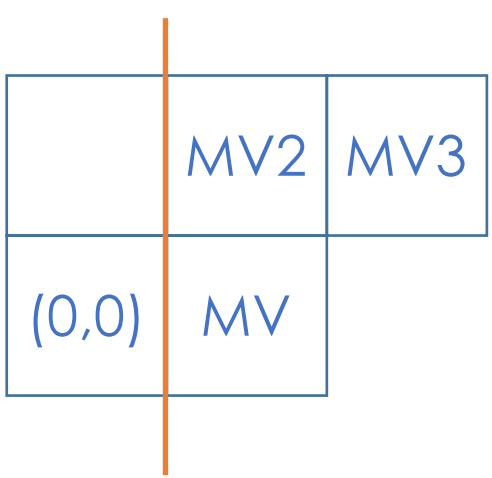
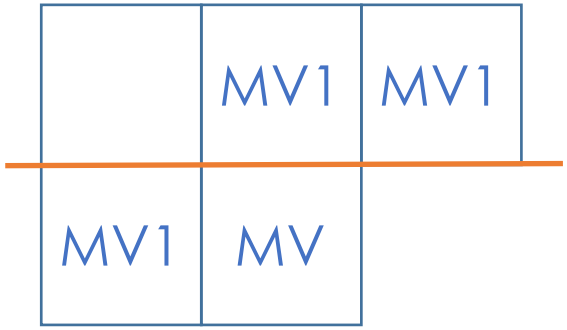
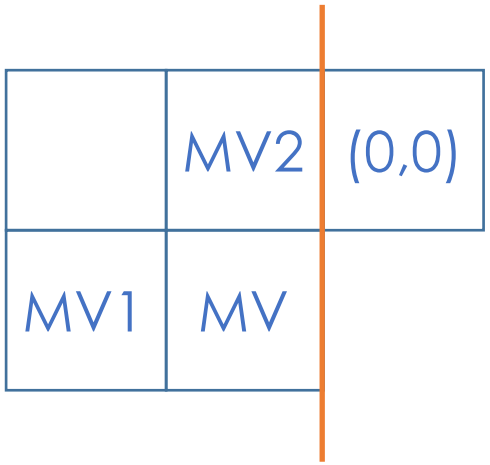


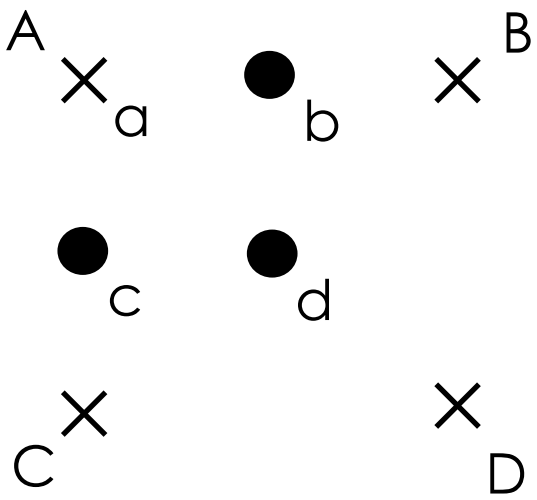




Picture of GoB border

Half-Pixel Prediction

- H.263 reduces prediction error by supporting **half-pixel prediction**
- Bilinear Interpolation
  - A and a: values at full-pixel positions and half-pixel position, respectively
  - searching range becomes [-16, 15.5]



× Integer pixel position
○ Half pixel position

a = A
b = (A + B + 1) / 2
c = (A + C + 1) / 2
d = (A + B + C + D + 2) / 4

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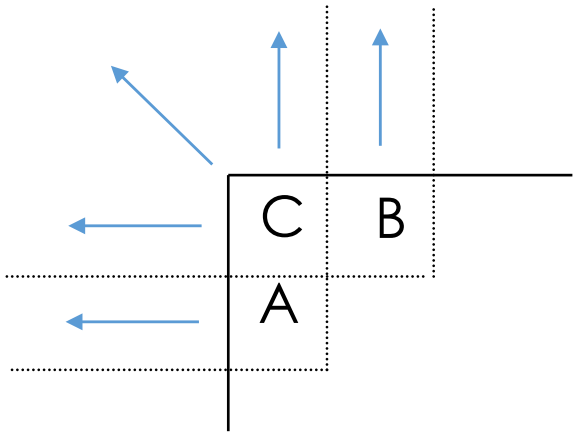
H.263 Optional Modes

- **Unrestricted Motion Vector Mode** (Annex D)
  - MVs are allowed to point outside (outside pixels obtained from boundary repetition extension)
  - Larger ranges: [-31.5, 31.5] instead of [-16, 15.5]
- **Syntax-Based Arithmetic Coding Mode** (Annex E)
  - Provide about 5% bit rate reduction and rarely used
- **Advanced Prediction Mode** (Annex F)
  - Allow 4 motion vectors per MB, one for each 8x8 block
  - Overlapped block motion compensation (OBMC) for luminance
  - Allow MVs point outside of picture
  - Reduce blocking artifacts and increase subjective picture quality
- **PB-Frames Mode** (Annex G) (similar to dual-prime motion estimation)
  - Double the frame rate without significant increase in bit rate

Unrestricted Motion Vector Mode

- Motion vectors are allowed to point outside the picture
  - Outside referenced pixels are extended from closest boundary pixels



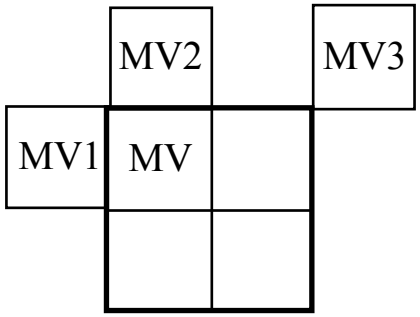
- Extended motion vector range from [-16, 15.5] to [-31.5, 31.5], with the following restrictions, depending on its predictor (P):
  - If 31.5 >= P >= 16.5, 31.5 >= MV >= 0
  - If 16 >= P >= -15.5, P + 15.5 >= MV >= -16 + P
  - If -16 >= P >= -31.5, 0 >= MV >= -31.5
  - Size of each MV stays the same

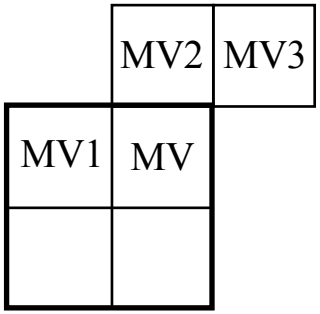
Syntax-based Arithmetic Coding Mode

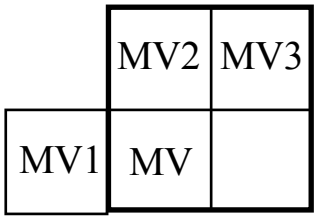
- Haffman coding encodes a symbol to a fixed, integral number of bits
- By using arithmetic coding, we can allow fractional number of bits
- In syntax-based arithmetic coding (SAC) mode, all variable-length coding operations are replaced with arithmetic coding

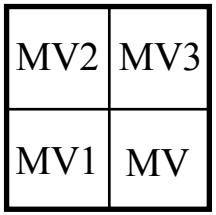
Advanced Prediction Mode

- Allow 4 motion vectors per MB (each block in MV has a motion vector)
  - Also calculate differential motion vector (DMV)
  - Motion vectors are differentially coded with a predictor as

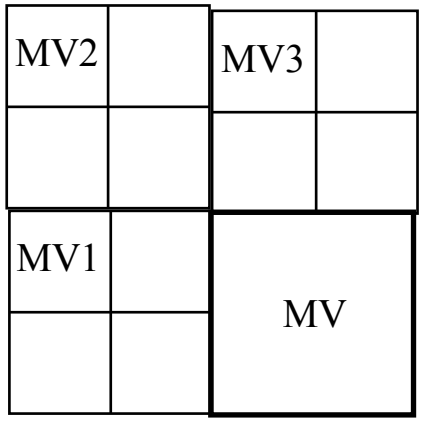








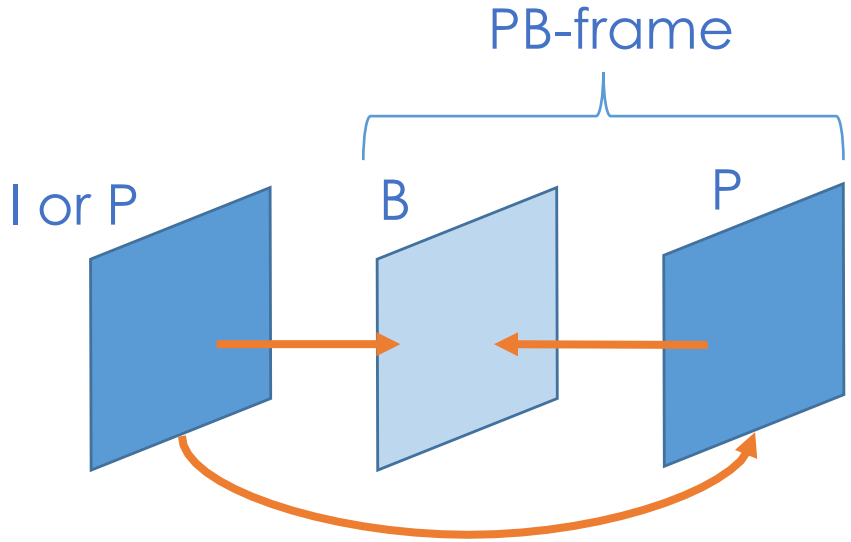
Median(MV1, MV2, MV3)



- More MV overhead but better prediction
- The chrominance MV is the sum of 4 MVs divided by 8

PB-Frames Mode

- A PB-frame consists of 2 pictures being coded as one unit

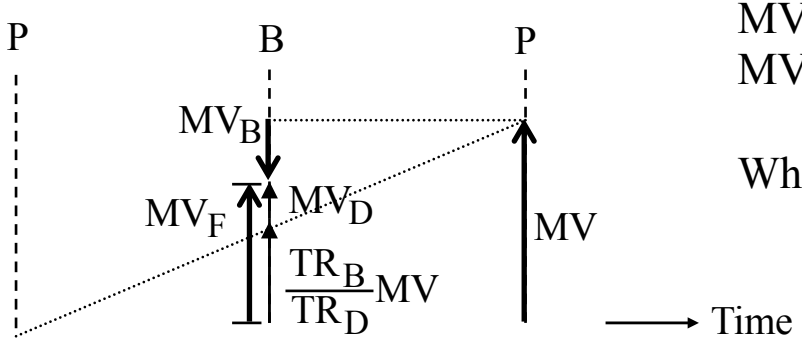


- In a PB-frame, a MB consists of 6 P-blocks and 6 B-blocks
- Double the frame rate but does not increase the data rate much

  → How? Leverage dual-prime prediction

PB-Frames Mode

- MV for the luminance P-block: same as usual
- MV for the luminance B-block: dual-prime prediction, which finds MV by interpolation and differential coding
  - difference is relatively small



$MV_F = (TR_B \times MV) / TR_D + MV_D$

$MV_B = ((TR_B - TR_D) \times MV) / TR_D$ if MV_D is equal to 0

$MV_B = MV_F - MV$ if MV_D is unequal to 0

Where MV: the motion vector for the P-block

MV_D: the delta motion vector given by MVDB

MV_F: forward motion vector (from previous P-picture)

MV_B: backward motion vector (from current P-picture)

TR_D: Temporal Reference Difference for the P-picture

TR_B: Temporal Reference for the B-picture

- For chrominance B-blocks, MV is the average of 4 MVs of the Y

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H.263+ Standard

- Official name: H.263 Version 2 approved in Jan. 1998
- Backward Compatible with H.263 Version 1: H.263 is one of many modes in H.263+
- Objectives:
  - Broaden the range of applications
  - Improve compression efficiency
- Custom Source Format (picture size, aspect ratio, clock frequency)
- Scalability
- Modified Unrestricted Motion Vector Mode
- 12 new optional modes

Some Important Options

- Refine the unrestricted motion vector mode
  - Use Reversible Variable Length Coding (RVLC) to encode the difference motion vectors for minimizing the impact of transmission error
  - Extend the range of MV to [-256, 256]
- The GOB layer is replaced by a *slice* structure
  - A slice contains a variable number of macroblocks
  - The shape of a slice is no need to be rectangular
- Implement *temporal*, *SNR* and *spatial* scalability
- Improve the PB-frame mode
  - B-frame does not have to be derived from the forward MV of P → Can be generated independently
- Apply deblocking filter in the coding loop
  - Reduce blocking effects to the edge boundaries

Difference between H.263 and H.263+

H.263	H.263+
Picture Size	
Sub-QCIF, QCIF, CIF, 4CIF, 16CIF	Sub-QCIF, QCIF, CIF, 4CIF, 16CIF, Custom Picture Size
Scalability	
Fix	Scalable (Temporal, SNR, Spatial)
Frame Format	
I, P, PB	I, P, PB, Improved PB, B, EI, EP
Frame Rate	
30 frames/second	15 ~ 1800 frames/second
Composition of Picture	
GOB	GOB, Slice
Macroblock Size	
16x16	16x16, 32x32
Block Size	
8x8	8x8, 16x16
Maximum Range of Motion Vector	
[-31.5, 31.5]	Unlimited