Video coding

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MPEG-1 : introduction

Motion Picture Expert Group

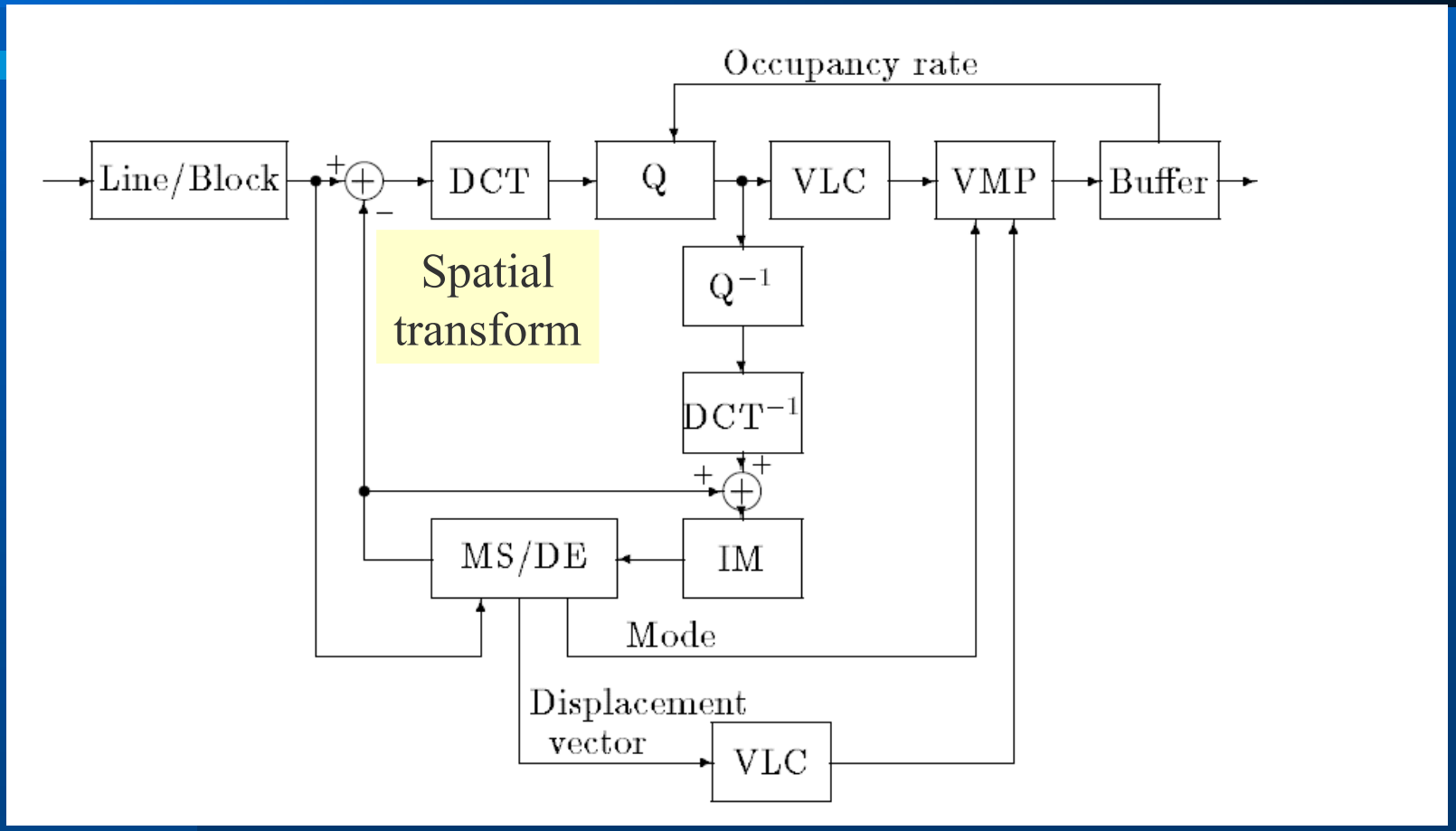
Publication 1990 (Intern. Standardization Organization)

CD-ROM, LAN, WAN, WWW

- **Related to : JPEG, H.261 (ISDN, p x 64 kbps)**
- **Video format : CIF (352** x 288 at 25 **fps)**

  Maximum resolution : 768 x 576 at 30 **fps**
- **YCbCr, 4:2:0** (chroma subsampling)
- **Bit rate (CIF) : 30.4 Mbps**
- **Compressed bit rate : 1.15 Mbps**
- **Low complexity decoder**

MPEG-1 : hybrid encoder

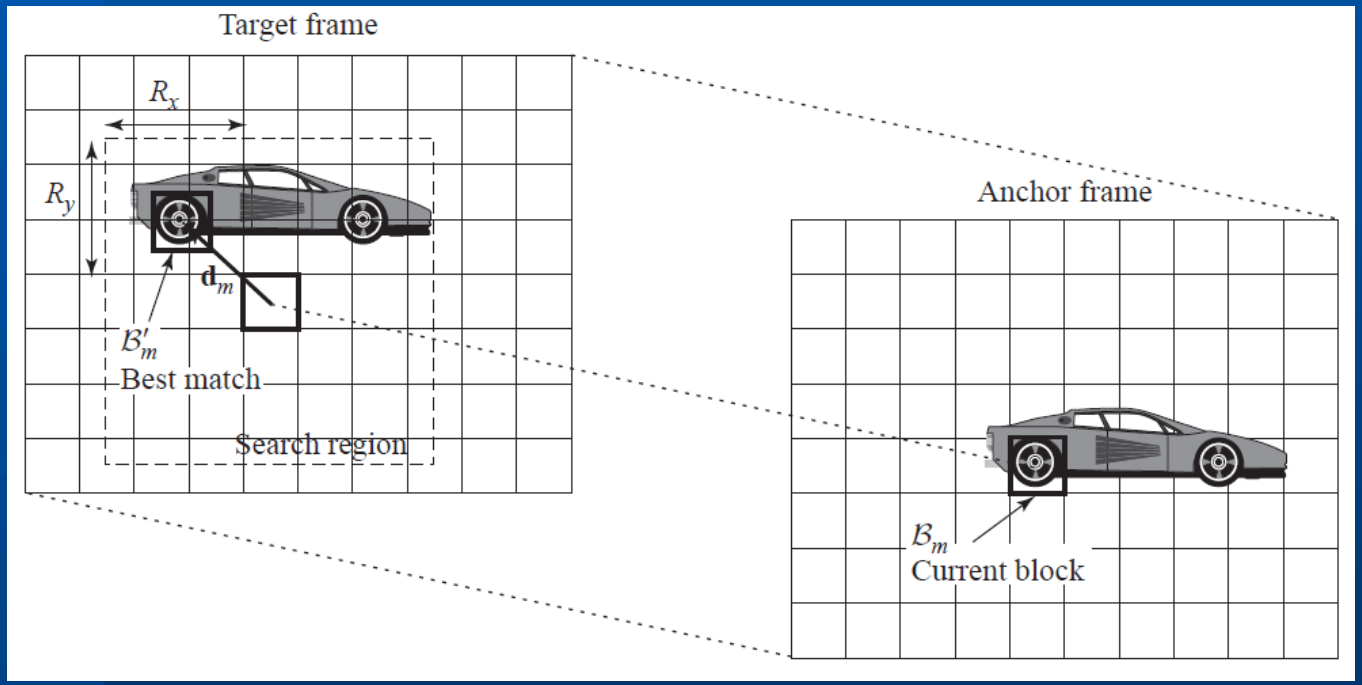


Spatial and temporal compression

Block matching

Translational motion

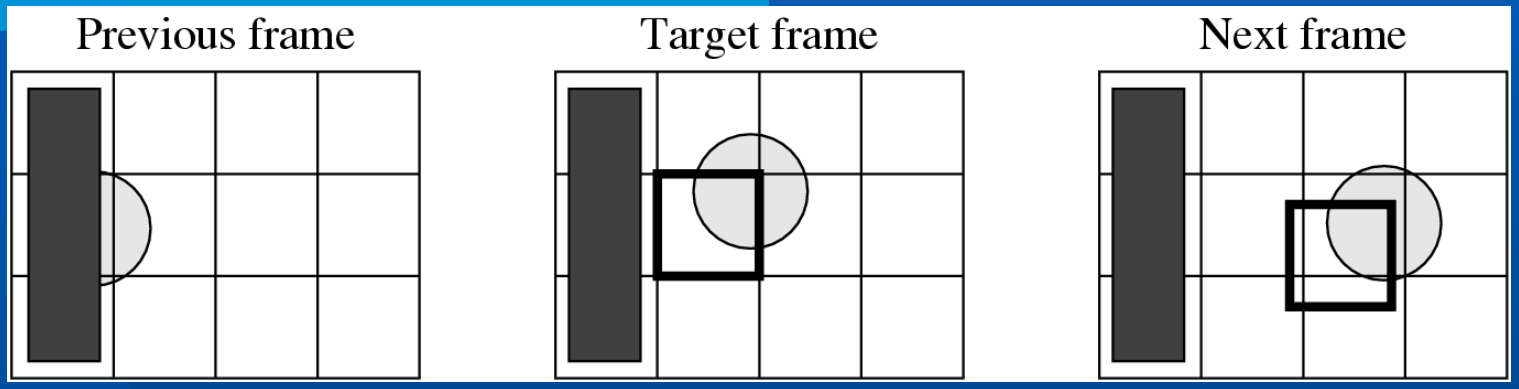
Minimum mean absolute difference



Block matching (exhaustive search)

```
BEGIN
   min_MAD = LARGE NUMBER;   /* Initialization */
   for i = -p to p {
       for j = -p to p {
           cur_MAD = MAD(i, j);
           if cur_MAD  <  min_MAD
           {
               min_MAD = cur_MAD;
               u = i; /* Get the coordinates for MV. */
               v = j;
           }}}
END
```

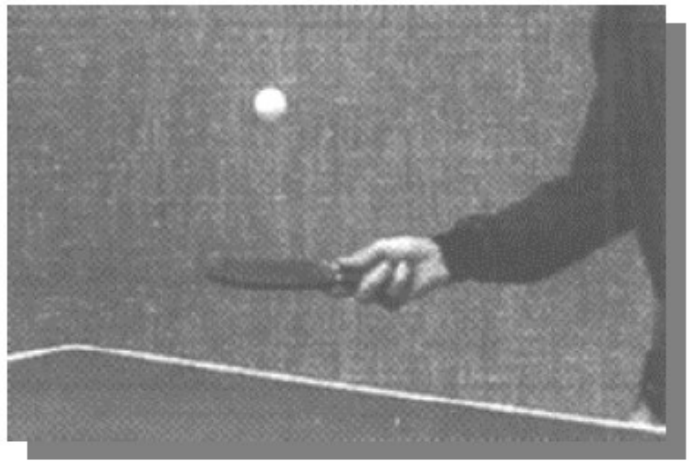
Bilateral block matching

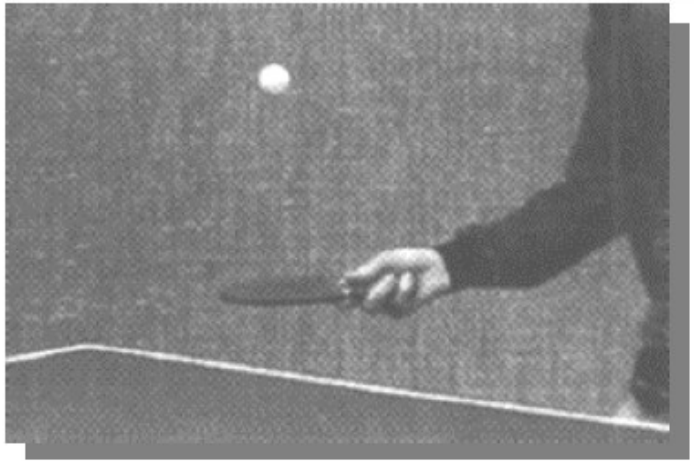


When the a bilateral matching is possible, linear interpolation

Otherwise, use the best prediction

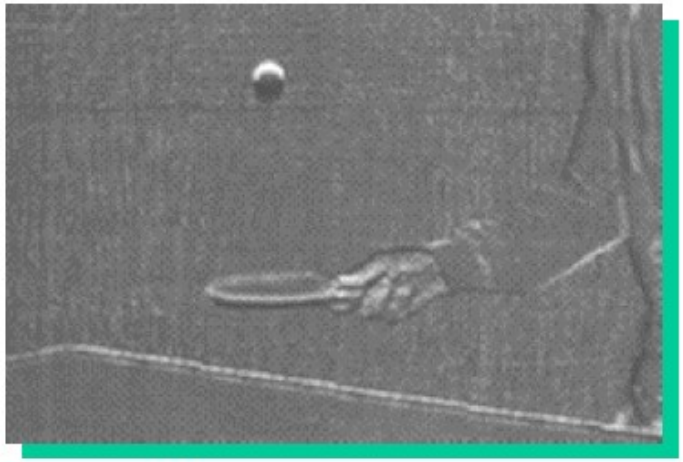
Motion compensation





Frame N

Frame N+1

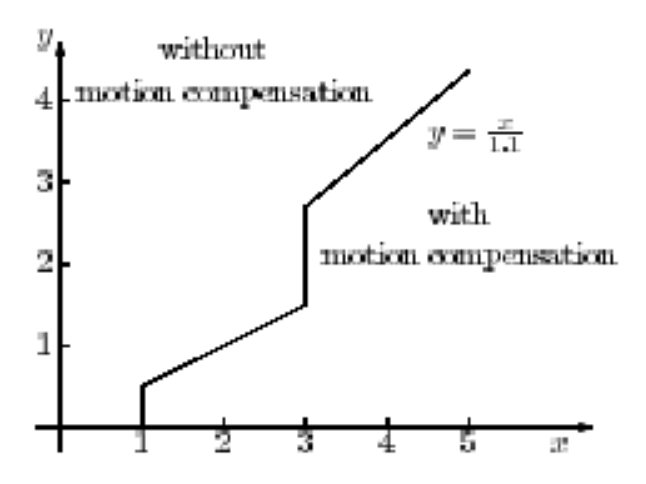


Difference Frame
Without Motion Prediction

Difference Frame
With Motion Prediction

MPEG-1 : motion compensation

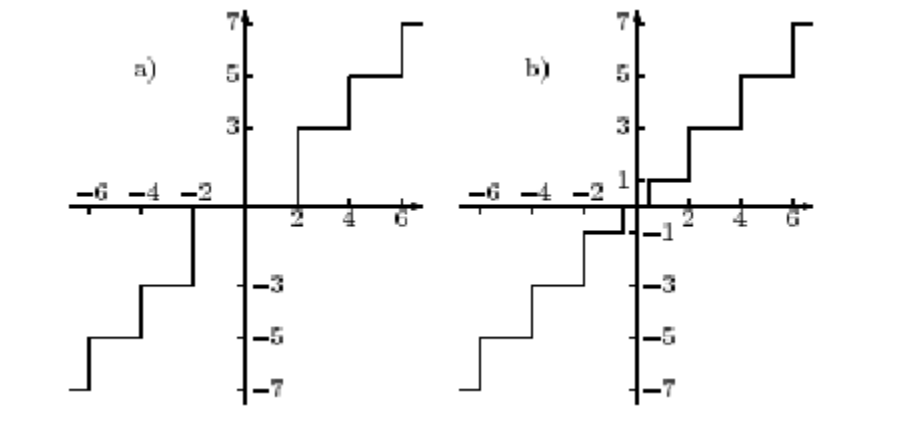
Motion vector estimation on macro-blocks (16 x 16)
½ pixel precision
Motion vectors : differential encoding (Huffman)
(often highly correlated)



average absolute difference
with or without
motion compensation

Predictive coding, if $\sigma_I > max(\sigma_p, 8)$

MPEG-1 : quantization



inter-frame intra-frame

DC coefficient in intra-frame mode : uniform, step = 8

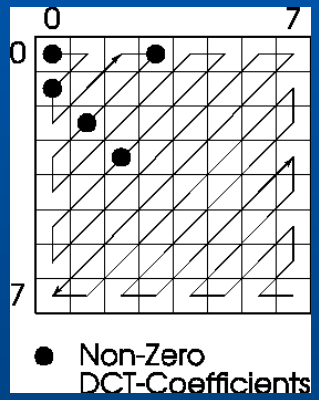
AC coefficients : uniform except ‘0’ zone

8	16	19	22	26	27	29	34
16	16	22	24	27	29	34	37
19	22	26	27	29	34	34	38
22	22	26	27	29	34	37	40
22	26	27	29	32	25	40	48
26	27	29	32	35	40	48	58
26	27	29	34	38	46	56	69
27	29	35	38	46	56	69	83

Visibility table (intra-frame)

MPEG-1 : encoder

DCT coefficients
Entropy coding (Huffman)
zigzag scanning :
('0' run length, non-zero coefficient)

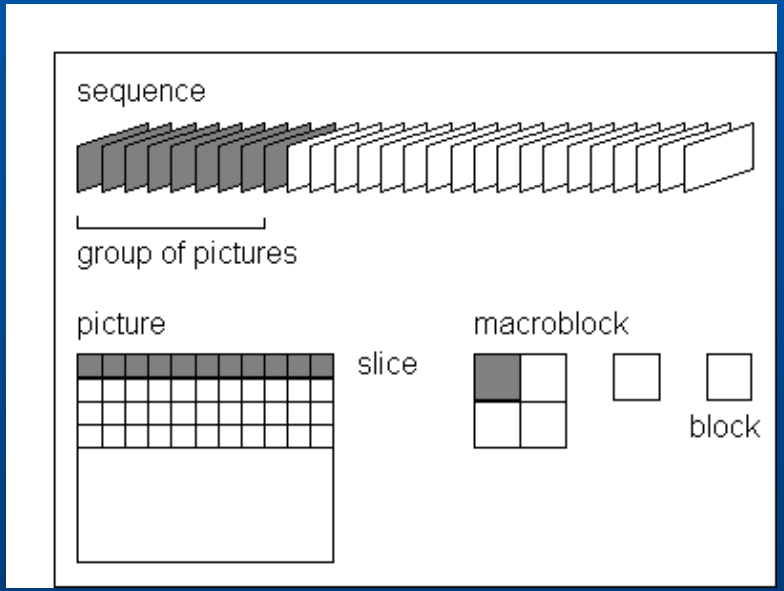


- **Mode : intra- or inter-frame,**
  motion compensation or no
- **MB : compensated or not**
- **Quantization step**

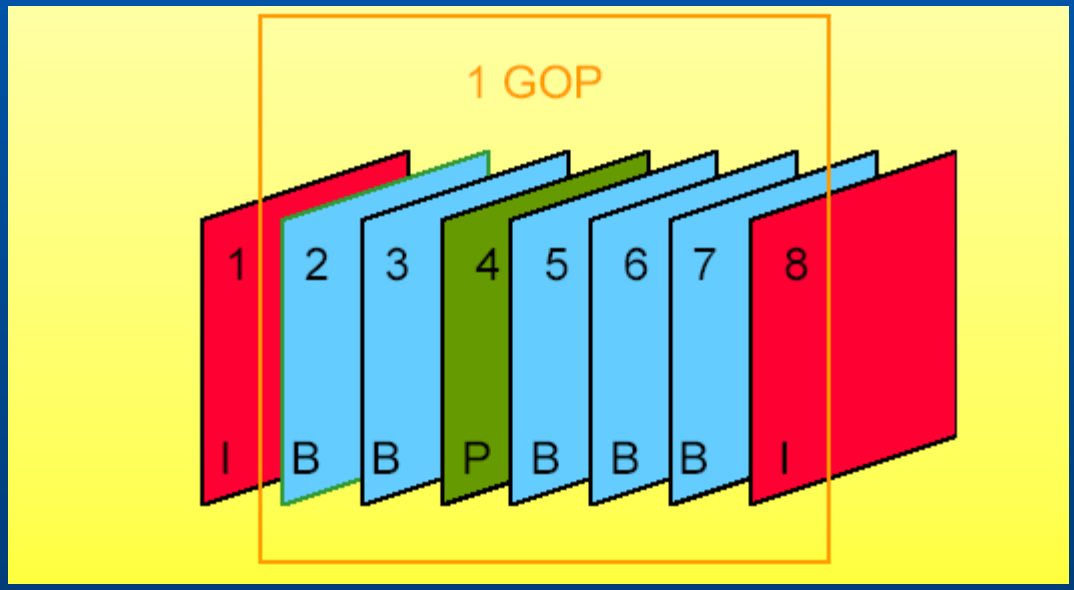
MPEG-1 : data structure

Data syntax :

- **image sequence**
  - **– content, features**
- **group of pictures (GOP) – random access**
- **image – synchronization,**
  - **image mode (D, I, P, B)**
- **slice – synchronization**
- **macro-block (MB, 16 x 16)**
  - **– compression mode,**
  - **compensation (F, B, A), static**
- **block (8 x 8)**
  - **– discrete cosine transform**



MPEG-1 : group of pictures (GoP)



Coding sequence : 1 4 2 3 8 5 6 7

MPEG-1 : performance

Type	Size	Compression
I	18kB	7:1
P	6kB	20:1
B	2.5kB	50:1
Avg	4.8kB	27:1

Z.-N. Li, M. Drew and J. Liu, *Fundamentals of multimedia*

MPEG-2 : introduction

Publication 1993 (Intern. Standardization Organization)

Digital television, satelite/cable television, video over Internet, VOD, HDTV, DVD

Based on : MPEG-1

Video format : CCIR-601

Bit rate (CCIR-601): 160 Mbps

Compressed bit rate : 4-15 Mbps

Low complexity decoder

MPEG-2 : profiles and levels

	Simple 4:2:0	Main 4:2:0	SNR scalable	Spatially scalable	High 4:2:0 ή 4:2:2
High (60 fps) 1920 x 1152		80 Mbit/s			100 Mbit/s
High-1440 (60 fps) 1440 x 1152		60 Mbit/s		60 Mbit/s για 3 στρώματα	80 Mbit/s
Main (30 fps) 720 x 576	15 Mbit/s	15 Mbit/s	15 Mbit/s για 2 στρώματα		20 Mbit/s
Low (30 fps) 352 x 288		4 Mbit/s	4 Mbit/s		

MPEG-2 : main profile

Level	Max. Resolution	Max fps	Max pixels/sec	Max coded Data Rate (Mbps)	Application
High	1920 × 1152	60	62.7×10^6	80	film production
High 1440	1440 × 1152	60	47.0×10^6	60	consumer HDTV
Main	720 × 576	30	10.4×10^6	15	Studio TV
Low	352 × 288	30	3.0×10^6	4	consumer tape equiv.

Z.-N. Li, M. Drew and J. Liu, *Fundamentals of multimedia*

MPEG-2 : scalabilities

MPEG-2 standard supports scalability to provide interoperability between different services and to support receivers with different display capabilities. Receivers not having the capability to reconstruct full resolution video can decode only a subset of the layered bitstream to reconstruct a reduced resolution video.

The bit-stream is organized into layers having two or three hierarchies. The bottom of the hierarchy contains base layer, which every receivers and every application must make use of. Above the base layer, enhancement layers exist, which will be used by high-end applications.

The scalability support is of particular interest for SDTV (Standard Definition Television) and HDTV applications. Instead of providing separate bitstreams for SDTV and HDTV, one common scalable bitstream is provided.

MPEG-2 : scalable schemes

Quality scalability. At the base-layer, the DCT coefficients are coarsely quantized to achieve moderate image quality at reduced bit rate. The enhancement layer encodes the difference between the nonquanitized DCT coefficients and the coarsely quantized coefficients from the base-layer with fine quantization step-sizes.

Spatial scalability. Spatial scalability is designed to support displays having different spatial resolution using one common layered bit-stream. This scheme best suits SDTV/HDTV applications. The base-layer encodes a spatially down-sampled video sequence and the enhancement layer encodes the extra information that would be necessary to support higher spatial resolution displays.

Temporal scalability. Temporal scalability is achieved by skipping certain fields/ frames at the baselayer. The skipped frames are then encoded at the enhancement layer.