TANDBERG Television

A Comparison of MPEG-2 Video, MPEG-4 AVC, and SMPTE VC-1 (Windows Media 9 Video)

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Terminology 101: Alphabet Soup

- **MPEG-2**
- **H.262**

The ubiquitous video codec standard used in digital television today – Terrestrial Broadcasting, Cable, DBS, DVD-V

- **MPEG-4 Part 2**
- **MPEG-4 SP/ASP**

A follow-on video codec standard – not widely used for DTV (*therefore not discussed further here!*)

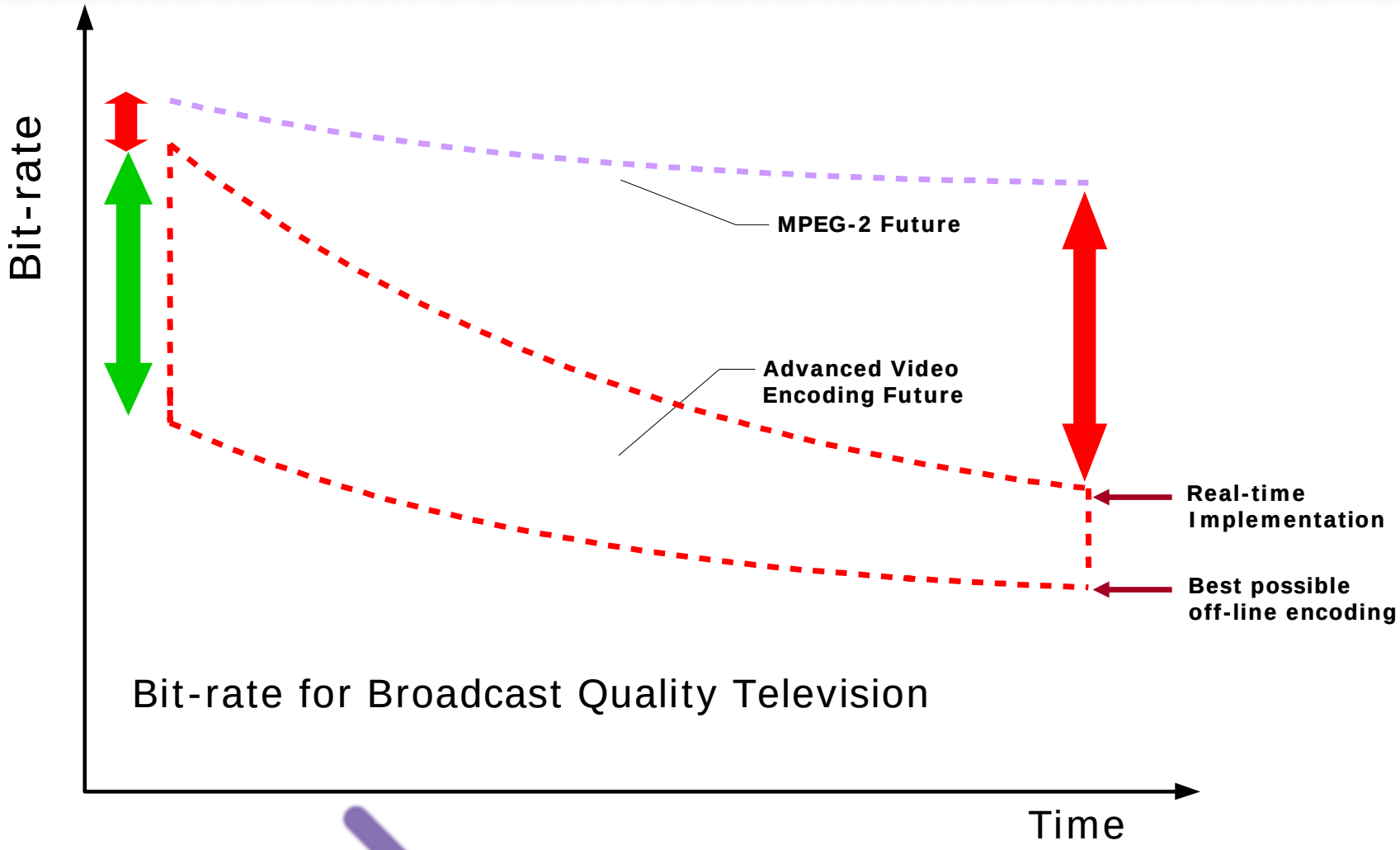
- **MPEG-4 Part 10**
- **MPEG-4 AVC**
- **H.264**
- **AVC**
- **"JVT"**

Advanced Video Codec (AVC) – A next generation video codec standard jointly developed by ISO/IEC MPEG and ITU-T VCEG

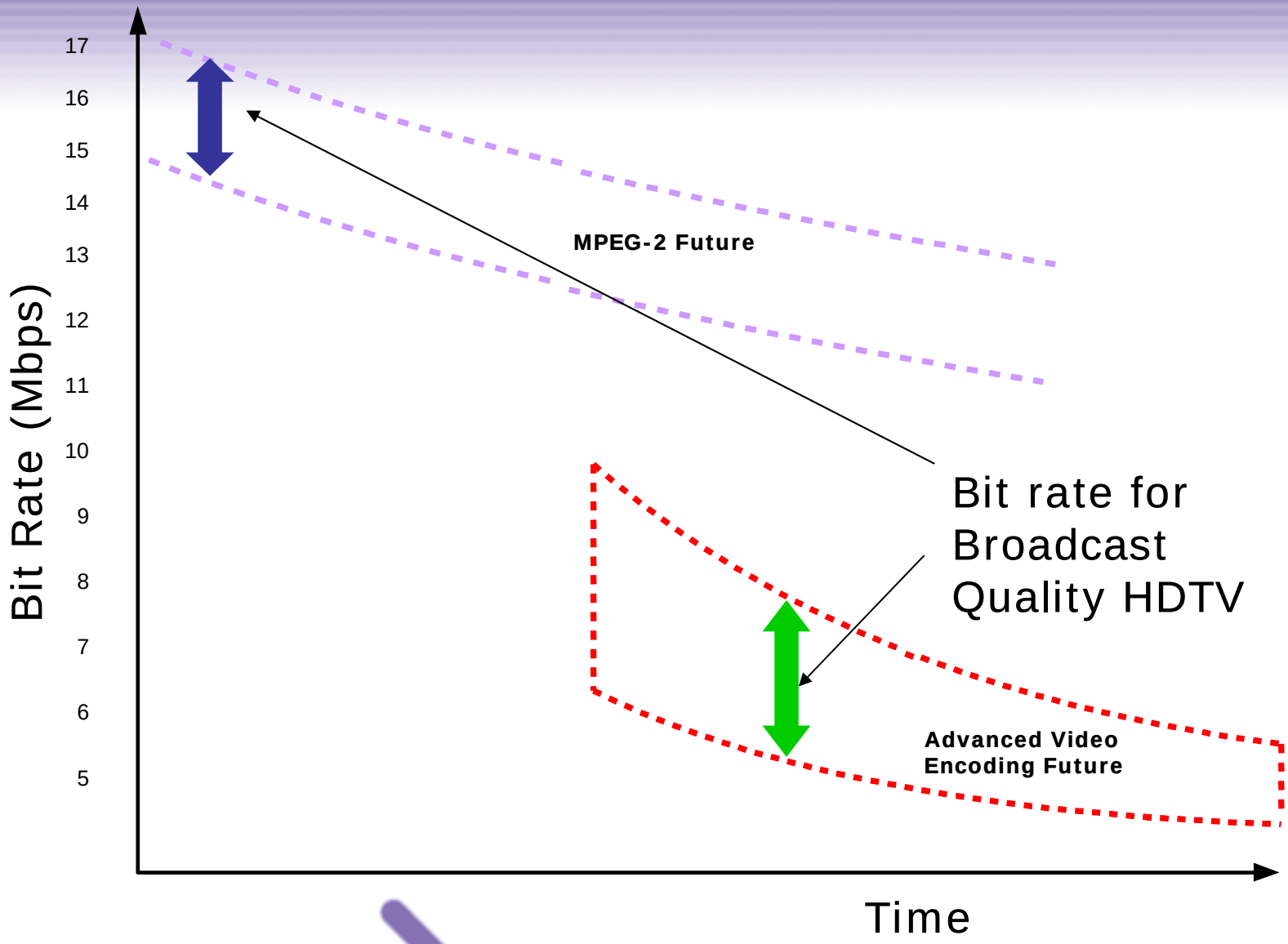
- **Windows Media 9 Video (WM9V)**
- **SMPTE VC-1**

A next generation video codec developed by Microsoft – now a proposed standard in The SMPTE

Real-time Encoding Performance



The HD Scenario



Applications → Video Profiles

Application	*MPEG-2 Video (H.262)*	*MPEG-4 AVC (H.264)*	*Windows Media™ 9 Video (SMPTE VC-1)*
Mobile Devices Video Conferencing Internet Streaming	-	Baseline	Simple
Broadcast Quality (TV, Cinema, etc.) to Progressive display devices	Main	Main	Main
Broadcast Quality (TV, Cinema, etc.), Progressive or Interlace		High	Advanced

The “Philosophy” of Engineering

- Computational complexity
  - A key factor in determining the technical success or failure of a codec
- What is “Quality”?
  - Impact of objective (rate-distortion curve) vs. subjective observations
- Tool and algorithm choices
  - Need to be taken as a whole, not individually
  - Optimizing for one content selection vs. being efficient for a wide range
- Bit rates are lower …
  - Traditional tool selection & optimization knowledge may not translate directly
- Theory vs. practice: Analogous issues apply
  - Differences in implementations of AVC and VC-1 vary more than differences in the algorithms themselves

Design Approaches

- **WM9V/VC-1**: Lower computational complexity, without “significant” performance loss
- **MPEG-4 AVC**: The most complex within “reason of practicality”
- Which approach is better?
  - “Decision by committee” vs. single-minded focus?
  - More diverse knowledge base vs. internally limited?
  - Issues other than technology – *not discussed here!*

Comparison of Tools (1)

Tool	*MPEG-2 Video (H.262)*	*MPEG-4 AVC (H.264)*	*Windows Media™ 9 Video (SMPTE VC-1)*
Intra Prediction	-None: MB encoded -DC predictors	- 4x4 Spatial - 16x16 Spatial - I_PCM	- Frequency domain Coefficient
Picture Coding Type	- Frame - Field - Picture AFF	- Frame - Field - Picture AFF - MB AFF	- Frame - Field - Progressive - Picture AFF
Motion Compensation Block Size	- 16x16 - 16x8, 8x16	- 16x16 - 16x8, 8x16 - 8x8 - 8x4, 4x8 - 4x4	- 16x16 - 16x8, 8x16 - 8x8 - 8x4, 4x8 - 4x4

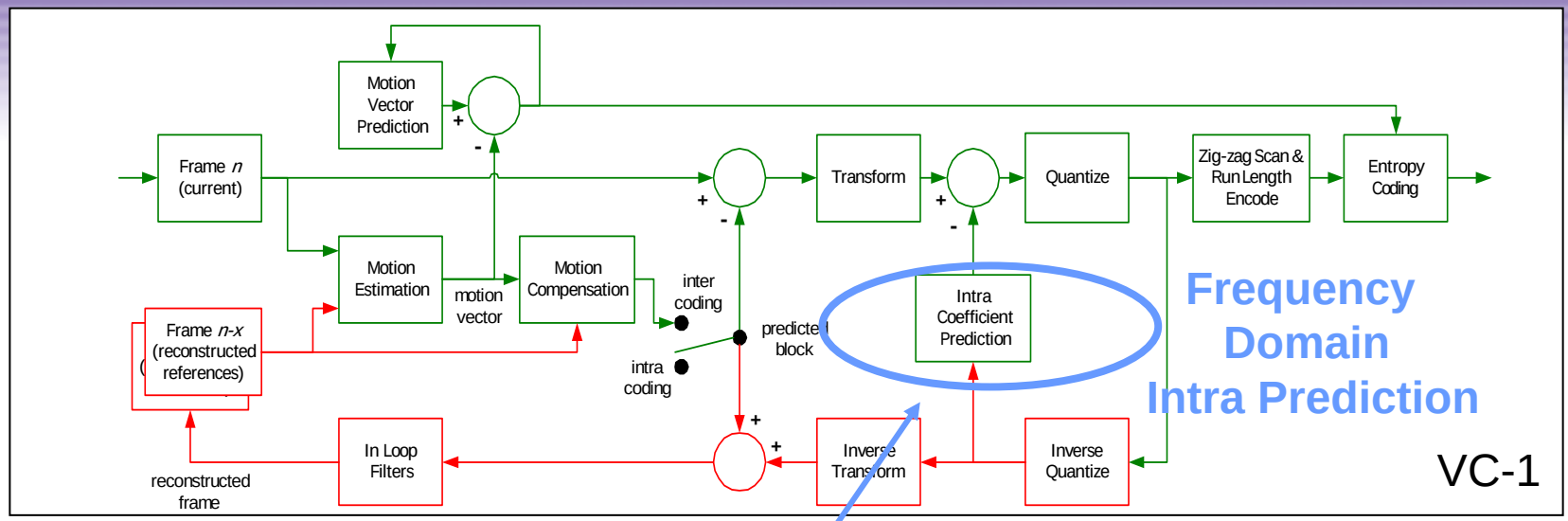
Comparison of Tools (2)

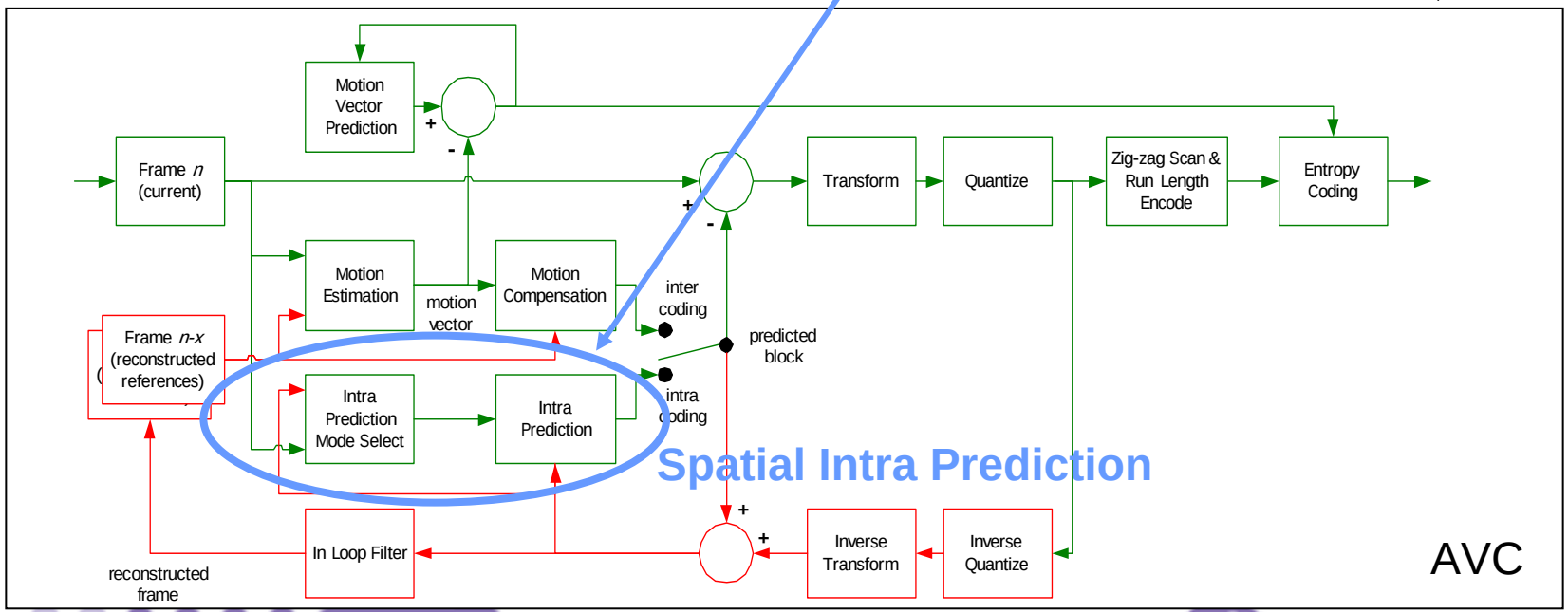
Tool	*MPEG-2 Video (H.262)*	*MPEG-4 AVC (H.264)*	*Windows Media™ 9 Video (SMPTE VC-1)*
Motion Vector Precision	- Full Pel - Half Pel	- Full Pel - Half Pel - Quarter Pel	- Full Pel - Half Pel - Quarter Pel
P Frame Feature	- Single Reference	- Single Reference - Multiple Reference	- Single Reference
B Frame Feature	- 1 Reference Each Way	- 1 Reference Each Way - Multiple Reference - Direct & Spatial Direct Modes - Weighted Prediction	- 1 Reference Each Way

Comparison of Tools (3)

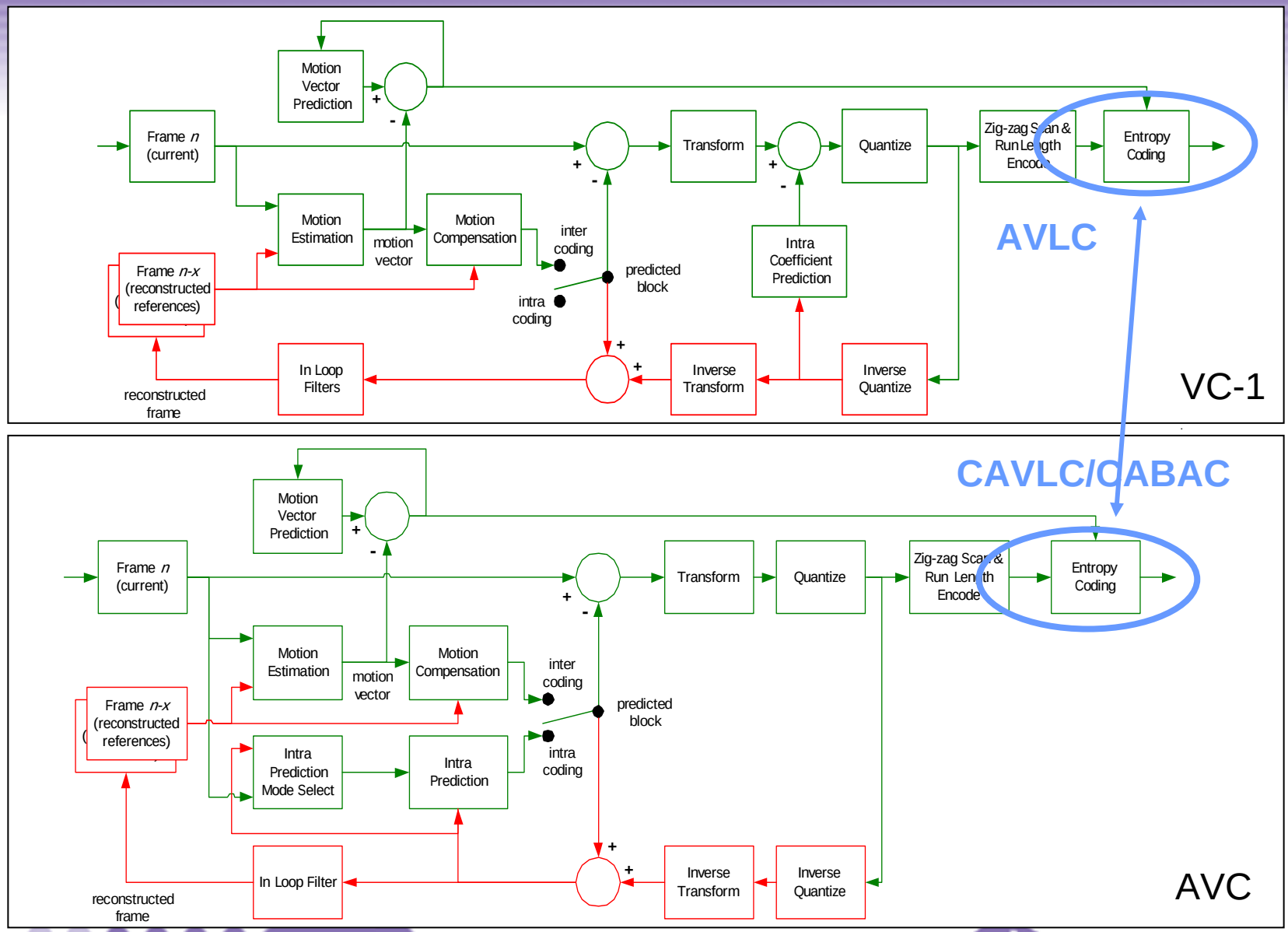
Tool	*MPEG-2 Video (H.262)*	*MPEG-4 AVC (H.264)*	*Windows Media™ 9 Video (SMPTE VC-1)*
In-Loop Filters	- None	- De-Blocking	- De-Blocking - Overlap Transform
Entropy Coding	- VLC	- CAVLC - CABAC	- Adaptive VLC
Transform	- 8x8 DCT	- 4x4 Integer “DCT” - 8x8 Integer “DCT”	- 4x4 Integer “DCT” - 8x4,4x8 Int “DCT” - 8x8 Integer “DCT”
Other	- Quantization Scaling Matrices	- Quantization Scaling Matrices	- Range Reduction - In-Stream Post Processing Control

WM9V/VC-1 & MPEG-4 AVC Differences

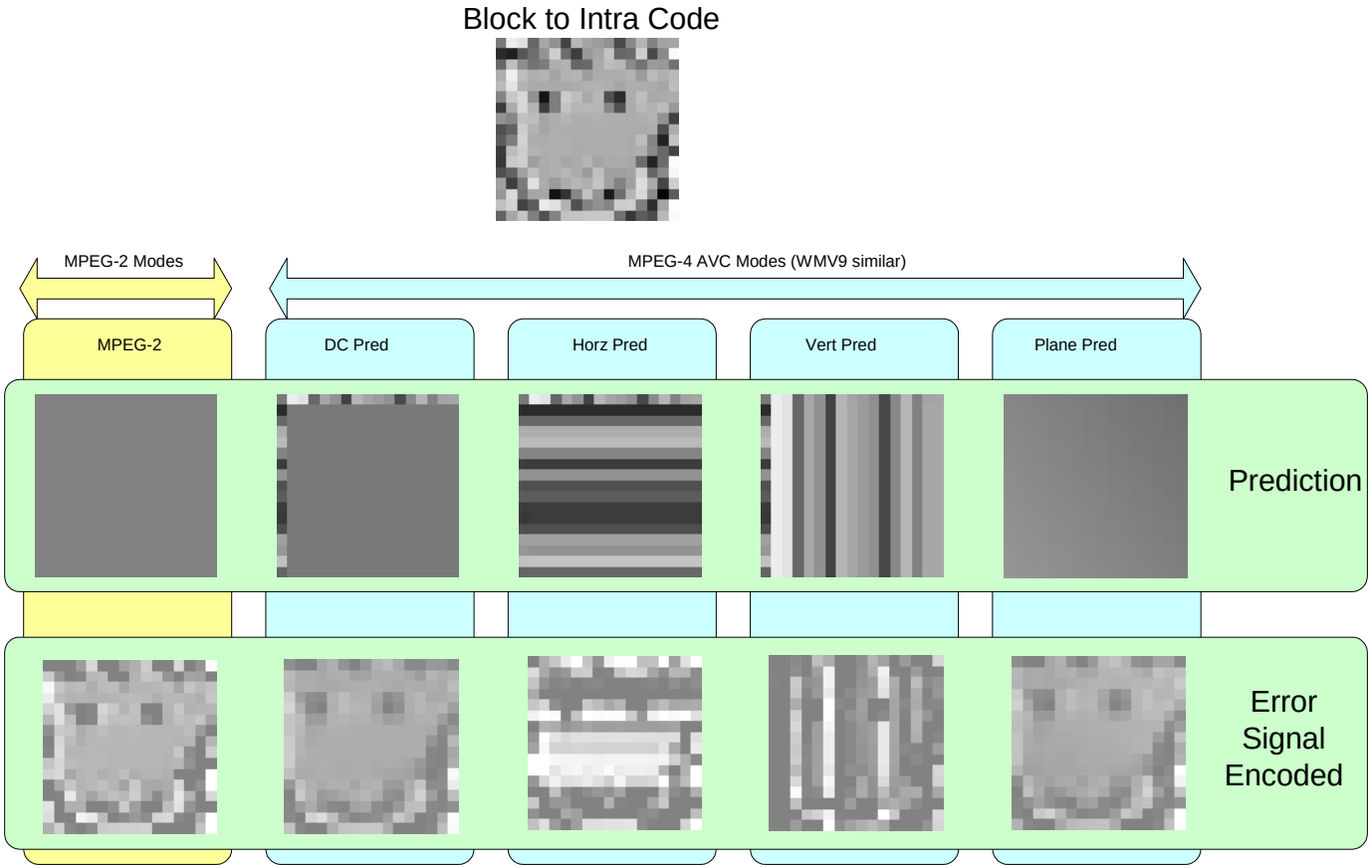




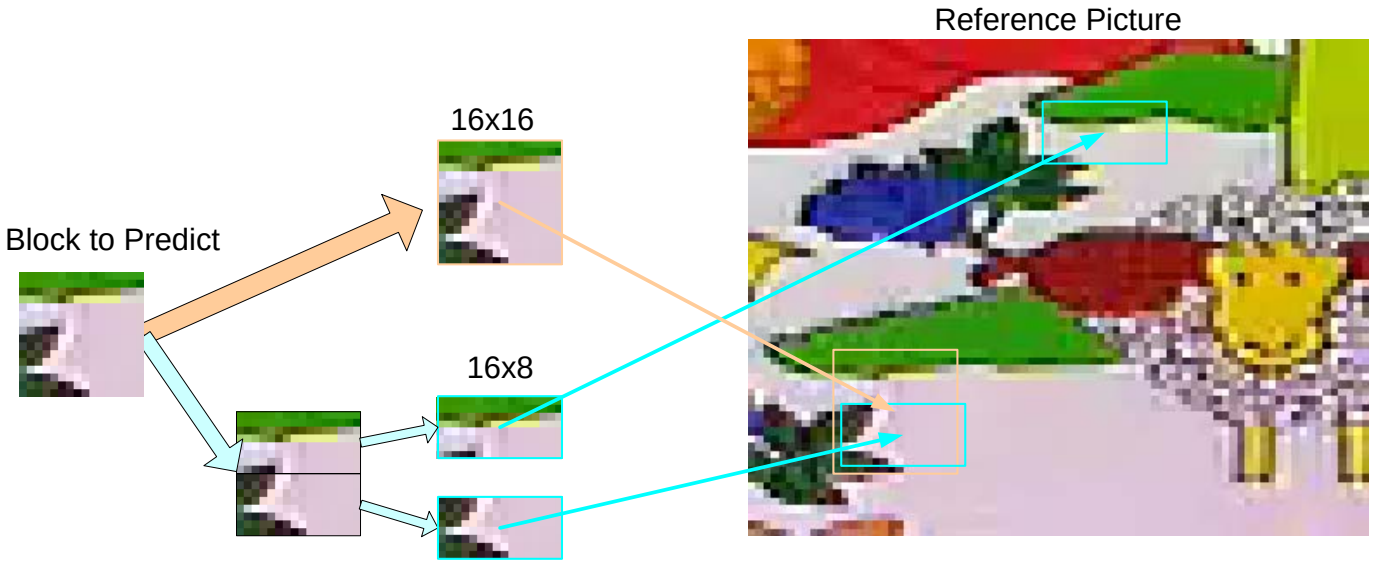
WM9V/VC-1 & MPEG-4 AVC Differences



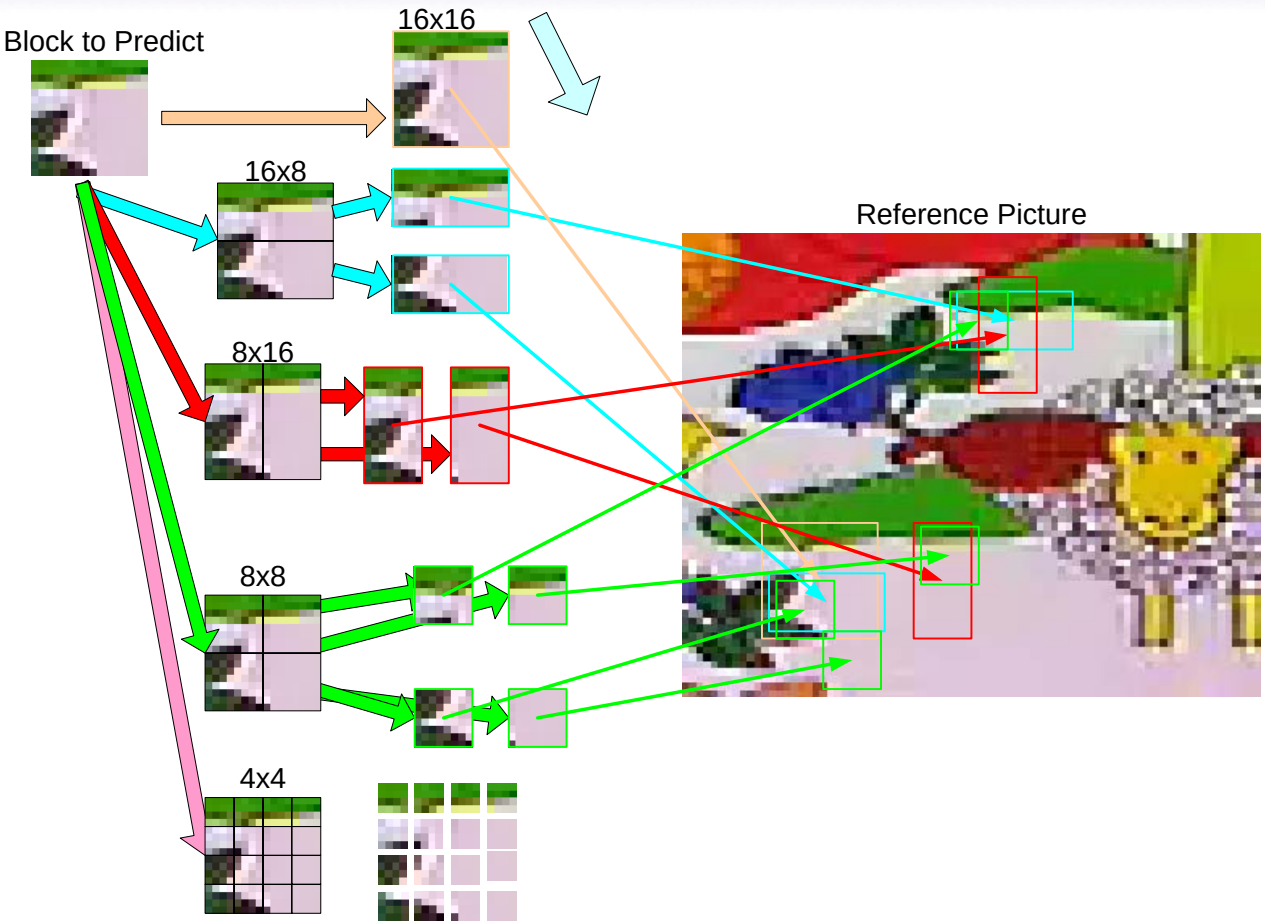
MPEG-2 vs. AVC/VC-1: Intra Prediction Modes



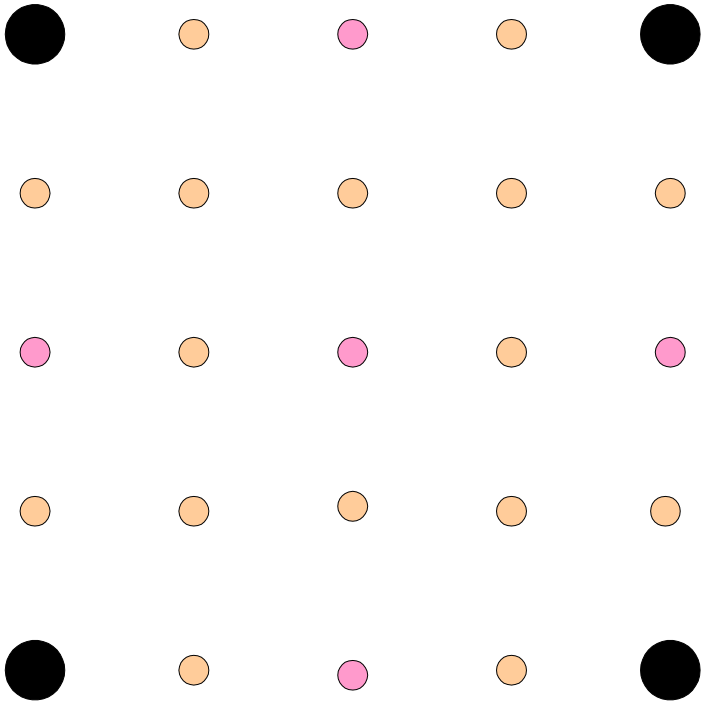
MPEG-2: Inter Prediction Modes



AVC/VC-1: Inter Prediction Modes



MPEG-2 vs. AVC/VC-1: Quarter Pel Motion-Compensation



Motion Comp Options

- Integer Pixels
- Half pel (MPEG-2)
- Quarter pel (AVC/VC-1)

MPEG-2 vs. AVC/VC-1: In-Loop De-Blocking Filter

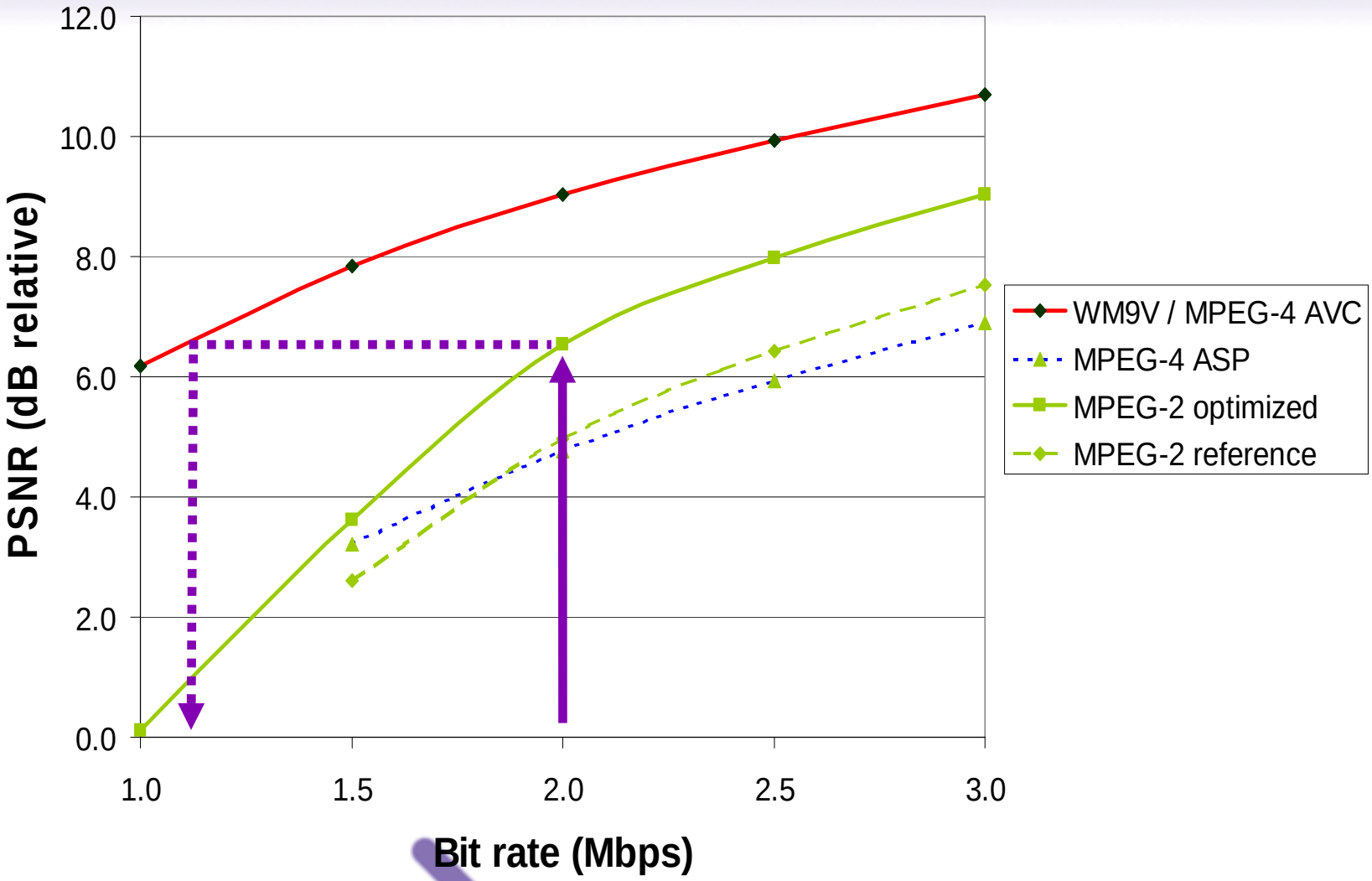
Without In-Loop Filter (MPEG-2)

With In-Loop Filter (AVC/WM9V)

Picture taken from www.codex.com

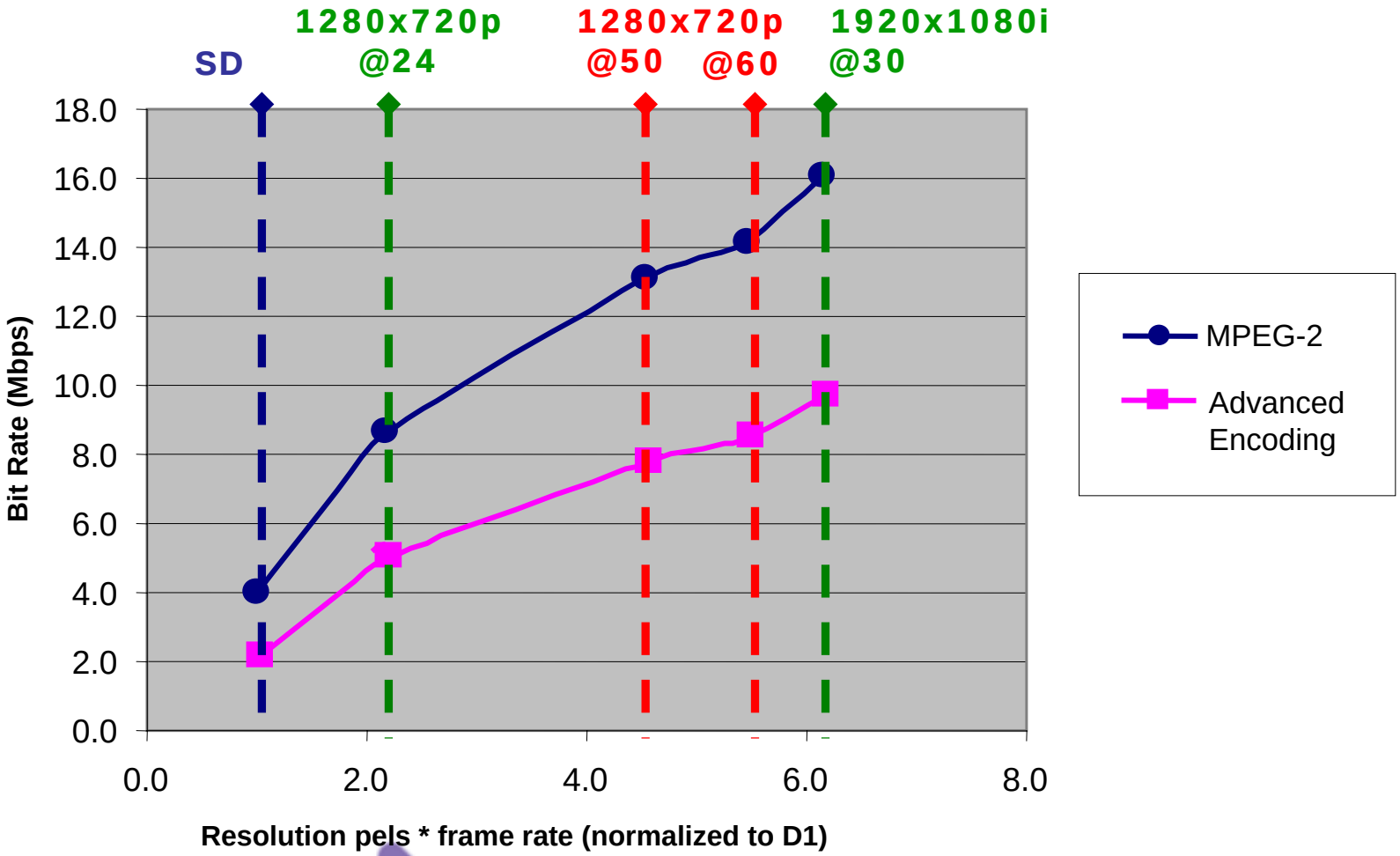
Performance Comparison

Example: Soccer at full ITU-R 601 resolution



HD Resolutions and Frame Rates

Example video bit-rate requirements (today)



In summary

- MPEG-4 AVC and WM9V/VC-1 have the potential for >2x compression efficiency over MPEG-2 Video
  - Good results so far
  - “Learning” and optimizations on-going (just like MPEG-2 in the “early days”)
- MPEG-4 AVC and WM9V/VC-1 real-time broadcast-quality SD/HD encoders are available now
- Which codec performs better?
  - Depends on the content and the implementation
  - “Let the games begin!”