H.264/MPEG-4 AVC
(Advanced Video Coding)
Decoder Design
H.264/AVC

◆ H.264, a.k.a. MPEG-4 Part 10, is a digital video codec standard written by the ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group (MPEG) as the product of a collective partnership effort known as the Joint Video Team (JVT).

◆ The ITU-T H.264 standard and the ISO/IEC MPEG-4 Part 10 standard (formally, ISO/IEC 14496-10) are technically identical, and the technology is also known as AVC, for Advanced Video Coding.

◆ Goals:
  
  good video quality at bit rates that are substantially lower (e.g., half or less) than what previous standards without excessive complexity
  
  applied to a very wide variety of applications (e.g., for both low and high bit rates, and low and high resolution video) and
  
  to work well on a very wide variety of networks and systems (e.g., for broadcast, DVD storage, RTP/IP packet networks, and ITU-T multimedia telephony systems).
Video CODEC is a mixture of algorithmic tools

- Tool 1 – Intra frames
- Tool 2 – Motion estimation
- Tool 3 – Search strategies
- Tool 4 – Block Matching
- Tool 5 – B frames
- Tool 6 - Transformation
- Tool 7 - Quantization
- Tool 8 – Entropy coding
- Tool 9 – Deblocking filter
Profiles

Profile: a set of coding tools or algorithms
(EX) Baseline decoder

Level: a degree of capability
(EX) Resolution or speed of decoding
## Coding Tools in Profiles

<table>
<thead>
<tr>
<th>Tools/Profiles</th>
<th>Baseline</th>
<th>Main</th>
<th>Extended</th>
<th>High</th>
<th>High 10</th>
<th>High 4:2:2</th>
<th>High 4:4:4</th>
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Encoding Block Diagram
Encoding flow chart

**Input Frame Fn**

**Each MB**

**Intra**

T/Q -> X : Coefficient

Q⁻¹/T⁻¹ : uF'ₙ (P MB)

Deblocking Filter

F’ₙ (Reconstructed MBs)

**Inter**

**ME : MVs**

**MC : MC MB (P MB)**

Dₙ : Current - P

T/Q -> X : Coefficient

Q⁻¹/T⁻¹ : D'_ₙ

P + D'_ₙ = uF’ₙ

Comparison : Current MB, uF’ₙ

Choose Intra Prediction

Intra prediction : Intra MB (uF’ₙ)

Reorder/Entropy encode

NAL

F’ₙ₋₁ (Previous encoded Frames : references)
Decoding Block Diagram
Decoding flow chart

NAL

Entropy decode/Reorder

X : Coefficient

Intra/Intra prediction

Q⁻¹/T⁻¹ : uF_n

Deblocking Filter

F'_n (Reconstructed MBs)

Inter

MC : MC MB (P MB)

Q⁻¹/T⁻¹ : D'_n

P + D'_n = uF'_n

F'_{n-1}
(Previous encoded Frames : references)
H.264/AVC Decoder Architecture

- Video decoder (VDEC) is H.264/AVC baseline decoder
- Dedicated, full hardwired ASIC design without utilizing any GPP/DSP cores
- RTL coded in Verilog-HDL
- Real-time H.264/AVC baseline decoding of QCIF(176x144) resolution
  - Intra/inter prediction
  - 4:2:0 sampling
  - Deblocking filter
  - CAVLC/Exp-Golomb
  - No B pictures
H.264/AVC Decoder frame resolution

Data size of a QCIF image
= 11 x 9 MB
= 99 x 6 blocks
= 99 x 6 x 8 x 8 bytes
= 38016 x 8 bits
= 9504 x 32 bits
(1 block = 8 x 8 pixels, 1 pixel = 8 bits)

1 MB consists of 4 Y, 1Cr, and 1Cb
Sample Code: H.264/AVC Decoder Template
H.264/AVC Decoder: Decoder Main Block
H.264/AVC Decoder: Decoder Top Block Diagram

H.264 decoder

Encoded stream buffer → NAL decoding → Syntax parsing

Stream parser

Entropy decoder

CAVLC

Exp-Golomb

Fixed-length

Coeff

Inverse scan
Inverse quantization

Intra prediction

Inter prediction

Inter/Intra MB

4x4

Boundary strength

Deblocking filter

Decoded frame buffer

Reference frame buffer
Timing Specification: Encoded Stream Buffer

Timing of Encoded stream buffer
Timing Specification: Decoded Frame Buffer

- Frame_sel = 0
  - buffer 0 → storing a decoded frame
  - buffer 1 → reading a reference frame

- Frame_sel = 1
  - buffer 1 → storing a decoded frame
  - buffer 0 → reading a reference frame

Timing of read signals (enable is negative active, frame_sel = 1)
Timing Specification: Decoded Frame Buffer

Generation of frame_sel signal

Timing of write signals (enable is negative active, frame_sel = 0)