MPEG-4 AVC/H.264
Digital Video Compression Standard

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MPEG-4 AVC/H.264

- History
- Technology
- Adoption
- Next Steps

- Start drinking from the fire hose
AVC/H.264

Better picture . . .

. . . Half the bit rate of MPEG-2
Objective

- PSNR vs Bit Rate

Subjective
Note: PSNR at a given bit rate is encoder dependent and will vary from one encoder to another.
MPEG-2, MPEG-4 ASP, AVC/H.264 (MP)
Mobile & Calendar (HHR - 352x480)
AVC/H.264 (MP) vs MPEG-2 (MP)

Mobil and Calendar (720x480)

Bitrate (kb/s)

PSNR (dB)

MPEG-4 AVC

MPEG 2
AVC/H.264 (MP) vs MPEG-2 (MP)

FI_HD (1920x1088)

Bitrate (kb/s)

PSNR (dB)

- MPEG-4 AVC
- MPEG 2

Joint ITU-T Workshop and IMTC Forum 2006 “H.323, SIP: is H.325 next?”
San Diego, 9-11 May 2006
~ % Bit rates required for the same PSNR (~ 32dB)
(Normalization: MPEG-2 = 100%)

Note: PSNR at a given bit rate is encoder dependent and will vary from one encoder to another.
Subjective Testing

- **MPEG Tests**
  - AVC/H.264 (Main Profile), MPEG-2 (Main Profile)

- **Blu-Ray Disc Founders (BDF)**
  - AVC/H.264 (High Profile), MPEG-2 (Main Profile)
MPEG Verification Test

- ITU-R 500-11
  - Double Stimulus Continuous Quality Scale (DSCQS) Method

- Mean Opinion Square and 95% Confidence Interval
MPEG Verification Test

New Mobile & Calendar 1080(30i)

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Blu-Ray Disc Founders (BDF)

- HDTV Subjective Testing
- High at 8 Mbps nominally beats MPEG-2 at 24 Mbps
- Nominally transparent on 1080p24 at 16 Mbps
Better picture ...  

... Half the bit rate of MPEG-2
AVC / H.264

- I, P, B, Bs, SP, SI
- Improved Spatial Prediction
  - 4x4
  - 8x8
  - 16x16
- Improved Temporal Prediction
  - Multiple reference frames
  - Variable block size MC - 7 Block Patterns
    - 16x16, 16x8, 8x16, 8x8, 8x4, 4x8, 4x4
  - Up to 16 MVs per MB
  - Quarter Pixel Interpolation
  - Loop filter
  - Skip
  - Direct
  - Weighted
- Interlaced Video Coding Tools
  - Frame or Field predictions
- Context-based Adaptive Binary Arithmetic Coding (CABAC)
- 4x4 or 8x8 Transforms
- Other
AVC/H.264 Coding Tools
Multiple Reference Frames

Decoded Pictures as Reference

Current Picture
AVC/H.264 Coding Tools

- Variable macroblock size
AVC/H.264 Coding Tools

- Variable macroblock size
AVC/H.264 Coding Tools

Legend: QCIF; Black Boundary Line – Skip; White – Intra; Gray - Inter (P)
o Motion estimation accuracy
  • ¼ Pixel
Built-in (In Loop) Debloocking Filter

No Debloocking

Debloocking
AVC/H.264 Profiles

- **Baseline**
  - I, P
  - CABAC
  - CAVLC
  - + Red. Slices
  - + ASO
  - + FMO

- **Extended**
  - SP, SI
  - Data
  - Partitioning
  - + CABAC
  - + SP, SI
  - + Data
  - + Red. Slices

- **Main**
  - + CABAC
  - + MBAFF

- **High**
  - + 8x8
  - + MBAFF
AVC/H.264 Profiles

- **High Profile**
  - Highest compression or video quality at a given bit rate
  - Suitable for good quality entertainment video distribution

- **Baseline Profile**
  - Least complexity
  - Error resilient
  - Suitable for telephony, conferencing application
## AVC/H.264 – Levels

- **Level 1.0**: QCIF @ 15 frames/sec
- **Level 1.1**: QCIF @ 30 frames/sec, CIF @ 7.5 frames/sec
- **Level 1.2**: CIF @ 15 frames/sec
- **Level 2.0**: CIF @ 30 frames/sec
- **Level 2.1**: HHR @ 25 or 30 frames/sec
- **Level 2.2**: SDTV @ 15 frames/sec
- **Level 3.0**: SDTV: 720x480x30i, 720x576x25i
  - 10 Mbps (max.), up to 5 (max. resolution) reference frames
- **Level 3.1**: HDTV - 1280x720x30p, SVGA (800x600) 50+p
- **Level 3.2**: HDTV - 1280x720x60p
- **Level 4.0**: HDTV (all formats) - 1920x1080x30i, 1280x720x60p, 2kx1kx30p
  - 20 Mbps (max.), up to 4 (max. resolution) reference frames
- **Level 4.1**: HDTV - 1920x1080x30i, 1280x720x60p, 2kx1kx30p
  - 50 Mbps, up to 4 (max. resolution) reference frames
- **Level 4.2**: S-HDTV - 1920x1080x60p
- **Level 5.0**: S-HDTV/D-Cinema - 2kx1kx72p
- **Level 5.1**: S-HDTV/D-Cinema - 2kx1kx120p, 4kx2kx24p, 4kx2kx30p
Transport of AVC / H.264

- Transport of MPEG-4 AVC using MPEG-2 System: ISO/IEC 13818-1
  - PDAM (Proposed Draft Amendment) in May 2002
  - FPDAM (Final Proposed Draft Amendment) in Dec 2002
  - FDAM in July 2003
  - Approved AMD

- IP delivery
  - MPEG-2 TS over UDP/IP, or
  - RTP over IP
AVC/H.264

- Applications
  - Wherever you need to save bandwidth and/or storage capacity
AVC/H.264 Adoption

- 3GPP
- 3GPP2
- ARIB (Japan)
- ATSC
- Blu-ray Disc
- DLNA
- DMB (Korea)
- DVB
- DVD Forum (HD-DVD)
- IETF AVT - RTP payload spec approved as RFC 3984
- ISMA
- SCTE
- US DoD MISB - Adopted as US government preferred codec up to 1080p
AVC/H.264 Commercial Deployment

- Direct Broadcasting Satellite
  - DirectTV, BSkyB, DISH, Premiere, Euro 1080
- Terrestrial broadcasting
  - HDTV pay DTV in France
- IPTV
  - KPN in Netherlands, Belgacom in Belgium, SBC/ATT ...
- Streaming
  - Quicktime
- Video Conferencing
- Mobile TV
- Portable Media Players
  - Video iPOD, Cell Phones
- HD-DVD
- Blu-Ray
- Video Games
- Digital Cable
**Products**

- NAB 2006: 125+ companies
  - Services
  - Encoders
  - Decoders
  - STB
  - ICs
  - Cores
  - Software
  - ...

**AVC/H.264 Commercial Deployment**
o Extensions
  • Higher resolution and quality
    – Studios, D-cinema
    – Very High Definition to home?
Higher Resolution and Quality

- 4:2:0/10bits - High 10 bit (Hi10P)
- 4:2:2/10bits - High 4:2:2 (Hi422)
AVC/H.264 Standard - Next Steps

• **Extensions**
  - Higher resolution and quality
    - Studios, D-cinema
    - Very High Definition to home?
  - **Scalable Video Coding (SVC)**
    - Multiple layers
    - Potential alternative for seamless mobility
      o Across networks
      o Across devices
      o Across applications
Scalability

Single Layer

Multiple Layers
Scalability

- Temporal
- Spatial
- SNR
- Fine Granular (FGS)
**AVC/H.264 Standard - Next Steps**

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  - Multi-View Coding
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- Next standard
  - Significant improvement over AVC/H.264?
    - H.265?
    - MPEG-x?
  - Hunt is ON