

# Encoding H.264 Video for Streaming and Progressive Download

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## Agenda

- Techie Overview
- Understanding H.264 encoding parameters
- Producing H.264 video for computers and devices
- Comparing the H.264 codecs
- Settings for common encoders
- Microsoft announcement
- Bonus subject: Producing for YouTube's new High Quality option



## Techie Overview



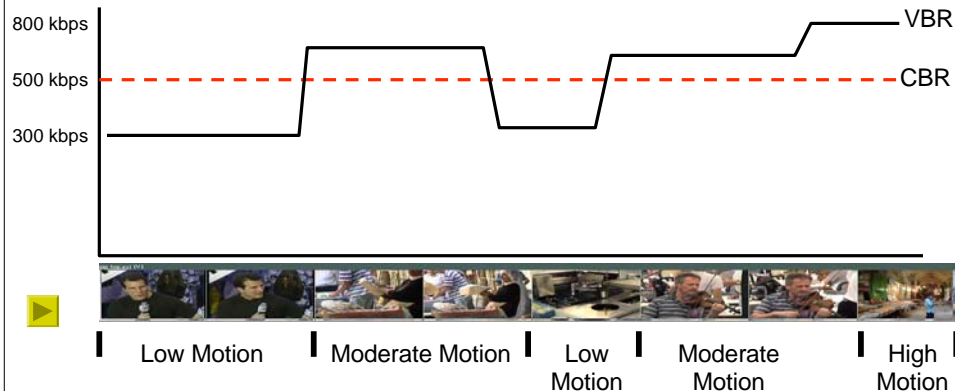
- Generic encoding parameters
  - Constant and variable bitrate encoding
  - Streaming vs. progressive download
  - I, B and P frames
- H.264 overview
  - What is H.264?
  - What does H.264 cost?

## Generic Encoding Parameters



- Terms and techniques
  - Constant and variable bit rate encoding
  - Streaming vs. progressive download
  - I, B and P frames

## Constant vs Variable Bit Rate



## Constant vs Variable Bit Rate



- Constant Bit Rate (CBR)
  - One bit rate applied to entire video, irrespective of content
  - Pros: Easy and fast
  - Cons: Doesn't optimize quality
- Variable Bit Rate (VBR)
  - Dynamic bit rate matches compression complexity (usually motion) in video
  - Pros: Best quality
  - Cons: Slow, can produce erratic stream

## When Should I Use VBR/CBR?



- Consider VBR when:
  - Clips are longer than 60 seconds
  - Varied motion in clip (some action, some talking head)
  - Producing for progressive download
  - Not in a hurry
- Consider CBR when:
  - In a hurry (or live encoding)
  - Producing for streaming
  - Consistent motion (especially talking head)

## Optimizing CBR Video

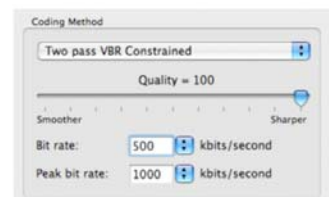
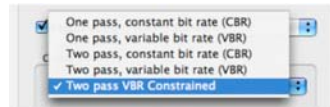


- Use 2-pass CBR
  - Scans file (like VBR), but packs data into a consistent stream
  - Best of both worlds when available
- 1-pass for live or draft work

## Optimizing VBR Video



- 2 passes or more
- Use “Constrained” to limit data rate
- Set Target and Max/Min
  - Overall target
  - Max/Peak bit rate-
    - Rule of thumb is 1.5 - 2X
  - Minimum bit rate (not shown)
    - Rule of thumb is .5X unless lots of very low motion



## Streaming vs. Progressive Download



- Streaming
  - Distributed by "streaming server"
  - Stream monitored and dished out as needed
- Progressive download
  - Starts playing before fully downloaded
  - Stream pushed out as quickly as possible

## Streaming vs. Progressive



- Most viewers can't tell the difference
  - YouTube and most UGV sites are progressive
  - Most of the network news is progressive
  - Most broadcast TV shows are streamed
- Streaming often for *producer*, not *viewer*
  - Security
  - More efficient delivery

## Streaming vs. Progressive Download



- When producing for streaming
  - Determine if any unique requirements for server
  - Determine if any unique streaming related features (multi-bit rate files)
  - **Typically, use CBR for steady stream**
- When producing for progressive download
  - Determine if any unique features (fast-start)
  - **Encode using VBR for best quality**

## I, B and P Frames

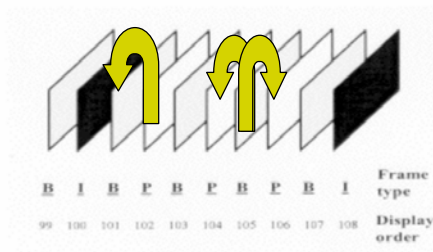


- Defined
- Relevant controls
- A note of caution
  - Frame controls vary by encoder
  - Controls in your program probably won't look like those shown here
  - General principles should work similarly

## What are I, B and P Frames?



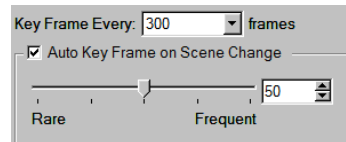
- I-Frame - encoded without reference to other frames (also called Key Frames)
- P - looks backward to I and P frames (predicted)
- B - looks forward and backward to I and P frames (Bi-directional interpolated)
  - No frames refer to B-frame



## What to Know About Key Frames



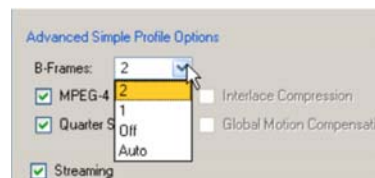
- Key frames enhance interactivity
  - All playback starts on a key frame
  - When seeking to a random frame, must start playback at key frame
- Key frames "reset" quality:
  - Useful at scene changes ("Natural" key frames)
- Recommended:
  - Make sure "natural" or equivalent is enabled
  - Typical duration for periodic keyframes is 5 - 10 seconds



## What to Know About B Frames?



- Typically most "efficient" frame
- Hardest to decode with greatest buffer requirements
  - B-frames are key difference between Baseline and other H.264 profiles
- Interval is usually the maximum number of sequential B frames between I and P frames
- 1-3 is recommended value





## H.264 Overview



- What is H.264?
- What's H.264 cost?
- What's with all the H.264 extensions?

## What is H.264?



ITU – International Telecommunications Union Telephone, Radio, TV		ISO – International Standardization Organization Photography, Computer, Consumer Electronics	
1984	H.120		
1990	H.261 – Video Conferencing		
1993		MPEG-1 – Video CD	
1994	(H.262)	MPEG-2 – Digital Cable and Satellite TV	
1995	H.263 – Improved Video Conferencing		
1997		ATSC – U.S. HDTV	
1999		MPEG-4	
2002	AVC (H.264)	AVC (MPEG-4 Part 10)	

- First standard adapted by ISO and ITU
- Called AVC or H.264
- First codec adopted by top three streaming providers (Apple, Adobe, Microsoft)

Streamcrest Associates  
<http://www.streamcrest.com/SDF%20Final1.pdf>

## What's H.264 Cost?



- MPEG-LA -
  - “For AVC video delivered via the Internet to an end user who does not pay for the right to view, i.e., neither title-by-title nor subscription, there will be no royalty through December 31, 2010”
  - **Are all AVC essential patents included?** No assurance is or can be made that the License includes every essential patent.”
    - AT&T has threatened to sue multiple companies, including Apple over MPEG-4 patents

## What is an MP4 file (and what are the variants)?



- .MP4 - official MPEG-4 wrapper
- .M4V - Apple's variant for iTunes and devices
- .MOV - H.264 file for editing or QuickTime delivery
- .F4V - H.264 for Flash
- .3GP - (not shown) - phone
- .MPG - H.264 in MPEG-2 transport stream
- W4M? - will Microsoft create a new extension?

File Format:	MPEG-4	:
Extension:	mp4	<input checked="" type="checkbox"/> Allow Job Segmenting

File Format:	H.264 for Apple Devices	:
Extension:	m4v	<input checked="" type="checkbox"/> Allow Job Segmenting

File Format:	H.264 for DVD Studio Pro	:
Extension:	mov	<input checked="" type="checkbox"/> Allow Job Segmenting

Stream Type	F4V
Video-Basic	MPEG-2 Transport Stream
Width	MPEG-4 System
Height	F4V
	Raw H.264 Stream

## H.264 Encoding Parameters



- The basics
  - Profiles
  - Levels
  - Entropy encoding
- Stream related options
- Search related options
- Miscellaneous options

## H.264 Encoding - The Basics



- Bitrate control/passes
  - Video
  - Audio
- Keyframe settings
- Profiles and Levels
- Entropy encoding

## What are H.264 Profiles?



- “Define a set of coding tools or algorithms that can be used in generating a bitstream”

	Baseline	Extended	Main	High	High 10	High 4:2:2	High 4:4:4 Predictive
I and P Slices	Yes	Yes	Yes	Yes	Yes	Yes	Yes
B Slices	No	Yes	Yes	Yes	Yes	Yes	Yes
Multiple Reference Frames	Yes	Yes	Yes	Yes	Yes	Yes	Yes
In-Loop Deblocking Filter	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CAVLC Entropy Coding	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CABAC Entropy Coding	No	No	Yes	Yes	Yes	Yes	Yes
Interlaced Coding (PicAFF, MBAFF)	No	Yes	Yes	Yes	Yes	Yes	Yes
8x8 vs. 4x4 Transform Adaptivity	No	No	Yes	Yes	Yes	Yes	Yes
Quantization Scaling Matrices	No	No	No	Yes	Yes	Yes	Yes
Separate Cb and Cr OP control	No	No	No	Yes	Yes	Yes	Yes
Separate Color Plane Coding	No	No	No	No	No	No	Yes
Predictive Lossless Coding	No	No	No	No	No	No	Yes
	Baseline	Extended	Main	High	High 10	High 4:2:2	High 4:4:4 Predictive

## Main vs. Baseline





## Main vs. Baseline

- Critical to know your target profile before encoding
- Device - iPod/iPhone - Always Baseline
- Computer playback - typically Main
  - QuickTime - need latest version of QuickTime Player to play High profile (so consider Main in the short term)
  - Flash - should be compatible with all relevant profiles



## What are H.264 Levels?

- “Constrains key parameters in the bitstream”

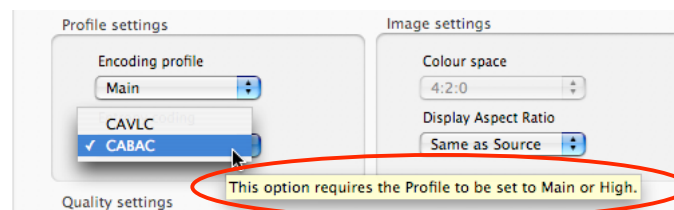
Level number	Max video bit rate (VCL) for Baseline, Extended and Main Profiles	Max video bit rate (VCL) for High Profile	Examples for high resolution @ frame rate (max stored frames) in Level
1	64 kbit/s	80 kbit/s	128x96@30.9 (8) 176x144@15.0 (4)
1b	128 kbit/s	160 kbit/s	128x96@30.9 (8) 176x144@15.0 (4)
1.1	192 kbit/s	240 kbit/s	176x144@30.3 (9) 320x240@10.0 (3) 352x288@7.5 (2)
1.2	384 kbit/s	480 kbit/s	320x240@20.0 (7) 352x288@15.2 (6)

## H.264 Levels



- Primarily an issue when encoding for devices
  - Must ensure that encoding parameters are within target *level* (most templates do this)
- For computer playback,
  - Both Flash and QuickTime Players support levels up to 1920x1080i
  - If this rez or lower, won't run into problems
  - More of a playback issue than level compliance
- Check <http://en.wikipedia.org/wiki/H.264> for maximum parameters for each level

## Entropy Encoding



- CABAC (Context-adaptive binary arithmetic coding)
  - More efficient (e.g. better quality), but harder to decode
- CAVLC (Context-adaptive variable-length coding)
  - Less efficient, easier to decode
- Big question - does quality improvement outweigh increase in required CPU horsepower

## CABAC vs CAVLC Quality



- In challenging scenes, CABAC was noticeably better
- Most authorities place quality advantage at 10-15%

## Real World Input - CABAC



Source	CABAC
Adobe TBD	Yes
Apple Compressor	No
Rhomet Carbon Coder - H.264 preset	Yes
Sorenson Squeeze - H.264 preset	Yes
Telestream Episode Pro - H.264 preset	No
Inlet HD Fathom - H.264	Yes
H.264 Trophy sites	23 - No 0 - Yes

## CABAC vs CAVLC Performance



	CABAC	CAVLC
HP 8710w - Core 2 duo (% of both CPUs)	31.1%	30.5%
PowerMac - Dual 2.7 GHz PPC G5 (% of 1 processor)	71.17	67.34

- Does increase playback requirements slightly on lower power computers
- My recommendation:
  - CABAC - unless really concerned about low power computers (schools, etc)

## Deep Dive into H.264 Parameters



- Caveats:
  - Presented differently by each encoding tool
  - Only have time to cover most critical parameters
- To understand *your* encoder
  - Read manual/help file to understand parameters and their trade-offs; generally involve
    - Encoding time vs. quality
    - Complexity (and maybe encoding time) vs. quality
- Use MainConcept's reference encoder to illustrate



## General Options



- Frame coding (progressive)
- Key frame interval
  - 300
  - Scene change detection
- Bitrate
  - CBR
  - Insert data rate

## Stream Structure



- Stream Structure
  - B-frame/reference frame related
  - Increase quality
    - Increase decompression complexity
    - Increase encoding time
- Biggest Decisions
  - Should you use B-frames
  - Number of sequential B frames used in the file

## B-frames - Yes/No



## B-frames - Yes/No



## Real World Input



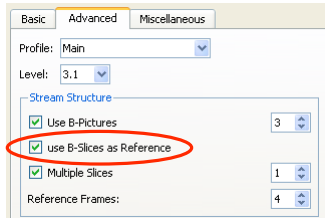
Source	B-frames - y/n	Number
Apple Compressor - 800 kbps preset	Yes	1
Adobe Media Encoder	NA	NA
Rhozet Carbon Coder - H.264 preset	Yes	2
Sorenson Squeeze - H.264 streaming preset	No	NA
Telestream Episode Pro - H.264 preset	Yes	1
Inlet HD Fathom - H.264	Yes	3
20 videos in HD trophy sites	6 - No 14 - Yes	1 - all that used B-frames used 1

## B-frames - Yes/No



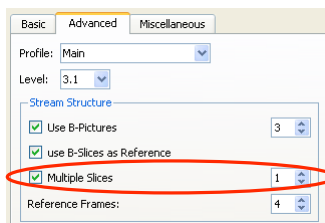
- Noticeable quality improvement
- 5-10% increase in decompression CPU load
- Recommend
  - Say “YES” to B-frames
  - 2-3 is a good number for live video
  - Experiment with higher numbers with animations

## Stream Structure



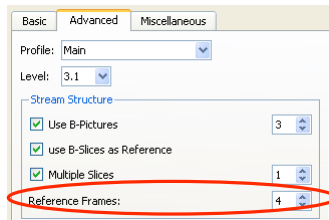
- B-Slices as references?
  - Use B-frames as references for B&P frames
  - Also called B-frame pyramid when enabled as reference for B-frames
  - Impact
    - Potential quality improvement (more redundancies)
    - Potential increase in encoding time

## Stream Structure



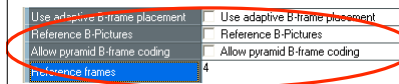
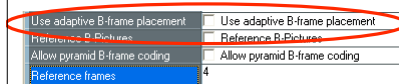
- Multiple Slices
  - Divides image up into “slices”
  - May speed encode on MP systems
  - May speed decode on MP systems
  - No real downside
  - Recommend - 2

# Stream Structure



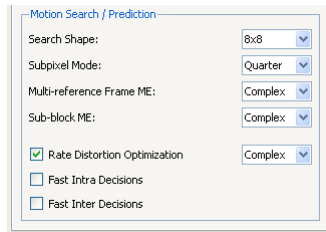
- Reference Frames
  - Number of frames searched for redundancies
  - Higher numbers may improve quality but lengthen encode time
  - Increase decode requirements
  - Recommend
    - 4 - for real world video
    - potentially more for animation

# More B-frame Options



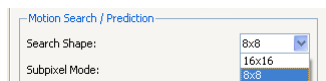
- Adaptive B-frame placement
  - Overrides B-frame quantity when necessary to improve quality
    - Like scene change
  - Always enable
- Separate presentation of Reference B-Pictures and Pyramid B-frame encoding

## Search/Prediction Related



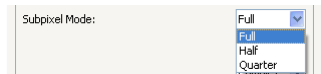
- In general, these manage the trade-off between search accuracy (and quality) and search time
  - Can improve quality
  - Minimal (if any) impact on required decompression

## Search Shape



- Search shape is the size of the macro block used for searching redundancies
- 8x8 is slower but more accurate than 16x16, potentially delivering better quality
- Use 8x8 unless in a huge hurry

## Sub-pixel Mode



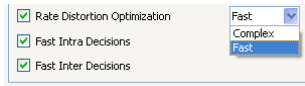
- Sub-pixel mode
  - Dictates depth of search shape
  - Full is faster but less accurate
  - Quarter is slower but may improve quality
  - Use Quarter unless in a real hurry

## Motion Estimation (ME) Algorithms



- Multi-reference Frame ME / Sub-block ME
  - Complex for quality (and longer encoding time)
  - Fast for encoding speed and less quality

## Other Search-Related Options



- Rate distortion manages quality/data rate trade-off
  - Fast - heuristic optimization that's faster, but can cause quality loss
  - Complex is slower, with better quality
- Fast Intra/Inter Decisions
  - Speed/quality trade-offs in decision metrics

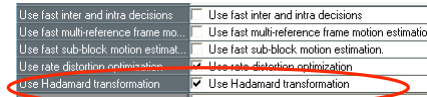
## Search Related Quality



- Observations:
  - Time differential can be +/- 50% on tested encoders
  - Quality difference was minimal on 2 of 3 tested encoders. I recommend:
    - Check the help file
      - Episode - help file says that settings beyond 50 typically won't increase quality
      - Test at both extremes to ID time/quality difference
      - Apply to your unique encoding situation

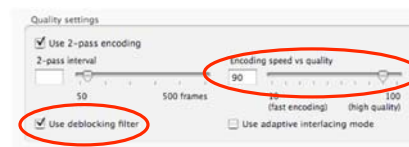


## Hadamard Transformation



- Enable/Disable Hadamard Transformation
  - Encoding technique to improve compressed quality
  - Yes - Better quality, longer encoding time
    - HP xw8400 DP QC, one minute SD file
      - 62 seconds with Hadamard enabled
      - 60 seconds without
  - No noticeable qualitative difference, but minimal affect on encoding time
  - Unless in a real hurry, opt yes

## Deblocking Filter/Other



- Deblocking filter
  - Minimizes blockiness, but extends encoding time and can slow decompression
  - Recommend - always enable
- Encoding Speed vs. quality
  - How encoder vendors combine multiple options into one slider
  - Varies by encoder/codec

## H.264 Encoding Summary



- Profiles/Levels - dictated by target
- Entropy Encoding - typically CABAC
  - Not available for Baseline
- B-frames - Use when available
  - Not available for Baseline

## H.264 Encoding Summary



- Divide other parameters into:
  - Boost quality/increase encoding time
  - Boost quality/increase decoding complexity (and perhaps encoding time)
    - As we'll see, max delta is around 10%
  - Make decision based upon your target viewers and encoding workload
    - More later

## Producing H.264 Video for Computers and Devices

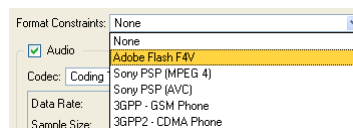


- Format specific considerations
  - Flash
  - QuickTime
- Optimizing for computer playback
- Optimizing for devices

## Flash and H.264



- Flash Player 9 Update 3 contained:
  - Software H.264 decoder (Baseline/Main/High profiles)
    - Not DivX, H.263 or Sorenson
  - AAC decoder
- Hardware scaling to full-screen mode, **but NO acceleration at normal resolution**
- No special encoding requirements for the Flash Media Server
- Flash player can play mp4, m4v, m4a, mov and .3gp files
  - Evolving best practice - FLV for VP6 and F4V for H.264



## Flash and H.264



- When should you switch from VP6 to H.264?
  - 80+% of Flash Players H.264 capable by 8/2008
- But, adoption has been slow in “real” markets (e.g non-trophy sites or movie trailers)
- Why?
  - Royalties may apply
  - Quality only slightly better than VP6
  - No compelling business case for switching
    - Cellular may change the equation

## Flash and the MOOV Atom



- MOOV atom contains file header info
  - If not located at the start of the file, video delivered via progressive download won't start until fully downloaded
  - Video streamed via FMS is OK
- Most pre-CS4 Adobe encoders put moov atom at the end
- Good description of problem here:  
<http://www.scottgmorgan.com/blog/index.php/tag/video/>

## Flash and the MOOV Atom

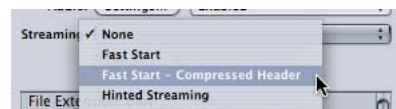


- How to get moov atom to the beginning of the file? Several utilities
  - <http://svn.mplayerhq.hu/ffmpeg/trunk/tools/qt-faststart.c?view=markup>
  - <http://renaun.com/blog/2007/08/22/234/>
- Should be fixed with CS4 encoders, but not yet verified

## Producing for QuickTime



- Customizing for QuickTime Streaming
  - When distributing via a streaming server, opt of Hinted Streaming
- For progressive download, use Fast Start - Compressed Header
  - Otherwise file may completely download before playing



## Optimizing H.264 for Computer Playback



- Perspective
  - We understand H.264 encoding params
  - We understand QuickTime/Flash specifics
- Now we learn how to configure a stream that will smoothly play on the lowest platform you care about

## H.264 Playback - SD File



	Dell Latitude	HP xw4100	MacBook Pro	Dell Precision 390
	1600 MHz Pentium M	3.0 GHz P4 with HTT	2.4 GHz Core 2 Duo	3.0 GHz Core 2 Duo
<b>SD Tests</b>				
H.264 - Main - tricked out (QT Player)	88 %	25 %	29 %	12 %
H.264 - Baseline (QT Player)	80 %	30 %	19 %	8 %

## H.264 Playback - 720p File



	Dell Latitude	HP xw4100	MacBook Pro	Dell Precision 390
	1600 MHz Pentium M	3.0 GHz 4 with HTT	2.4 GHz Core 2 Duo	3.0 GHz Core 2 Duo
<b>HD Tests</b>				
H.264 – High	99 %	78 %	50 %	28 %
H.264 – Baseline	100 %	68 %	58 %	21 %

## H.264 Playback - 1080i File



	Dell Latitude	HP xw4100	MacBook Pro	Dell Precision 390
	1600 MHz Pentium M	3.0 GHz P 4 with HTT	2.4 GHz Core 2 Duo	3.0 Ghz Core 2 Duo
<b>HD Tests</b>				
H.264 - Main - tricked out (QT Player)	100 %	69 %	48 %	40 %
H.264 – Baseline (QT Player)	100 %	79 %	42 %	26 %

## H.264 Compared to Other Codecs



- 720p playback tests
- H.264 requires less CPU to playback than VP6 or Silverlight

	Flash VP6E	Flash H.264 - High	Silverlight
<b>HP xw4100</b> , 3.0 GHz P4 with HTT Processor CPU during playback Drop frames	54.6% <b>Yes</b>	45.1% No	52.5% No
<b>HP 8710P</b> , 2.2 GHz Core 2 Duo Processor CPU during playback Drop frames	51.9% No	34.8% No	47.3% No
<b>Precision 390</b> , 2.9 GHz Core 2 Duo Processor CPU during playback Drop frames	22.7% No	7.7% No	26.0% No

## Lessons from the Field



- The Dow Jones 30
- Movie Trailers
- Hi-Def Trophy Sites
- Broadcast Usual Suspects
- Presets of the Rich and Famous



## The Dow Jones 30



- Typical Business Use
  - Straight from the stock market listing
  - Not stretching the envelop

Who	Resolution	FPS	Video Bitrate	Profile	Audio Bitrate	Key Frame
Wal-Mart	640x480	29.97	1.538 m	Main	128 k	24

## Movie Trailers



- Four levels of trailers (Apple QuickTime Trailer site)

Who	Rez	FPS	Video Bitrate	Profile	Audio Bitrate	Key Frame
Real Time	640x316	24	1.36 mbps	Main	96 kbps	47
480p	848x352	24	2.1 mbps	Main	448 kbps	12
720p	1280x544	24	5.8 mbps	Main	448 kbps	12
1080p	1920x816	24	9.8 mbps	Main	448 kbps	12

## H.264/High Bandwidth Trophy Sites



- Apple, Adobe, Akamai
- Insane encoding parameters

Who	Rez	FPS	Video Bitrate	Profile	Audio Bitrate	Key Frame
Real Time	640x420	27	1.3 mbps	Baseline	128 kbps	150
480p	868x488	27	2.9 mbps	Main	124 kbps	97
720p	1280x720	26	7.0 mbps	Main	154 kbps	63
1080p	1920x1080	27	15 mbps	Main	149 kbps	86

## Broadcast Usual Suspects



- Major networks, news and prime time shows, high profile web-only (NY Times, CNET, etc)

Who	Rez	FPS	Video Bitrate	Profile	Audio Bitrate	Key Frame
CBS - SD	853x480	NA	1.36 mbps*	NA	128 kbps*	NA
CBS - HD	1280x720	NA	3.5 mbps*	NA	128 kbps*	NA
DL.TV	640x480	27	508 kbps	Main	96 kbps	150
DL.TV -WMV	640x480	29.97	512 kbps	NA	80 kbps	82

## Presets of the Rich and Famous - 1 (TBA)



Who	Rez	FPS	Video Bitrate	Profile	Audio Bitrate	Key Frame
1080p	1920x1080	SAS	9 mbps	High	128 kbps	30
720p	1280x720	SAS	6 mbps	High	128 kbps	30
Web large 4:3	640x480	SAS	1.5 mbps	Main	128 kbps	30
Web large 16:9	720x400	SAS	1.5 mbps	Main	128 kbps	30
1080p 1/4 size	480x270	SAS	600 kbps	Main	128 kbps	30
Web medium 4:3	360x272	SAS	400 kbps	Main	128 kbps	30
Web medium 16:9	360x200	SAS	600 kbps	Main	128 kbps	

SAS = Same as source

## Presets of the Rich and Famous - 2



Preset	Rez	FPS	Video Bitrate	Profile	Audio Bitrate	Key Frame
<b>Compressor</b>						
LAN Streaming	640x480	SAS	1.4 mbps	Main	128 kbps	150
800 kbps	320x240	SAS	672 kbps	Main	128 kbps	150
300 kbps	320x240	15	220 kbps	Main	80 kbps	75
<b>Episode Pro</b>						
640x480 - Widescreen	640x360	29.97	1200	Main	64 kbps	Auto
640x480 - 4:3	640x360	29.97	1600	Main	128 kbps	Auto
<b>Squeeze</b>						
768 kbps	480x360	SAS	629	Baseline	56 kbps	300

## My Take on H.264 Quality



- H.264 produces better quality than VP6 or VC-1
- If converting from either codec, assume that you can use the same encoding parameters with no loss in quality
- If a new implementation, start with closest template
  - Set key frame interval to 150 - 300, with scene detection
  - Use Main profile,
  - Enable B-frames and set to 2-3
  - Enable CABAC
  - Test at increasingly lower data rates until you see unacceptable artifacts
    - Then, use the lowest data rate that delivers acceptable quality

## Producing for Computers



- Mind your format specific parameters
- Choose profile, resolution and other parameters that ensure smooth playback on your target
  - Or, offer multiple files and let viewer decide which to download
  - In general, if you're converting over from another codec, H.264 will be similar in quality and required playback horsepower to other codecs

## Optimizing for Devices



- Digesting iPod/iPhone Specs
- Lessons from iTunes
- Recommendations

## iPod Specs



	Original iPod (pre-5g)	iPod Nano	iPod Classic	iPod Touch/ iPhone
Device resolution	320x240	320x240	320x240	480x320
Aspect Ratio	4:3	4:3	4:3	16:9-ish
Video codec	H.264	H.264	H.264	H.264
Data rate	768 kbps	2.5 Mbps	2.5 Mbps	2.5 Mbps
Resolution	320x240	640x480	640x480	640x480
Frame rate	30 fps	30 fps	30 fps	30 fps
Profile	Baseline Profile to Level 1.3	Baseline Profile up to Level 3.0	Baseline Profile up to Level 3.0	Baseline Profile up to Level 3.0
Audio codec	AAC-LC	AAC-LC	AAC-LC	AAC-LC
Data rate	160 kbps	160 kbps	160 kbps	160 kbps
Audio parameters	48 kHz, stereo	48 kHz, stereo	48 kHz, stereo	48 kHz, stereo
Formats	m4v/mp4/mov	m4v/mp4/mov	m4v/mp4/mov	m4v/mp4/mov



## Lessons from iTunes

- Best practices of current producers
  - Downloaded and analyzed 50 podcasts from iTunes
  - Review standard encoding parameters
  - Key mistakes that prevented podcasts from playing on iPod
  - Optimizing 16:9 video



## Encoding Parameters - Video

	Size	Frame Rate	Codec H.264/ MPEG-4	Aspect 4:3/ 16:9	Data Rate	Extension mov/m4v/mp4	Key Frame
Small	320x240 (25/44)	4 - 15f 21 - 30f	22/2	20/5 (2 letterbox)	605K average	2/13/10	94 average
					low - 83K hi - 1.4 mbps		low - 24 hi - 300
Large	640x360+ (19/44)	1-15f 4-24f 14-30f	18/1	13/6	1.281 mbps average	2/11/5	121 average
					low - 813K hi - 2 mbps		low - 32 hi - 300

## Encoding Parameters - Audio



- All used Low Complexity AAC audio
- Average data rate - 116,000+
- Stereo/Mono - 42/2
- Low data rate - 32kbps/High - 160 kbps

## Errors that Prevented Playback



- Main or High Profile - 5
- Exceed data rate - 4 (high of 6.5 mbps)
- Exceed resolution - 2
- Wrong codec - 1 (Sorenson Video 3)

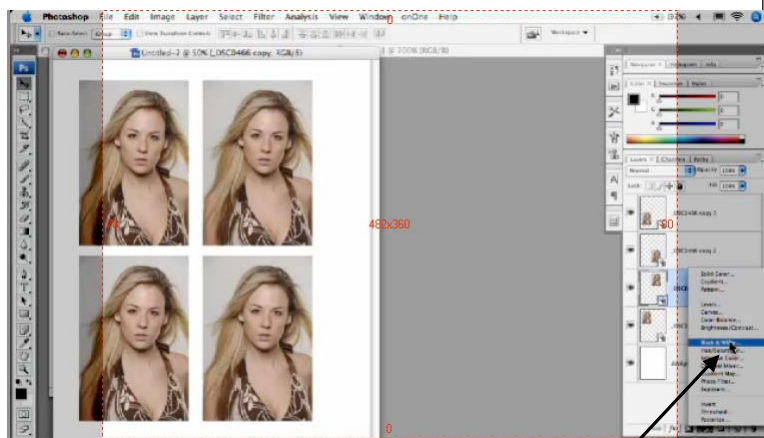
Note that there were some duplication of errors. A total of six videos wouldn't load, including videos produced by HBO, E-Online and Discovery Channel

## Optimizing 16:9 Video



- If producing 16:9 video, note that:
  - iPod Touch/iPhone is 16:9, all others 4:3
  - At default configuration, 4:3 players will display “center cut”, cutting off right and left edges
  - OK for many videos, but a potential problem when critical content is on the edge

## Center-Cut - Screenshot



Screen action not visible in 4:3 display



## Center-Cut - Real World Video



Oprah - logo cut off, but shot with 4:3 safe zones

## When Producing 16:9 Video

- Shoot for center cut display (like Oprah)
- Or, instruct viewers to change default playback parameters from “center cut” to letterbox
  - Videos > Settings > Fit to Screen > Off

## Sub-Optimal Encoding Decisions



- Data rates above ~ 1.3 for 640x480
  - Typically minimal quality improvement; just longer downloads and increased space consumption
- Key frame intervals below 100
  - Can cause pulsing

## Recommended Encoding Parameters



	320x240	640x480 <sup>1</sup>
<b>Video codec</b>	H.264 codec, Baseline profile	H.264 codec, Baseline profile
Data rate	768,000/CBR	1,120,000/CBR
Key frames	150 - 300	150 - 300
Frame rate	match source	match source
<b>Audio</b>	AAC Low	AAC Low
Data rate	128 kbps/stereo	128 kbps/stereo
Extension	.mv4	.mv4

<sup>1</sup> From Compressor

## Comparing the H.264 Codecs



- Test description
  - Apple, Dicas (Episode Pro), Main Concept (Carbon Coder/Squeeze)
  - Three files
    - SD - 640x480@30 fps, 468/32, 2-pass VBR, highest supported profile/quality options
    - HD - 1280x720@30 fps, 800/128, 2-pass VBR, highest supported profile/quality options
    - Screencam - 1024x768@15 fps, 200/32, 2-pass VBR, highest supported profile/quality options

## HD Test Results



	Apple	Dicas	Main Concept
Still Quality	3	2	1
Motion Quality	3	2	1
Smoothness	1	1	1
Total	7	5	3

Lower score is better

## HD Samples



- All codecs perform well with low motion footage



- Walking around (and panning) tends to separate the contenders (note detail in curtain)

## HD Samples



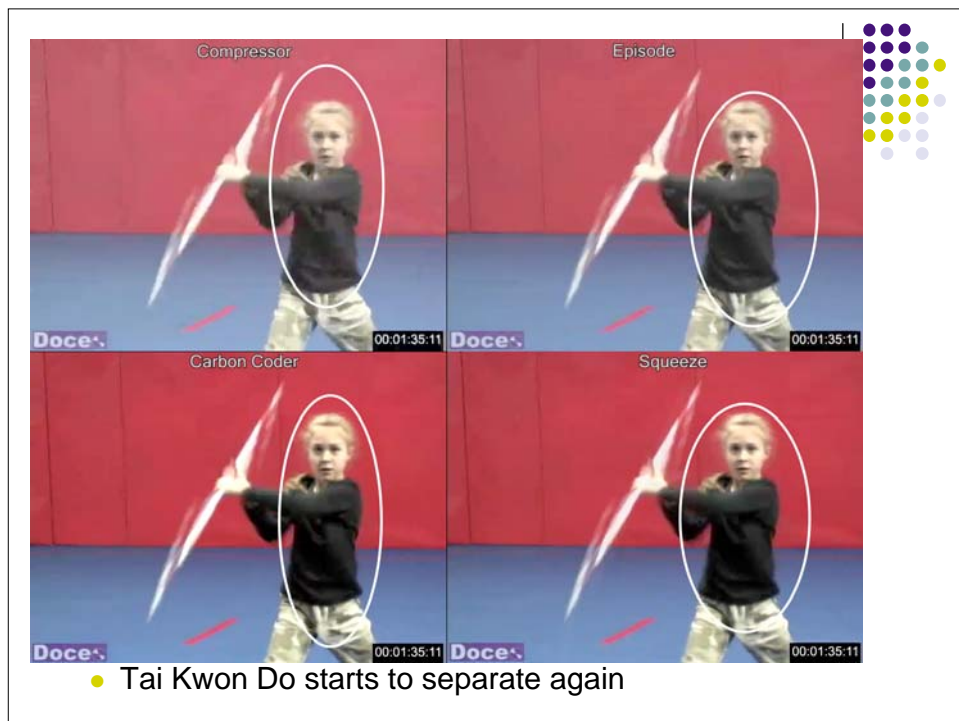
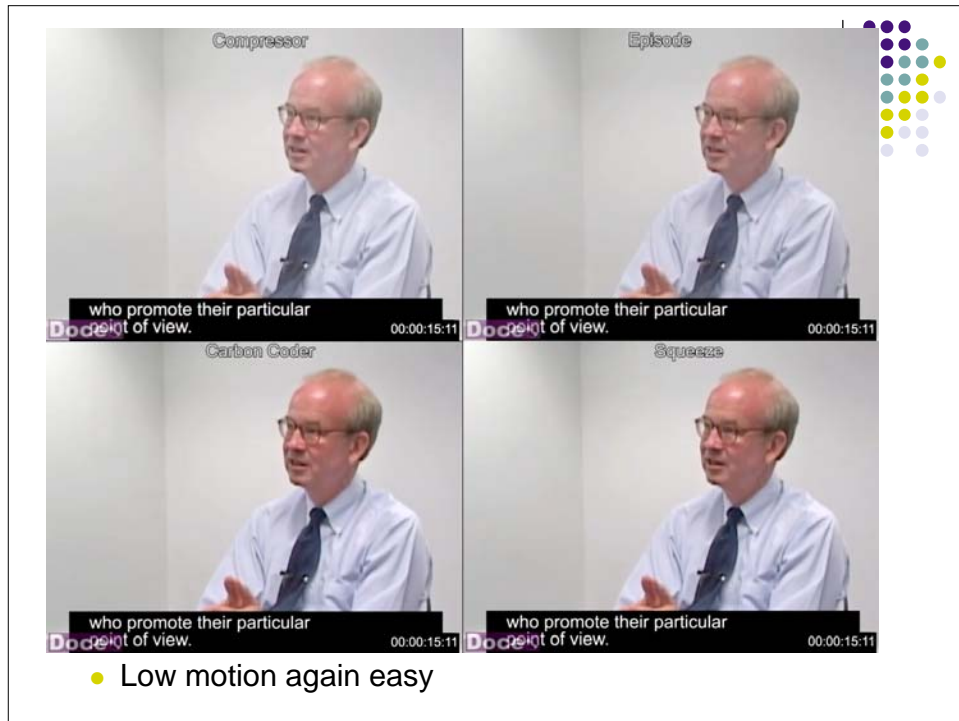
- Jumping further separates the contenders

## SD Test Results

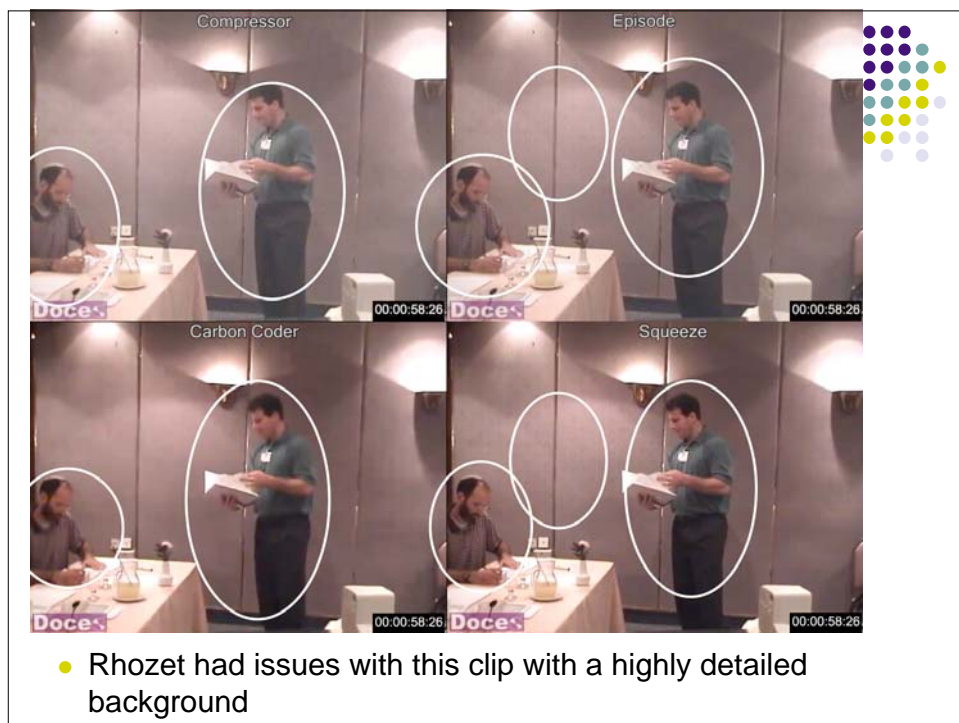
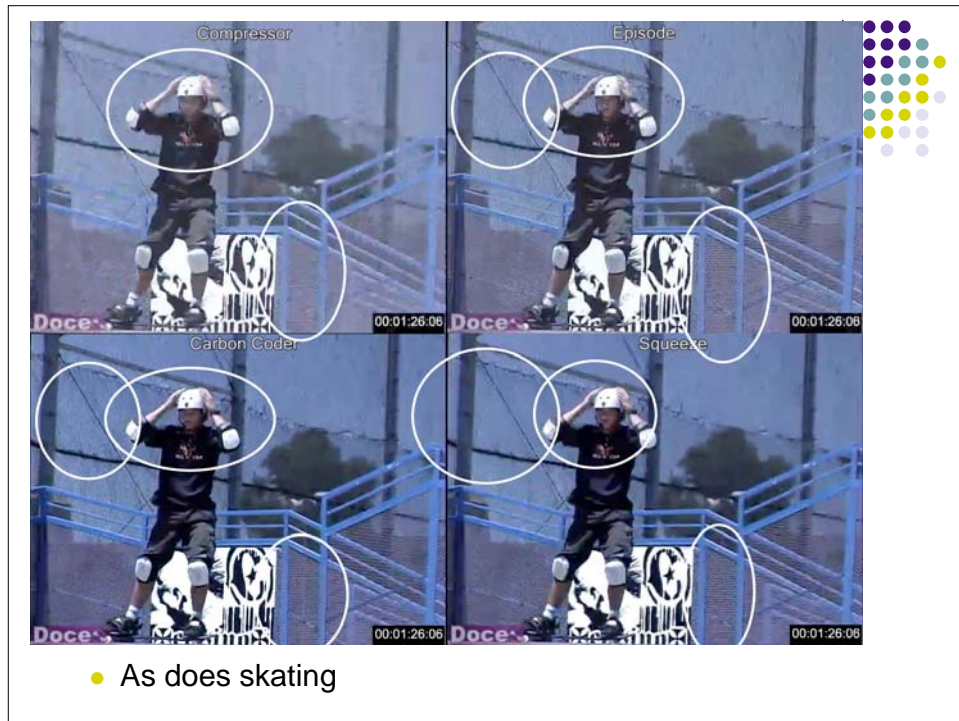


	Apple	Dicas	Main Concept
Still Quality	3	2	1
Motion Quality	3	2	2
Smoothness	1	1	1
Total	7	5	4

Lower score is better







## Screencam Test Results



	Apple	Dicas	Main Concept
Still Quality	3	1	1
Motion Quality	3	2	2
Smoothness	1	1	1
Total	7	4	4

Lower score is better





## Overall Results



	Apple	Dicas	Main Concept
HD	3	2	1
SD	3	2	1
Screencam	3	1	1

## Settings for Common Encoders



- Apple Compressor
- Adobe Media Encoder CS3
- Sorenson Squeeze
- Telestream Episode Pro
- Inlet Fathom

# Apple Compressor - Compression Settings



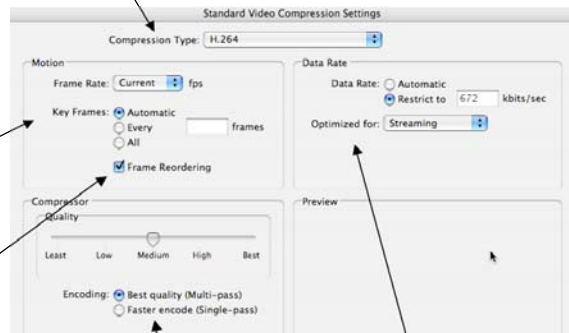
**Compression Type:**  
Choose codec here

**Key Frames:**  
- Choose Automatic to select scene change detection

**Frame Reordering:**  
- Uncheck for Baseline Profile  
- Check for Main with 1 B frame

**Encoding:**  
- Best - multi-pass  
- Faster - single-pass

**Optimized for:**  
- Streaming: CBR  
- Download: VBR



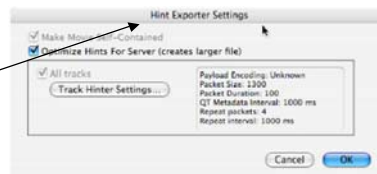
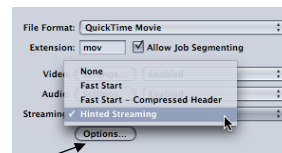
# Apple Compressor - Streaming Related Settings



**Streaming:**  
- None - disc based playback  
- Fast start - Compressed Header - web, no streaming server  
- Hinted Streaming: QuickTime Streaming Server

**Click here:**

**To open this:**



# Adobe Media Encoder - QuickTime Export



**Format:**  
 - QuickTime for MOV extension

**Set key Frame Distance**  
 (otherwise 30):

**Click Frame Reordering**  
 to enable B-frames

**Enter Hiner Track Settings**  
 (check "For Streaming Server"  
 in Alternates tab to make  
 these appear)

# Adobe Media Encoder - H.264 Export



**Format:**  
 - H.264 for devices

**Profile/Level:**  
 Set to desired parameters

**Set key Frame Distance**  
 (otherwise 30):

**Click Multiplexer tab:**  
 To access 3GPP or MP4  
 settings. MP4 has settings for  
 Standard, PSP and iPod

# Sorenson Squeeze



**Stream Type:**  
- Hint or not hint

**Codec:**  
Multiple H.264/MPEG-4  
codecs; MainConcept is the  
best (and the default in 5.0)

**Set key Frame Distance**  
Enable Auto Key

Stream Type: Streaming (Hinted) ☐ C

☒ Video ☐ Audio

Non-Streaming (Not Hinted)

Streaming (Hinted)

Codec: MainConcept H.264

Method: Sorenson MPEG4 Pro

Sorenson H.264

Data Rate: Apple H.264

Frame: MainConcept H.264

Key Frame Every: 300 frames

☒ Auto Key Frame on Scene Change

Rare  Frequent

# Sorenson Squeeze



**Profile:**  
- Baseline/Main/High

**Encoding Effort:**  
Next slide

**B-frames:**  
3 maximum

**CABAC Coding:**  
Yes/no

**Slices:**  
No impact on encoding time  
on 8-core HP workstation

AVC Profile: Main

Interface Mode: Progressive

Interface Mode: Top Field First

Encoding Effort: Fast

B-Frames: 3

CABAC Coding: Yes

Slices: 0

## Sorenson Squeeze

Encoding Effort	Fast
B-Frames	Best
CABAC Coding	Medium
	Fast

- Assume amalgam of search functions
- Best produces noticeably better quality in challenging scenes



**Best:** 63.23 to encode 1 minute file

**Fast:** 48:34 to encode 1 minute file

## Telestream Episode - General

**Keyframe control:**  
- Natural and Forced

**Reference frames:**  
- As normal (2-5)

**B-frames:**  
- As normal (2-3)

## Telestream Episode - Profile & Quality



**Profile:**  
- Baseline, Main and High

**Entropy Encoding:**  
- As normal

**Use Deblocking filter:**  
- Always

**Encoding Speed vs. Quality:**  
- Help file - values over 50 won't yield quality improvements

## Telestream Episode - Advanced



**Slices:**  
- Leave on auto

**All others:**  
- Retain at their defaults

## Inlet Fathom



**Video Compression**

Preset: H.264 Main\* (modified)

Encoding mode: VBR Constrained

Frame rate: 29.97 Key frame interval: 300 frames

Target bit rate: 800 Kbps

Profile: H.264 Main Level: 3.1

Peak bit rate: 1600 Kbps

Buffer size: 688 (msec) ☐ Buffer size in bytes

**Extended Parameters**

SliceArg	1
UseHadamardTransform	True
VBVBuFFullness	50
VideoFormat	Auto
VideoFullRange	False
VideoPulldownFlag	None
WeightedPrediction	True
WriteAUDelimiters	True
WriteSeqEndCode	True

- Provides full control over virtually all H.264 parameters
- No “abstraction,” so great ability to customize encoding parameters

## Rhozet Carbon Coder



**H.264 Encoder Settings-Basic**

Profile: Main

Level: 3.0

Enable Scene Change detection: ☒ Enable Scene Change detection

Size of Coded Video Sequence: 60

Number of B-Pictures: 2

Entropy coding mode: CAVLC

**H.264 Encoder Settings-Advanced**

Minimum IDR interval: 1

IDR frequency: 1

Use adaptive B-frame placement: ☒ Use adaptive B-frame placement

Reference B-Pictures: ☒ Reference B-Pictures

Allow pyramid B-frame coding: ☒ Allow pyramid B-frame coding

Reference frames: 2

Search shape: 8x8

Use fast inter and intra decisions: ☐ Use fast inter and intra decisions

Use fast multi-reference frame mo.: ☐ Use fast multi-reference frame motion estimation

Use fast sub-block motion estimat.: ☐ Use fast sub-block motion estimation

Use rate distortion optimization: ☒ Use rate distortion optimization

Use Hadamard transformation: ☒ Use Hadamard transformation

Motion estimation subpixel mode: Quarter pixel

Write Timestamps: ☒ Write Timestamps

Write Access Unit Delimiters: ☒ Write Access Unit Delimiters

Write Sequence End code: ☐ Write Sequence End code

- Same paradigm
- Direct access to critical parameters
- Minimal abstraction

## Encoding Tool Summary



- All present different parameters in different ways
- Generally two trade-offs
  - Trade encoding time for video quality
  - Trade quality (and perhaps encoding time) for decompression complexity
- Understand and categorize parameters, and apply them to your unique situation

## H.264 and MPEG-4 for Silverlight



Initial details  
Ben Waggoner



## Silverlight MPEG-4/H.264 Support



- Silverlight getting support for H.264 and AAC
  - First quarter of 2009
  - Silverlight 2 final release coming this fall
- MPEG-4 “.mp4” files via progressive download
  - IIS 7 Media Pack has great support for .mp4
    - Bitrate throttling so bits are delivered as needed
    - Web play lists to ensure content is played in order
  - Also .3gp, .f4v, and .mov files with compatible content

## Silverlight MPEG-4/H.264 Support



- H.264 and AAC muxed into ASF
  - Live/on-demand via Windows Media Services
  - Working with tool providers to add support
- Expression Encoder getting H.264 compression
  - Initially just device presets

## Why H.264?



- Microsoft's history with H.264
  - We've been involved with H.264 since its inception
  - Dr. Gary Sullivan has been chair or co-chair of H.264 effort for years
    - On team that won an Emmy for H.264 High Profile
  - We participate in both patent pools
  - H.264 already supported in MediaRoom, Xbox, and Zune
  - Silverlight aims to offer support for all RIA scenarios
  - Lots of customers have H.264 libraries they want to play in Silverlight

## What about VC-1?



- What about Windows Media and VC-1?
  - Windows Media better than ever in Silverlight
    - Improved performance, Windows Media DRM support in Silverlight 2
  - Continuing to roll out VC-1 Encoder SDK for better VC-1 quality/speed
  - WMV and VC-1 are the best media formats built into Windows

## Accessing YouTube's New HQ Mode



- New HQ mode recently launched
- Upload requirements
- Producing the optimal file
- Playback requirements

## New HQ Mode



## New HQ Mode



## New HQ Mode - Compared



	Low Quality	High Quality
Codec	Spark (H.263)	Spark (H.263)
Encoded Resolution	320x240	480x360
Displayed resolution	480x360	480x360
Data rate	329 kbps	628 kbps
Frame rate	SAS	SAS
Audio	64 kbps, mono	96 kbps, mono

HQ - <http://www.youtube.com/watch?v=8E7pxSJXeHc>

LQ - <http://www.youtube.com/watch?v=1DNGgZdM-k8>

## Accessing HD Mode



- Upload file with resolution of 480x360 or higher
  - Still 10 minute limit, which means max per second data rate of 13 mbps
- New 1 GB limit for uploaded file

## Suggested Parameters



Video-Basic	
Width	480
Height	360
Frame Rate(fps)	29.97
Aspect Ratio	Video: [4 : 3], Pixel: [1 : 1]
Interlacing	Non-Interlaced
Bitrate	
Video Bitrate mode	VBR
Number of passes	2 pass
Video Bitrate(kbps)	6000
Maximum bitrate(kbps)	12000
H.264 Encoder Settings-B...	
Profile	Main
Level	3.1
Size of Coded Video Sequ.	300
Number of B-Pictures	2
Entropy coding mode	CABAC
Audio-Basic	
Use Audio	Use if Exist
Audio compression	HE-AAC version 1
Bits / Sample	16
Channels	Mono
Sample Rate(kHz)	48.000
Audio Bitrate(kbps)	64

- Codec - H.264
- Rez - 480x360
- Data rate - 6 mbps (max)
- Audio
  - Mono, 96 kbps max
- Other details as shown

## Viewing the HQ Version - While Playing



High Quality Test



## Viewing the HQ Version - Configuration Options



### [My Account](#) / **Video Playback Quality**

You can choose the playback quality of the videos you watch; the default is to let YouTube choose. If you're always on a fast connection, you may want to choose the setting which corresponds to your usual speed.

[Email Options](#)  
[Personal Profile](#)  
[Blog Posting Settings](#)  
[Mobile Profile](#)  
[Mobile Video Upload Settings](#)  
[Change Password](#)  
[Active Sharing](#)  
[Authorized Sites](#)

Save Settings

Choose the default setting for viewing videos

- ☐ Choose my video quality dynamically based on the current connection speed.
- ☐ I have a slow connection. Never play higher-quality video.
- ☒ I have a fast connection. Always play higher-quality video when it's available.

Save Settings

## Questions?

- Thanks for coming

