Encoding H.264 Video for Streaming and Progressive Download

Jan Ozer
www.streaminglearningcenter.com
jozer@mindspring.com/
276-238-9135

Agenda

- Generic encoding parameters
- Understanding H.264 encoding parameters
- Producing H.264 video for computer playback
- Producing H.264 for iTunes
- Encoding for the iPad/iPhone
- Comparing the H.264 codecs
- If you see red – pay attention

Generic Encoding Parameters

- Terms and techniques
  - Bandwidth and data rate
  - Constant and variable bit rate encoding

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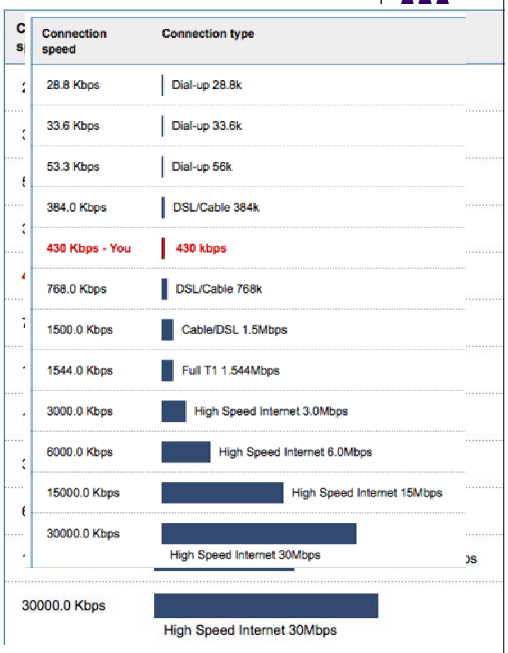
Bandwidth

- Viewer's connection speed to the Internet
- Other relevant speeds
  - Mobile broadband ~ 1.4 gbps



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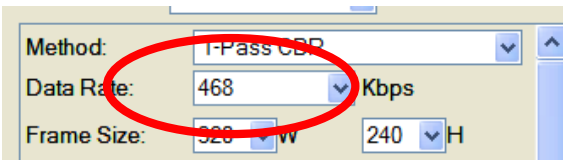
Cellular Bandwidths

Gen	Maximum and Typical Throughput
1G	9.6/14.4
2G	9.6/14.4
2.5G	171 kbps (20 - 40 k)
3G	3.1 mbps peak, 500 - 700 kbps (144 kbps - fast motion, 384 kbps low motion, 2mbps - still)
3.5G	up to 3.6/7.2/14.4 mbps 1-3 mbps on average
4G	100-300 mbps 3-5 mbps when moving

What is Data Rate?

- Every time you produce a streaming file, you have to choose a data rate
  - Considerations - quality, cost, viewer bandwidth
- Uncompressed video is very, very large, to bulky to efficiently deliver - so you have to compress a lot!



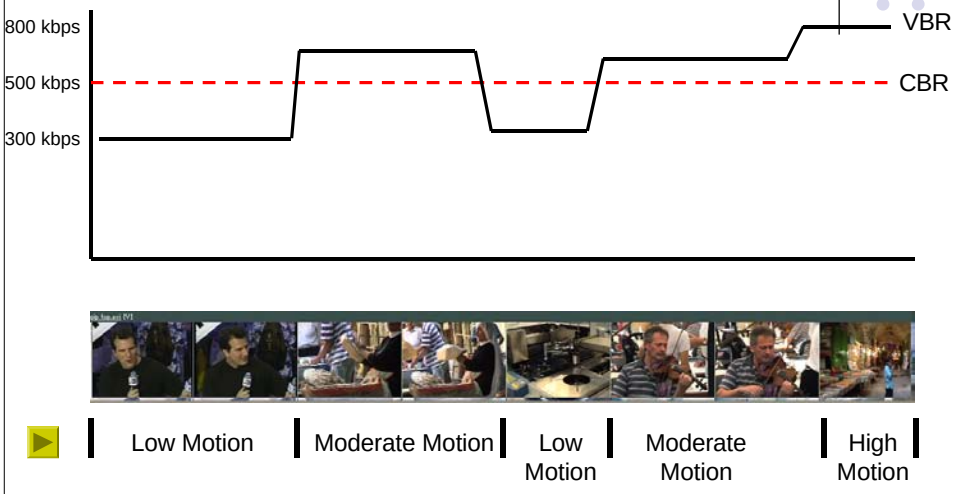
What's Compression?

- To achieve the target data rate, you have to compress
- Compression is "lossy," the more you compress, the more you lose
  - This is immutable

Bitrate Control

- Techniques for achieving your target data rate
  - Constant bit rate encoding (CBR)
  - Variable bit rate encoding (VBR)

Constant vs Variable Bit Rate



Low Motion | Moderate Motion | Low Motion | Moderate Motion | High Motion

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Constant vs Variable Bit Rate

- Constant Bit Rate (CBR)
  - One bit rate applied to entire video, irrespective of content
- Pros:
  - Computationally easy
  - Fast - one pass will do it
- Cons: Doesn't optimize quality

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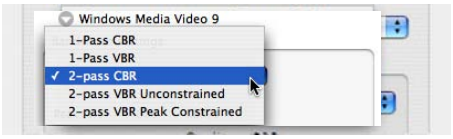
Constant vs Variable Bit Rate

- Variable Bit Rate (VBR)
  - Dynamic bit rate matches motion in video
- Pros: Best quality
- Cons:
  - Need two or more passes
  - Can produce erratic stream

When Should I Use VBR/CBR?

- Traditional
  - CBR for streaming
  - CBR for cellular
  - CBR for live
  - VBR for progressive delivery
- In practice today
  - Constrained VBR for most streaming applications
    - Broadband has sufficient headroom to handle spikes
  - Constrained VBR for virtually all progressive delivery
  - Constrained VBR for most cellular connections, though not universally
  - CBR for live, particularly when constrained

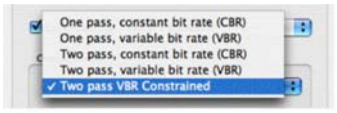
How do I Produce the Best Quality CBR?

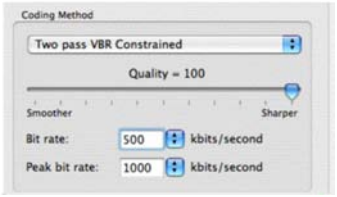


- Use 2-pass CBR when available
  - Scans file (like VBR), but packs data into a consistent stream
  - Best of both worlds when available
- 1-pass of live or draft work

How Do I Produce the Optimal VBR File?

- 2 passes or more
- Use "Constrained"
  - Constrains to data rate to specified max
- Set Target and Max/Min
  - Overall target – 500 kbps
  - Max/Peak bit rate – how high rate can go when varying
    - Rule of thumb is 1.5 - 2X of target
    - If minimum setting, use .5x





H.264 Specific Parameters

- Introduction to H.264
- Common H.264 encoding parameters
  - Theory and application

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)

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

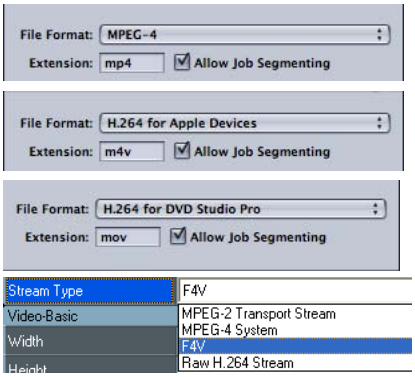
- Adapted by ISO and ITU
  - Telephony/cellular
  - TV - consumer electronics
  - Computer electronics
- Only codec adopted by top three streaming providers (Apple, Adobe, Microsoft)

What's H.264 Cost?

- For free Internet video (e.g. no subscription or pay per view), free in perpetuity
  - Still technically a licensing obligation, but there are no teeth and no motivation to enforce
- For subscription or PPV, there may be a royalty obligation
- Check www.mpeg-la.com

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



H.264 Encoding Parameters

- The basics
- Stream related options
- Search related options
- Miscellaneous options

H.264 Encoding - The Basics

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

Which Profile?

Which Profile?

- Critical to know your target profile before encoding
  - Device
    - iPod/iPhone - always Baseline
    - iPad - Main
  - Computer playback - High for all targets
- Issues to consider
  - iPad/iPhone/iPod Touch – one file for all, use Baseline
  - Computer/iPad - use Main

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

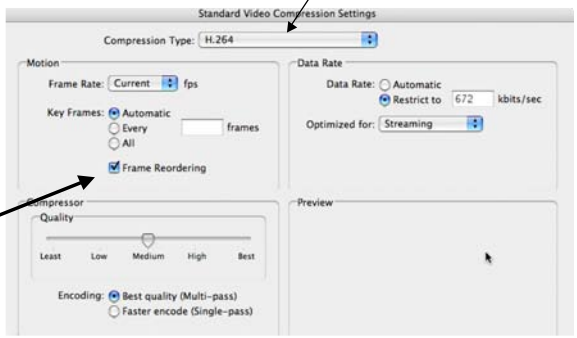
- Primarily an issue when encoding for devices
  - Must ensure that encoding parameters are within target *level* (most templates do this); otherwise video won't load onto the device
- For computer playback,
  - Flash/QuickTime/SL/HTML5 can play ALL levels of ALL supported profiles – so level isn't a concern
  - Rather, it's can the computer play the file as configured
    - A netbook will try to load a 1080p file encoded for Flash
    - Flash Player won't complain
    - But playback won't be pretty

H.264 Levels – Bottom Line

- With devices, choosing the right profile and level is critical
- With computers, profiles and levels don't determine whether the file will load or play well
- Rather, you have to choose a resolution and data rate that will play smoothly on your targets

Apple Compressor - Compression Settings

- Available options and presentation varies by encoding tool
- Apple's is very simple



Compression Type: Choose codec here

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

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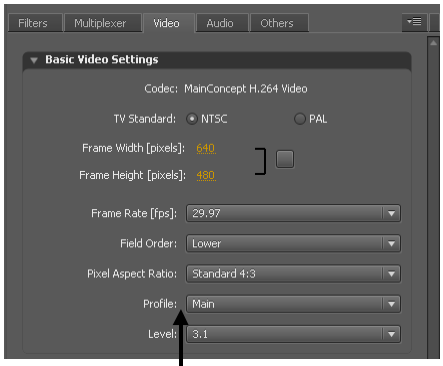
AME - Compression Settings

- Adobe lets you choose Profile and level directly
- If level too low for selected encoding parameters, you'll see an error message
  - Just increase the level until the error message goes away



Profile/Level:

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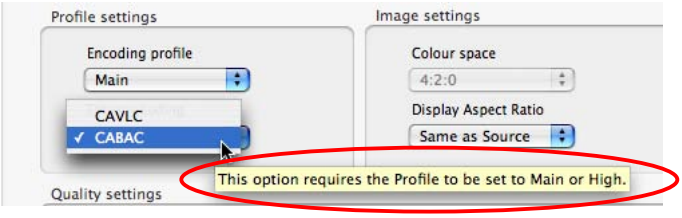
Entropy Encoding



- 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

CABAC CAVLC

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

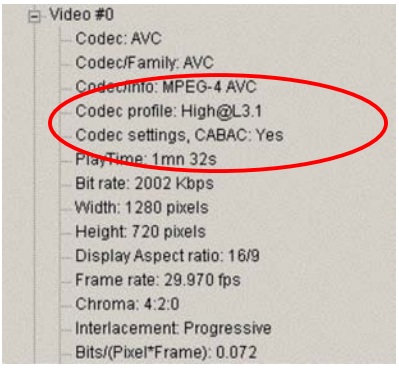
CABAC vs CAVLC Performance

Playback 720p files	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

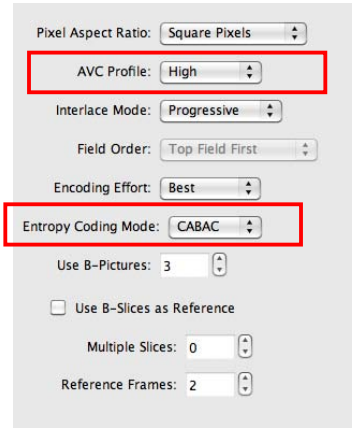
- Does increase playback requirements slightly on lower power computers
- My recommendation:
  - Always enable CABAC

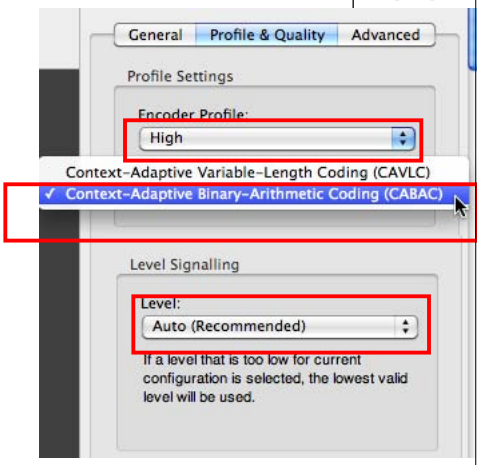
Reality Check - YouTube 720P

- High Profile
- CABAC



Profile/CABAC in Squeeze and Episode





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Deep Dive into H.264 Parameters

- Caveats:
  - Presented differently by each encoding tool
  - Will only cover most critical and most common parameters
- To understand *your* encoder
  - Read manual/help file to understand parameters and their trade-offs; generally
    - Encoding time vs. quality
    - Complexity (and encoding time) vs. quality

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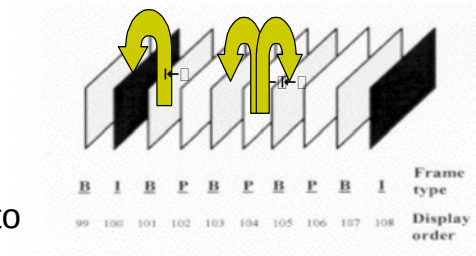
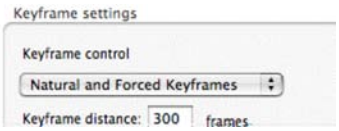
What are I, B and P Frames?



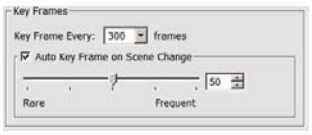
- I-Frame - encoded without reference to other frames (also called Key Frames)
- P - looks backward to I and P frames (predictive)
- B - looks forward and backward to previous I and P frames (Bi-directional interpolated)
  - No frames refer to B-Frame (most of the time)

What do I Need to Know About Key Frames?

- Least efficient – so largest (which is bad)
- But, key frames enhance interactivity
  - All playback starts on a key frame
  - When seeking to random frame, must start playback at key frame
  - Maximum interval should be 5-10 seconds



- Key frames "reset" quality:
  - Useful at scene changes
  - Enable natural key frames or key frames at scene changes



What do I Need to Know About B Frames?

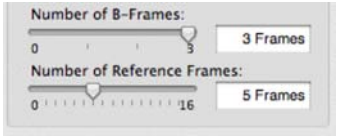
- The most “efficient” frame
  - So improves quality (comparisons to come)
- Hardest to decode
  - Decoder has to have all referenced frames in memory to decode B-frame
  - Frame usually delivered out of order, which also complicates playback

B-frames - Yes/No

B-frames - Yes/No

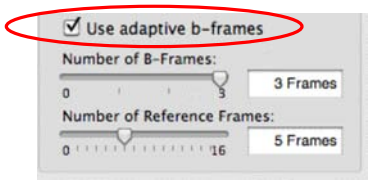
- Noticeable quality improvement
- 5-10% increase in decompression CPU load
- Recommend
  - Say “YES” to B-frames
  - 3 is a good number for real world video
  - Experiment with higher numbers with animations

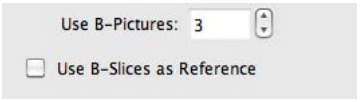
Typical B-Frame Encoding Parameters



- Number is number of B frames between I and P-Frames; (IBBBPBBBPBBBPBBBP)
  - 3 is recommended
- Reference frames
  - Number of frames searched for redundancies
  - 5 is recommended setting

Advanced B-frame Options



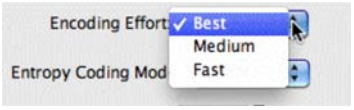


- Adaptive B-frames -
  - Will change order if it will improve quality (e.g. insert a key frame at a scene change)
- B-slice as reference
  - Allow B-frames to be reference frames for P-frames
  - Some quality improvement, can cause playback issues on low power devices

Search Related Options

- Searching for redundancies; Juggle multiple factors
  - Reference frames (covered)
  - Search shape (8x8/16x16) – size of shape used for searching (smaller is more accurate
  - Sub-pixel mode – (full/half/quarter pixel) – smaller is more accurate
- In general, increase encoding time with potential to improve quality
- Most encoding tools don't show; those that do conglomerate functions into one control

Sorenson Squeeze - Effort Matters



- Fast/Medium/Best settings controls unspecified search and other parameters
  - Substantial difference in time and quality
    - Fast - 8:10
    - Best - 18:37
- Use Fast for draft work
- Use Best for final unless time constrained

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Sorenson Squeeze - Effort Matters

Episode – Not so Much

- Help file: “In general, values over 50 yield very small improvements in visible image quality."
- My tests confirmed those results:
  - Encoding time at 50 - 3:33
  - Encoding time at 100 - 8:03
- Difference noticeable on only one video within test sequence

Search Related Options

- Other tools
  - Compressor/Adobe Media Encoder – no search related Options
  - High end tools – Rhozet Carbon Coder, Inlet Fathom
    - Unique controls; check help file

Slices

- Slices (Episode and Squeeze)
  - Divides frames into segments to speed encoding
  - Can't search between slices
  - Can reduce quality
  - Set to lowest value (either 0 or 1)

H.264 Specific Encoding Tutorials

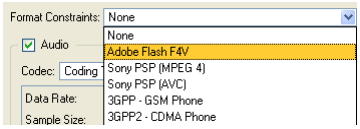
- Understanding key H.264 Encoding Parameters
  - http://www.vimeo.com/5377029
- Apple Compressor
  - http://vimeo.com/5462108
- Adobe Media Encoder CS4
  - http://www.vimeo.com/5118579
- Sorenson Squeeze
  - http://www.vimeo.com/5279015
- Telestream Episode Pro
  - http://www.streaminglearningcenter.com/articles/producing-h264-files-for-flash-distribution-with-telestream-episode-pro.html

Producing H.264 Video for Computer Playback

- Format specific considerations
  - Flash
  - QuickTime
  - Silverlight
  - HTML5
- Optimizing for computer playback

Flash and H.264

- Flash Player 9 Update 3 contained:
  - Software H.264 decoder (Baseline/Main/High profiles)
  - AAC decoder
- 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

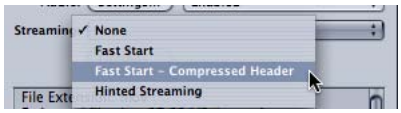


Flash Player 10.1

- Uses the GPU to accelerate H.264 playback, but not VP6
- If looking for a reason to switch over to H.264, this is it!
  - Especially considering no-royalty policy

Producing for QuickTime

- Customizing for QuickTime Streaming
  - When distributing via a QuickTime streaming server, use for Hinted Streaming
- For progressive download, use Fast Start
  - Otherwise file may completely download before playing
  - Don't use Compressed Header, can make incompatible with Flash/Silverlight



Don't use Compressed Header, can make incompatible with Flash/Silverlight

Producing for Silverlight

- File requirements
  - Self-contained .mp4 (including .f4v and .m4a) and .mov file formats
  - Simple, Main, and High 4:2:0 profiles (progressive only)
  - AAC-LC audio mono or stereo (HE AAC will play back with lower fidelity, as in QuickTime)
  - Local files or http progressive download.
- Or, sliced another way, Silverlight 3 will play pretty much all MPEG-4 files that would play back well in both QuickTime and Flash.

http://blogs.iis.net/benwagg/archive/2009/03/18/silverlight-3-beta-what-s-new-for-media.aspx

Producing for HTML5

- All browsers create own players, no specifications (that I could find)
  - Baseline, Main, High all supported up to 1080p
- Best practice seems to be an MP4 file since F4V or MOV could trigger Flash or QuickTime players

Optimizing H.264 for Computer Playback

- Perspective
  - We understand H.264 encoding params
  - We understand QuickTime/Flash/SL/ HTML5 specifics
- Now we learn how to configure a stream that will smoothly play on the platforms you care about

Flash H.264 Playback - Windows

Windows	Mobile			Desktop		
Launched	2004	2007	2008	2003	2006	2006
Computer	Dell Latitude D800	HP mobile 8710p	Acer Aspire One	HP xw4100	HP xw 4300	Precision 390
CPU	1.6 GHz Pentium M	2.2 GHz Intel Core 2 Duo	1.60 GHz Intel Atom	3 GHz Pentium 4	3.4 GHz Pentium D	2.93 GHz Core 2 Duo
GPU	GeForce 4200	Quadro FX 1600M	Intel 945 Express	Quadro4 380XGL	Quadro FX 3450	Quadro FX 3500
320x240	38	12	37	21	4	2
480x360	63	14	37	28	9	5
640x360	75	14	35	36	12	6
640x480	79	17	57	40	15	8
848x480	NA	16	NA	49	18	10
720p	NA	27	NA	78	41	24

www.doceo.com/playback/Main.html

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Flash H.264 Playback - Mac

Mac			
Launched	2005 (est)	2007	2009
Computer	Dual G5 PPC	iMac	MacBook Pro
CPU	Dual 2.7 GHz	2.0 GHz Core	3.06 GHz
GPU	GeForce 6800	ATI Radeon	NVIDIA
320x240	23	22	17
480x360	27	33	17
640x360	31	30	28
640x480	37	33	24
848x480	43	34	39
720p	73	53	56

www.doceo.com/playback/Main.html

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Compared to Other Codecs (for those considering a switch)

	Flash VP6E	Flash VP6S	Flash H.264	Silverlight VC-1
HP 8710P, 2.2 GHz Core 2 Duo CPU utilization	45.7%	49.8%	24.4%	42.8%
MacBook Pro, 3.06 GHz Core 2 Duo CPU utilization	39.1%	39.3%	22.9%	37.0%

- With hardware acceleration available, H.264 is clearly the most efficient codec
- You can switch from VP6/VC-1 and not worry about requiring a higher end playback platform

Flash H.264 Compared to Silverlight

	SL-VC1	SL-H.264	Flash H.264
HP 8710P, 2.2 GHz Core 2 Duo CPU utilization	42.8%	40.0%	24.4%
MacBook Pro, 3.06 GHz Core 2 Duo CPU utilization	37.0%	44.0%	22.9%

- In my tests, H.264-based Silverlight was about the same as VC-1
- Flash was more efficient
- Don't have comparative data on how how Flash GPU acceleration compares to SL

H.264 Compared to Other Codecs – No GPU Acceleration

- 720p playback tests
- H.264 requires less CPU to playback than VP6 or Silverlight (pre- Flash GPU acceleration)

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

Choosing your Configuration

- Now we know what plays on our targets
  - How H.264 compares to others
- How should we configure our video?
  - Choosing your resolution/frame rate
  - Choosing your video data rate
  - Choosing your audio configuration

Choosing Resolution

- What the media tells us
- What corporations tell us
  - B2C
  - B2B

What the Media Tells Us

Networks	Width	Height	Total Pixels	Frame Rate
News (5 of 7 16:9)	577	352	206,757	30
Sports (4 of 4 16:9)	613	345	211,920	27
Full episodes (7 of 8 16:9)	627	367	232,182	28
Excerpts/Previews/Other (3 of 4 16:9)	609	343	210,346	30

- Observations
  - News tends to be a bit smaller
  - 16:9 is now the norm
  - **640x360 is the new 320x240**
  - Full frame rate is the norm - all 24/29.97/30

What European Media Tells Us

BBC	Width	Height	Total Pixels	Frame Rate
MyChannelOne	480	268	128,640	25
Financial Times	480	270	129,600	25
BBC News	512	288	147,456	25
Average	**491**	**275**	**135,232**	**25**
BBC Sports	640	360	230,400	25
Sky 1 -	640	360	230,400	25
Telegraph.co.uk	640	360	230,400	25
Channel 4	720	406	292,320	25
Average	**660**	**372**	**245,880**	**25**

- Observations
  - Most European sites prohibit viewing from US :-(
  - 480x268 is the smallest/640x360 is most commonly used
  - All 25 fps

What B2C Tells Us

B2C Brands	Width	Height	Total Pixels	Frame Rate
Conservative (4)	549	307	169,680	26
Mid-range (7)	658	371	244,777	27
Aggressive (6)	949	497	474,047	25

- Who are they? (Nike, Coke, Porsche, Burberry, 17 total)
- Conclusions:
  - Range of resolutions, from 480x268 to 1024x572
  - Most at full frame rate (all 24, 25 or 30)
  - Most also 16:9

What B2B Tells Us

B2B Brands	Width	Height	Total Pixels	Frame Rate
HP	480	360	172,800	29.97
UPS	640	360	230,400	29.97
Fedex	638	480	306,240	30
Adobe	768	432	331,776	30
Cisco	902	507	457,314	30
GE	934	524	489,416	30
Average	**727**	**444**	**331,324**	**30**

- Conclusions:
  - Range of resolutions, starting at 480x360, most 640x360 or larger
  - All full frame rate (15 fps is dead)
  - Some 4:3, most 16:9

What EURO Corps Tell Us

European sites (15 total)	Width	Height	Total Pixels	Frame Rate
Conservative (9)	440	273	123,343	24
Mid-range (4)	692	389	269,599	25
Aggressive (2)	692	450	309,468	25

- Conclusions:
  - Generally more conservative than US
  - Almost exclusively 16:9
  - 1 of 15 used 15 fps, the rest were 24/25/30

Synthesis

Organization	Minimum	Recommend	Frame Rate
Media - US News	480x270	640x360	full
Media - US Other	640x360	640x360	full
Media - UK (sorry)	480x270	640x360	full
B2C - US	480x270	640x360 plus	full
B2B - US	480x270	640x360 plus	full
Euro Corp	320x240	640x360 plus	full

- Size should match content
  - Interviews, statements, etc - OK at 640x360 and smaller (like US new organizations)
  - B2C product videos (L'Oreal - 686x386) should go big

What Data Rate?

- Understanding bits/pixel
- Lessons from the field
- Synthesis

Bits Per Pixel

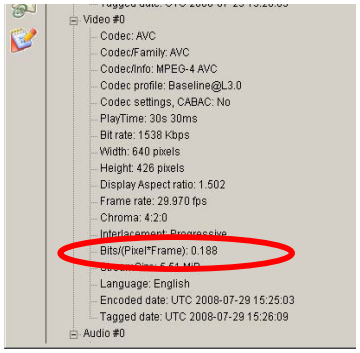
- What is it?
  - A measure of how much data is allocated per pixel of the compressed file
- Why useful?
  - Allows us to compare data rates for files with different resolutions

	Width	Height	Total Pixels	Frame Rate	Video Data Rate	Bits per pixel
Adobe	768	432	331,776	30	650	0.07
Cisco	902	507	457,314	30	700	0.05
HP	480	360	172,800	29.97	550	0.11
GE	934	524	489,416	30	1200	0.08
UPS	640	360	230,400	29.97	800	0.12
Fedex	638	480	306,240	30	917	0.10

Calculating Bits Per Pixel

- Formula
  - Data rate / (pixels x frame rate)
- Or, get MediaInfo, a free file analysis tool

mediainfo.sourceforge.net/en



Lessons from the Field - US Media

Networks	Width	Height	Total Pixels	Frame Rate	Video Data Rate	Bits per pixel	Range
News (7 samples)	577	352	206,757	30	536	0.092	.076 - .130
Sports (4 samples)	613	345	211,920	27	803	0.141	.085 - .179
Full episodes (8 samples)	627	367	232,182	28	866	0.132	.075 - .201
Excerpts/Previews/Other (4 samples)	609	343	210,346	30	777	0.118	.058 - .174

- Observations
  - News (low motion) is lower than sports (high motion)
  - Full episodes (presumed broadcast quality?) around .132

Lessons from the Field - US B2C

B2C Brands	Width	Height	Total Pixels	Frame Rate	Video Data Rate	Bits per pixel	Range
Conservative (4)	549	307	169,680	26	721	0.154	.08 - .27
Mid-range (7)	658	371	244,777	27	579	0.091	.04 - .14
Aggressive (6)	949	497	474,047	25	1,814	0.177	.04 - .44

- Observations
  - Much greater range than networks (only one network site was greater than .2)
  - Buick @ .44, Ford @ .27 and Apple @ .26 were outliers - take these out and overall average drops from .177 to .098

Lessons from the Field - US B2B

B2B Brands	Width	Height	Total Pixels	Frame Rate	Video Data Rate	Bits per pixel
HP	480	360	172,800	29.97	550	0.11
UPS	640	360	230,400	29.97	800	0.12
Fedex	638	480	306,240	30	917	0.10
Adobe	768	432	331,776	30	650	0.07
Cisco	902	507	457,314	30	700	0.05
GE	934	524	489,416	30	1200	0.08
Average	**727**	**444**	**331,324**	**30**	**803**	**0.087**

- Smaller sample, more conservative range

Lessons from the Euro Zone

European sites	Width	Height	Total Pixels	Frame Rate	Video Data Rate	Bits per pixel	Range
Media - Conservative (3)	491	275	135,232	25	551	0.167	.079 - .262
Media - Mid (4)	660	372	245,880	25	1,022	0.170	.115 - .224
Corp - Conservative (9)	440	273	123,343	24	484	0.163	.095 - .292
Corp - Mid-range (4)	692	389	269,599	25	667	0.101	.055 - .139
Corp - Aggressive (2)	692	450	309,468	25	712	0.092	.052 -.131

- Bits per pixel averages range from .092 to .17
  - Corporate bits per pixel goes down as resolution increases

Data Rate Synthesis - Media

- US media sites range from .075 (Disney) to .201 (USA Networks)/Euro is .079 (BBC News) to .262 (My Channel One).
- Average is around .12 US/.168 Euro
  - US News (low motion) averages .092
  - US Sports (high motion) averages .141
  - Prime time episodes average .132
- Going much higher or lower than these averages could either result in ugly video or wasted bandwidth costs

Data Rate Synthesis - Other

- US Corps range from .04 to .44/Euro ranges from .052 to .292.
- US corps average .141/Euro .118
- Value proposition of corporate video is different
  - Media - are entertaining or informing - viewers *want to* watch
  - Corps are generally selling something - we *want* people to watch - quality standard is a little higher
- Start at averages:
  - Increase to achieve good quality
  - Decrease until artifacts appear, then back off

Perspective

- Most sites included in the survey used VP6, not H.264
- H.264 should deliver the same quality at a data rate of 5 - 10% less
- Figures should be considered conservative
  - If shooting for averages, start about 10% less
  - Should stay away from maximums

Recommended Application

- Choose a target resolution
- Choose a reasonable bits per pixel
  - Low motion - start at .1
  - High motion - start at .15
  - Adjust target for larger sizes
    - 848x480 - reduce by 10% (eg. from .1 to .09)
    - 720p - reduce by 20% (eg. from .1 to .08)
    - 1080p - reduce by 30% (eg. from .1 to .07)
- Test and see

Cheat Sheet - 29.97/30 fps

				Data rate at this bits/pixel				
Width	Height	Total Pixels	Frame Rate	0.080	0.100	0.125	0.150	0.175
480	270	129,600	29.97	310,729	388,411	485,514	582,617	679,720
640	360	230,400	29.97	552,407	690,509	863,136	1,035,763	1,208,390
848	480	407,040	29.97	975,919	1,219,899	1,524,874	1,829,848	2,134,823
1280	720	921,600	29.97	2,209,628	2,762,035	3,452,544	4,143,053	4,833,562
1920	1080	2,073,600	29.97	4,971,663	6,214,579	7,768,224	9,321,869	10,875,514
320	240	76,800	29.97	184,136	230,170	287,712	345,254	402,797
400	300	120,000	29.97	287,712	359,640	449,550	539,460	629,370
480	360	172,800	29.97	414,305	517,882	647,352	776,822	906,293
640	480	307,200	29.97	736,543	920,678	1,150,848	1,381,018	1,611,187

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Cheat Sheet - 24 fps

				Data rate at this bits/pixel				
Width	Height	Total Pixels	Frame Rate	0.080	0.100	0.125	0.150	0.175
480	270	129,600	24	248,832	311,040	388,800	466,560	544,320
640	360	230,400	24	442,368	552,960	691,200	829,440	967,680
848	480	407,040	24	781,517	976,896	1,221,120	1,465,344	1,709,568
1280	720	921,600	24	1,769,472	2,211,840	2,764,800	3,317,760	3,870,720
1920	1080	2,073,600	24	3,981,312	4,976,640	6,220,800	7,464,960	8,709,120
320	240	76,800	24	147,456	184,320	230,400	276,480	322,560
400	300	120,000	24	230,400	288,000	360,000	432,000	504,000
480	360	172,800	24	331,776	414,720	518,400	622,080	725,760
640	480	307,200	24	589,824	737,280	921,600	1,105,920	1,290,240

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Cheat Sheet - 25 fps

Horizontal	Vertical	Total Pixels	Frame Rate	Data rate at this bits/pixel				
				0.080	0.100	0.125	0.150	0.175
480	270	129,600	25	259,200	324,000	405,000	486,000	567,000
640	360	230,400	25	460,800	576,000	720,000	864,000	1,008,000
848	480	407,040	25	814,080	1,017,600	1,272,000	1,526,400	1,780,800
1280	720	921,600	25	1,843,200	2,304,000	2,880,000	3,456,000	4,032,000
1920	1080	2,073,600	25	4,147,200	5,184,000	6,480,000	7,776,000	9,072,000
320	240	76,800	25	153,600	192,000	240,000	288,000	336,000
400	300	120,000	25	240,000	300,000	375,000	450,000	525,000
480	360	172,800	25	345,600	432,000	540,000	648,000	756,000
640	480	307,200	25	614,400	768,000	960,000	1,152,000	1,344,000

Adaptive Bitrate Streaming

- What it is
- Why you care
- Alternatives

Adaptive Bitrate Streaming

- Concept
  - Customize experience for viewer device and bandwidth
    - High power/high bandwidth – great experience
    - Love power/low bandwidth – lesser experience, but it plays
  - Adapt to changing conditions
  - All transparent to the viewer

Major League Baseball

- Example
  - MLB offers 11 streams in subscription service
  - Intelligent player
    - Monitors CPU
    - Monitors buffer level
  - System adjusts speed to ensure optimal quality stream

Advantages of Adaptive Bitrate Streaming

- Enables highest quality viewing experience
  - Can create very high quality streams because the system will shift to lower quality if required
  - Rewards high performance/high bitrate consumers while not penalizing those at the other end of the spectrum

Who's Using

- According to a recent Streaming Media Survey
  - 38% of all Flash-driven sites used Adobe's adaptive streaming (called Dynamic Streaming)
  - 45% of Silverlight-driven sites used Microsoft's adaptive streaming (called Smooth Streaming)
- Even more important when delivering to mobile viewers (cellular or Wi-Fi) because of potential low effective throughput

Alternatives

- Multiple options
  - Adobe's Dynamic Streaming
  - Move Networks Adaptive Streaming
  - Microsoft's Smooth Streaming
  - Apple's HTTP Live Streaming
    - Only option to iPhone/iPad/iPod Touch
  - H.264 Scalable Video Coding -
  - Akamai HTTP HD Streaming
  - Adobe HTTP streaming

Adaptive Streaming - Summary

- Enables higher quality of service to high and low bit rate customers
- Is currently used on a significant number of web sites and usage will increase with mobile support
- If you're not implementing this now, it needs to be on your short term technology agenda

Encoding for Adaptive Bitrate Streaming

- Varies by technology. In general:
  - Use shorter key frame intervals – 2-3 seconds
  - Key frame interval should be identical for all streams (except Apple)
  - Audio config should be the same (to avoid popping)
  - Can be VBR or CBR
- See:
  - http://www.streaminglearningcenter.com/blogs/encoding-for-adaptive-streaming---an-overview.html

Optimizing for Devices

- iDevice Spec Overview
- Tethered delivery (iTunes)
  - Low resolution iDevices
  - High resolution iDevices
- WiFi/3G
  - Multiple file delivery
  - Single file delivery

iDevice Specification Overview

	Original iPod (pre-5g)	iPod Nano/Classic	iPod Touch/ iPhone	iPhone 4/iPod Touch	iPad
Screen res.	**320x240**	**320x240**	**480x320**	**960x640**	**1024x768**
Aspect ratio	**4:3**	**4:3**	**16:9-ish**	**16:9-ish**	**4:3**
Video codec	H.264	H.264	H.264	H.264	H.264
Max data rate	768 kbps	2.5 Mbps	2.5 Mbps	14 Mbps	14 Mbps
Resolution	**320x240**	**640x480**	**640x480**	**720p**	**720p**
Frame rate	30 fps	30 fps	30 fps	30	30
Profile/Level	**Baseline** to Level 1.3	**Baseline** to Level 3.0	**Baseline** to Level 3.0	**Main to Level 3.1**	**Main to Level 3.1**
Audio codec	AAC-LC	AAC-LC	AAC-LC	AAC-LC	AAC-LC
Data rate	160 kbps	160 kbps	160 kbps	320 kbps	320 kbps
Audio params	48 kHz, stereo	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	m4v/mp4/mov

Tethered Deliver via iTunes

- Decisions, decisions
- Survey results
- Recommended encoding parameters
  - 320x240
  - 640x360
  - 720p

Decision Time

- Decision 1:
  - Abandon older iPods that supports only 320x240?
- Decision 2:
  - Support low and high resolution iDevices with single max 640x480 stream?
- Decision 3:
  - Distribute multiple files?

iTunes Survey

- 48 files from 34 different producers
  - Three letter networks
  - Prominent technology and other popular sites
  - Featured podcasts
  - All FREE downloads

Findings

- Abandon 320x240?
  - Only 9 of 48 produced at 320x240 or lower
  - 1 produced at 640x480 with MPEG-4 codec
    - Lower quality, but should play on older devices
- Go exclusively big screen?
  - 11 of 12 producing at 720p also produced at 640x480 or lower
  - If you go big, you should also go small
- Distribute multiple files?
  - 12 produced **same show** in different sizes
  - 4 others produced **different shows** in different sizes
  - 18 were single size only

Encoding Parameters - 320x240

	320x240 - Compressor	Survey
Video codec	H.264 codec, Baseline profile	H.264 codec, Baseline profile
Data rate average/max	600/768 kbps	528 kbps (average)
Key frames	120	120
Frame rate	match source	match source
Audio	AAC Low	AAC Low
Data rate	128 kbps/stereo	111 kbps/stereo
Extension	.mv4	.mv4

- Compressor preset is realistic

Encoding Parameters - 640x360

	640x480 - Compressor	Survey
Video codec	H.264 codec, Baseline profile	H.264 codec, Baseline profile
Data rate average/max	1.5/2.5 mbps	1.319 mbps
Key frames	120	120
Frame rate	match source	match source
Audio	AAC Low	AAC Low
Data rate	128 kbps/stereo	114 kbps/stereo
Extension	.mv4	.mv4

- Compressor preset is realistic

Encoding Parameters - 720p

	720p - Compressor	Survey
Video codec	H.264 codec, Baseline profile	H.264 codec, 11 of 12 are Main or High profile
Data rate average/max	10/14 mbps	2.845 mbps
Key frames	120	120
Frame rate	match source	match source
Audio	AAC Low	AAC Low
Data rate	256 kbps/stereo	134 kbps/stereo
Extension	.mv4	.mv4

- Compressor preset is probably too high for both audio and video

Producing for the iPhone/ iTouch for Cellular or WiFi Delivery

- Using Apple's HTTP Live Streaming
- Static file delivery

HTTP Live Streaming

- Apple spec released in June, 2009
  - Live and on-demand
- HTTP technology
  - No streaming server needed
  - Works only with iPhone/iPod Touch/iPad
  - Macs with QuickTime X (Snow Leopard only) with no Windows component
    - Pretty much device-only solution

HTTP Live Streaming

- Apple Tech Note is best source
  - http://developer.apple.com/iphone/library/technotes/tn2010/tn2224.html#
  - Guides for iPad only, iPhone only and iPhone/iPad combined delivery (iPad below)

iPad								
16:9 Aspect Ratio								
	Dimensions	Frame Rate *	Total Bit Rate	Video Bit Rate	Audio Bit Rate	Audio Sample Rate	Keyframe	Restrict Profile to:
CELL	480x320	na	64**	na	40	22.05	na	na
CELL	400x224	10	150	110	40	22.05	30	Baseline, 3.0
CELL	400x224	12 to 15	240	200	40	22.05	45	Baseline, 3.0
CELL	400x224	29.97	440	400	40	22.05	90	Baseline, 3.0
WIFI	640x360	29.97	640	600	40	22.05	90	Baseline, 3.0
WIFI	640x360	29.97	840	800	40	22.05	90	Main, 3.1
WIFI	640x360	29.97	1240	1200	40	22.05	90	Main, 3.1

HTTP Live Streaming

- Apple has not updated recommendations for iPhone 4/iPod Touch
- If producing for HTTP Live Streaming, should probably support all devices, from original iPhone/iTouch to iPad

Static File Delivery

- Adaptive via HTTP Live Streaming is preferred delivery technique
- When not using adaptive, you can offer:
  - High quality stream that only viewers on fast connections can view
  - Lowest common denominator stream that plays everywhere but doesn't look so great
  - Multiple streams, selectable by the viewer

Recommended Encoding Parameters – Static Delivery

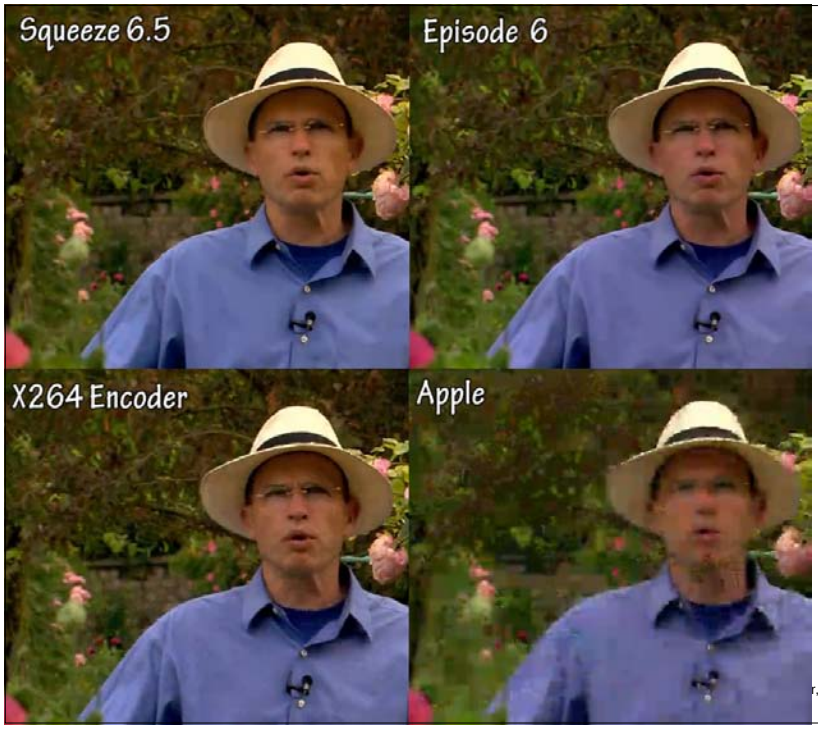
Encoding Parameters	**High Quality Stream**	**High Quality Stream**	**Lowest Common Denominator**
Video			
Resolution	640x360	400x224	400x224
Frame rate	29.97	Full frame rate	1/3 frame rate
Profile/Level	Baseline/3.1	Baseline/Level 3	Baseline/Level 3
Bitrate control	CBR	CBR	CBR
Video data rate	600 kbps	400 kbps	110 kbps
Key frame interval	3 seconds (90 frames)	3 seconds (90 frames)	3 seconds (90 frames)
Audio	AAC-LC, 40 kbps, mono, CBR	AAC-LC, 40 kbps, mono, CBR	AAC-LC 40 kbps, mono, CBR

Comparing the H.264 Codecs

- Test description
  - Apple, Main Concept (Squeeze/Episode), x264
    - Episode started using MainConcept with version 6.0
  - Two files
    - SD - 640x480@30 fps, 468/32, 2-pass VBR, highest supported profile/quality options (.051 bits per pixel)
    - HD - 1280x720@30 fps, 1200/128, 2-pass VBR, highest supported profile/quality options (.044 - bits per pixel)

Test Description

- Still image quality
  - Grab frames and compare
- Motion quality
  - Compare quality during real time playback
  - Look for motion artifacts like banding and mosquitoes
- Smoothness
  - Whether codec/encoder dropped frames at selected parameters



HD Samples

Streaming Learning Center

HD Samples

Streaming Learning Center

HD Test Analysis

- In this test configuration, which is aggressive:
  - MainConcept and x264 pretty much equivalent
  - Apple clearly behind
    - At about 2.5 mbps, the quality is nearly the equivalent of the others
    - If you're looking for optimum quality and efficiency, look elsewhere
- Episode 6
  - Substantial quality improvement - must have upgrade for H.264 producers

Who Uses What Codec

- Main Concept
  - Adobe Media Encoder
  - Rhozet Carbon Coder
  - Sorenson Squeeze
  - Microsoft Expression Encoder 4 (3 used MS own codec)
- Dicas
  - All Telestream products prior to 6
- Apple
  - Apple Compressor

SD Comparisons

- Still frames
- Analysis
- Following clips available at http://www.doceo.com/episode6/Main.html

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Squeeze 6.5
Episode 6
X264 Encoder
Apple
00:01:40:17


Squeeze 6.5
Episode 6
X264 Encoder
Apple
00:01:26:08

SD Test Analysis

- No meaningful difference between x264 and Main Concept in SD clips
  - MainConcept in most batch encoding tools
  - x264 mostly in roll-your-own encoding systems
- Apple again lagging
  - Though fine for low volume SD production where data rate isn't critical

What about x264

- Caveat!!! Some compatibility issues downstream
  - QuickTime Streaming Server
  - QuickTime Broadcaster
  - iPhone/iPad
- So - test throughout entire distribution workflow before implementing
  - Plays fine in Flash and QuickTime Player
  - Reportedly used by most UGC websites

http://www.streaminglearningcenter.com/blogs/if-youre-encoding-in-quicktimecompressor-you-gotta-checkout-x264.html

Wrapping up

- Questions?
- Complete surveys

Streaming Learning Center