Encoding H.264 Video for Streaming and Progressive Download

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Agenda

- 1:30 – 1:50 Generic encoding parameters
- 1:50 – 2:30 Understanding H.264 encoding parameters
- 2:30 – 3:00 Producing H.264 video for computer playback
- 3:15 – 3:35 Producing H.264 for iTunes
- 3:35 – 4:05 Encoding for the iPad/iPhone
- 4:05 – 4:30 Comparing the H.264 codecs

Generic Encoding Parameters

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

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Bandwidth

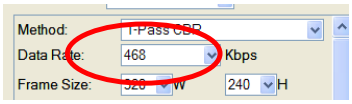
- Viewer's connection speed to the Internet
- Other relevant speeds
  - Mobile broadband ~ 1.4 gbps

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!



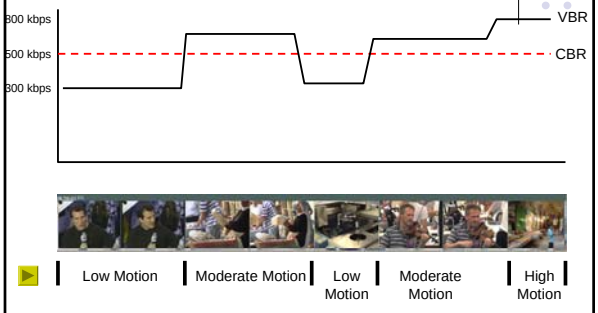
What's Compression?

- 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



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

Constant vs Variable Bit Rate

- Variable Bit Rate (VBR)
  - Dynamic bit rate matches motion in video
  - Pros: Best quality
  - Cons: Slow, can produce erratic stream

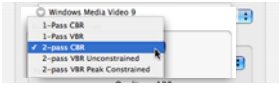
When Should I Use VBR/CBR?

- Consider VBR when:
  - Clips are longer than 60 seconds – too short, no difference
  - Producing for ***progressive download***

When Should I Use VBR/CBR?

- Consider CBR when:
  - In a hurry (or live encoding)
  - Producing for ***streaming*** (as opposed to progressive download – to produce more consistent stream)
  - Restricted bandwidth delivery (e.g. cellular)

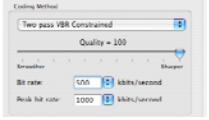
How do I Produce the Best Quality CBR?



- 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
- 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

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What is H.264?

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

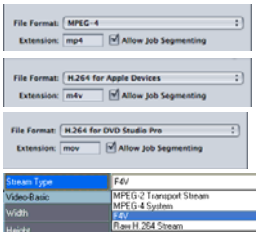
Streamcrest Associates
http://www.streamcrest.com/SDF%20Final1.pdf

What's H.264 Cost?

- For free Internet video (e.g. no subscription or pay per view), free until at least 2015
  - 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
- W4M? - will Microsoft create a new extension?

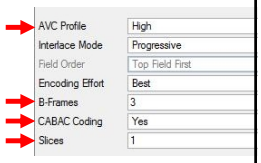


H.264 Encoding Parameters

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

What's the Point?

- Typical encoding tool gives you several H.264 encoding options
- Here we explain these options, so you can understand how to set them later



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

What are H.264 Levels?

- "Constrains key parameters in the bitstream"

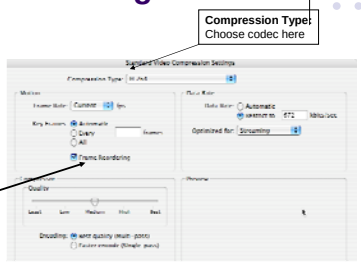
Level number	Max video bit rate (VCL) for Baseline, Extended and Main Profiles	Max video bit rate (VCL) for High Profile	Examples for high resolution @ frame rate (max stored frames) in Level
1	64 kbit/s	80 kbit/s	128x96@30.9 (8) 176x144@15.0 (4)
1b	128 kbit/s	160 kbit/s	128x96@30.9 (8) 176x144@15.0 (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 play
- For computer playback,
  - Flash/QuickTime/SL can play ALL levels of ALL supported profiles – so not a concern

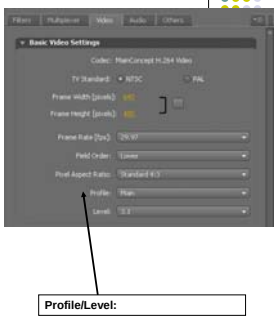
Apple Compressor - Compression Settings

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

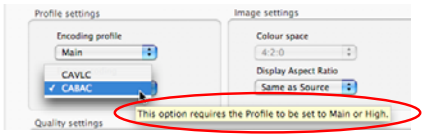


AME - Device - Video

- 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



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

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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

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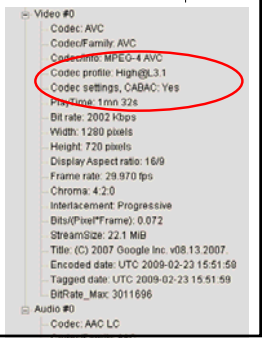
Reality Check - YouTube 720P

- High Profile
- CABAC



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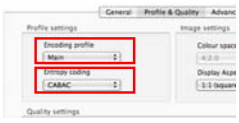
Deep Dive into H.264 Parameters

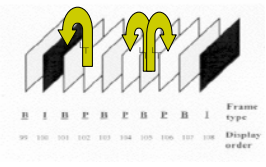
- Caveats:
  - Presented differently by each encoding tool
  - Only have time to cover most critical parameters
- To understand *your* encoder
  - Read manual/help file to understand parameters and their trade-offs; generally
    - Encoding time vs. quality
    - Complexity (and maybe encoding time)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

Profile/CABAC in Squeeze and Episode



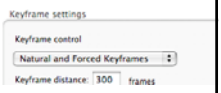
What are I, B and P Frames?

- 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?

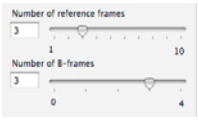
- The most “efficient” frame
  - So improves quality (comparisons to come)
- Hardest to decode
  - Decoder has to have all referenced frames in memory to decode B-frame
  - Frame usually delivered out of order, which also complicates playback

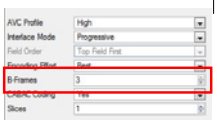
B-frames - Yes/No

B-frames - Yes/No

- Noticeable quality improvement
- 5-10% increase in decompression CPU load
- Recommend
  - Say “YES” to B-frames
  - 2-3 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
  - 3 is recommended setting

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

- 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

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Episode – It Doesn't

- Similar tests revealed little difference in time/quality
- Help file says values beyond 50 typically don't increase quality
- I use 90 (for no reason I can recall)

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Search Related Option

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

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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)

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Producing H.264 Video for Computer Playback

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

S/be 2:30

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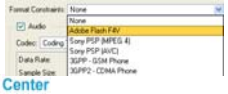
Flash and H.264

- 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



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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!

Producing for QuickTime

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

Producing for Silverlight 3

- 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

Optimizing H.264 for Computer Playback

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

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H.264 Playback - SD File

	Dell Latitude	HP xw4100	MacBook Pro	Dell Precision 390
SD Tests – QuickTime Player	1600 MHz Pentium M	3.0 GHz P4 with HTT	2.4 GHz Core 2 Duo	3.0 GHz Core 2 Duo
H.264 - High	88%	25%	29%	12%
H.264 – Baseline	80%	30%	19%	8%

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Updated Tests - Flash Player

	MacBook Pro (2.2 GHz C2D)	iMac (2.0 Ghz C2D)	HP 8710w (2.2 Ghz C2D)	Acer Netbook (1.5 GHz Atom)
Baseline	24%	34%	9%	54%
High	25%	35%	10%	58%

SD Tests - 640x480@ 1 mbps

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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
HD Tests				
H.264 – High	99%	78%	50%	28%
H.264 – Baseline	100%	68%	58%	21%

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Updated Tests - Flash Player

	MacBook Pro (2.2 GHz C2D)	iMac (2.0 Ghz C2D)	HP 8710w (2.2 Ghz C2D)	Acer Netbook
Baseline	35%	63%	33%	NA
Main	39%	68%	38%	NA

HD Tests - 720p@ 2 mbps

	MacBook Pro (2.2 GHz C2D)	iMac (2.0 Ghz C2D)
Main - Chrome	89%	68%
Main - Safari	39%	68%

HD Tests - 720p@ 2 mbps

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H.264 Playback – 1080p File

QuickTime Player	Dell Latitude	HP xw4100	MacBook Pro	Dell Precision 390
HD Tests	1600 MHz Pentium M	3.0 GHz P 4 with HTT	2.4 GHz Core 2 Duo	3.0 Ghz Core 2 Duo
H.264 - High	100%	69%	48%	40%
H.264 – Baseline	100%	79%	42%	26%

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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
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

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Updated Tests - VP6

	MacBook Pro (2.2 GHz C2D)	iMac (2.0 Ghz C2D)	HP 8710w (2.2 Ghz C2D)	Acer Netbook
VP6	23%	33%	15%	49%
H.264 High profile	25%	35%	10%	58%
SD Tests - 640x480@ 1 mbps				

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My Take on H.264 Quality

- H.264 produces better quality than VP6 or VC-1
- Very close to same CPU requirements
- If converting from either codec, you can use the same encoding parameters with:
  - No loss in quality
  - No increase in required CPU on playback station

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Choosing your data rate

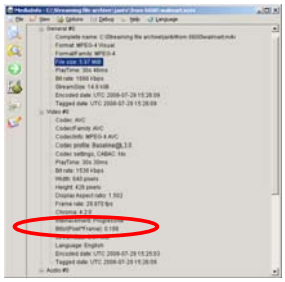
- Using bits/pixel/frame
  - Calculating bits/pixel/frame
- Lessons from the field

Bits Per Pixel

- In general
  - .1 or lower should be fine
  - .15 is very conservative; beyond that is a waste
  - The larger the resolution, the lower you can go
    - .1 @ 320x240 could be dicey
    - .1 @ 720p should be fine
  - Formula
    - Data rate / (pixels x frame rate)

Bits Per Pixel

- Or, get MediaInfo



mediainfo.sourceforge.net/en

Lessons from the Field

	Width	Height	Total Pixels	Frame Rate	Video Data Rate	Bits/p/f
Efficient						
CNET - large	852	480	408,960	30	645	**0.053**
ABC - Castle	768	432	331,776	23.976	602	**0.076**
Apple battery video	848	480	407,040	29	1,089	**0.092**
CNN - video library	640	360	230,400	29.97	735	**0.106**
CBS - HQ	853	480	409,440	24	1,066	**0.108**
GE - library	480	268	128,640	29.97	452	**0.117**
Could be Lower						
Tiger Woods	640	360	230,400	29.97	942	**0.136**
Sports Illustrated	668	376	251,168	29.97	1,098	**0.146**
CNN - embedded	416	236	98,176	29.97	432	**0.147**
Apple - iPad small	640	360	230,400	23.976	926	**0.168**
Apple - iPad big	848	480	407,040	23.976	2,579	**0.264**

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Adaptive Bitrate Streaming

- What it is
- Why you care
- Alternatives

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Adaptive Bitrate Streaming

- Concept
  - Customize file for viewer device and bandwidth
  - Adapt to changing conditions
  - All transparent to the view

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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

Disadvantages of Adaptive Bitrate Streaming

- Bandwidth cost
  - You pick maximum stream bandwidth, so can control cost
  - Can implement to ensure service to lower connection speed customers
- Multiple file administration
  - If live, need more real time encoders
  - More space on servers
- Cost/Complexity
  - Getting cheaper and easier as more companies adapt
  - Available via most third party service providers

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 -
  - 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

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

Encoding for Adaptive Bitrate Streaming

- Varies for Adobe, Microsoft and Apple Solutions
- See:
  - http://www.streaminglearningcenter.com/blogs/encoding-for-adaptive-streaming---an-overview.html

Optimizing for Devices

- Digesting iPod Specs
- Lessons from iTunes
- Recommendations

S/be 3:15

iPod Specs

	Original iPod (pre-5g)	iPod Nano	iPod Classic	iPod Touch
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

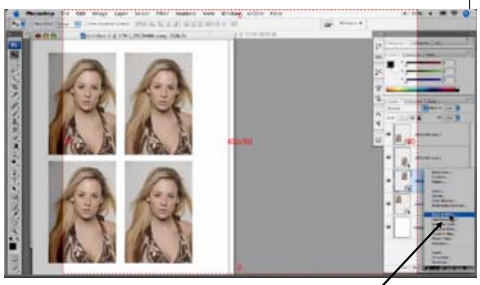
- Main or High Profile - 5
- Exceed data rate - 4 (high of 6.5 mbps)
- Exceed resolution - 2
- Wrong codec - 1 (Sorenson Video 3)

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 - Screencam



Screencam 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

Recommended Encoding Parameters

	320x240	640x480[1]
Video codec	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
Audio	AAC Low	AAC Low
Data rate	128 kbps/stereo	128 kbps/stereo
Extension	.mv4	.mv4

[1] From Compressor

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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

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Producing for the iPhone/iPad

- iPhone
  - iTunes (covered)
  - 3G/Wi-Fi
- iPad
  - Cable (direct encode/iTunes)
  - Wi-Fi
  - 3G

S/be 3:40

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Producing for the iPhone

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

HTTP Live Streaming

- Apple spec released in June, 2009
- 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

Producing for HTTP Live Streaming

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

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
WIFI	400x224	29.97	440	400	40	22.05	90	Baseline, 3.0
WIFI	400x224	29.97	640	600	40	22.05	90	Baseline, 3.0

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	**Reasonable Quality**	**Lowest Common Denominator**
Video		
Resolution	400x224	400x224
Frame rate	29.97	10 (assuming 30 fps source)
Profile/Level	Baseline	Baseline
VBR/CBR	CBR	CBR
Video data rate	400 kbps	110 kbps
Key frame interval	3 seconds (90 frames)	3 seconds (30 frames)

Recommended Encoding Parameters – Static Delivery

Audio	**Reasonable Quality**	**Lowest Common Denominator**
Codec	AAC-LC	AAC-LC
Data rate	40 kbps	40 kbps
Channels	Mono	Mono
Sample rate	22.05	22.05
VBR/CBR	CBR	CBR

Producing for the iPad

- Encoding for iTunes/Demo Reel
- Encoding for Wi-Fi/3G

Encoding for iTunes

- The 4:3 iPad display
- Alternatives – 16:9
- The 4:3 option

iPad/iPhone/iPod Touch Specs

	iPad Video Specs	iPod Touch/ iPhone
	H.264	**H.264**
Device resolution	**1024x768**	**480x320**
Aspect Ratio	**4:3**	**16:9-ish**
Video codec	H.264	H.264
Data rate	14 mbps	2.5 Mbps
Resolution	**1280x720**	**640x480**
Frame rate	30	30 fps
Profile	Main, up to level 3.1	**Baseline** Profile up to Level 3.0
Audio codec	AAC-LC	AAC-LC
Data rate	160 kbps	160 kbps
Audio parameters	48 kHz, stereo	48 kHz, stereo
Formats	.m4v, .mp4, .mov	.m4v, .mp4, .mov

Displaying 720p

iTunes Alternatives

- 16:9
  - 720p – best alternative if producing for both computer playback and iPad playback
  - 1024x576 - 36% fewer pixels than 720p, looks the same as 720p
  - 960x540 – How iTunes encodes when you choose Advanced > Encode for iPad or Apple TV
  - 640x360 – Apple PM – “iPad scaler is so good that sending content at higher res than 640x360 just isn’t worth the bandwidth”

Assessing the 16:9 Alternatives

Lessons from the Field – Hollywood (and wannabees)

	Width	Height	FPS	Kb/s	B/P/F	Profile	CABAC
Washington Post	1280	720	24	4,947	0.224	Main	No
NASA - Spirit of Mars	1280	720	29.97	4,612	0.167	High	No
Lost	1280	720	29.97	4,135	0.150	Main	No
What did you see *	960	720	29.97	4,109	0.198	Main	No
Victorious	1280	720	23.98	4,089	0.185	High	No
Inside Breaking Bad	1280	720	23.98	4,088	0.185	High	No
Damages: Willful Acts	1280	720	23.98	4,015	0.182	High	No
Night of 140 Tweets *	960	720	29.97	3,994	0.193	Main	No
CNET	1280	720	24	2,160	0.098	BL	No
TekZilla – (mixed video/screencam)	1280	720	23.98	1,463	0.066	Main	Yes
Mac Break (mixed video/screencam)	960	540	23.98	549	0.044	Main	No

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Lessons from the Field/Audio

- 9 of 11 used between 115-160 kbps stereo audio
  - Most Hollywood shows at 160 kbps
  - 128 kbps should be fine
- One at 384 kbps, another at 256 kbps
  - Probably on the far side of diminishing returns

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Lessons from the Field – Multi-Purpose Files

Video	Width	Height	FPS	kbps	B/P/F	Profile	CABAC
Ted Talks	850	480	29.97	1,734	0.142	BL	No
GBTV - Geek Brief	640	360	23.98	1,200	0.217	BL	No
National Park Service - Yosemite	640	480	29.97	1,482	0.161	BL	No
Morning Yoga with Tara Styles	640	480	29.97	1,508	0.164	BL	No

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Creating Multi-Purpose Files

- iPad/Web – 850x480 – Main Profile
- iPad/iPhone – 4:3 – 640x480, Baseline
- iPad/iPhone – 16:9 – 640x360, Baseline

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4:3 on the iPad – Full Screen

- Why? Best use of all available pixels on the iPad
- Good if shooting in HD and outputting in 4:3 anyway, though relatively few producers are doing this

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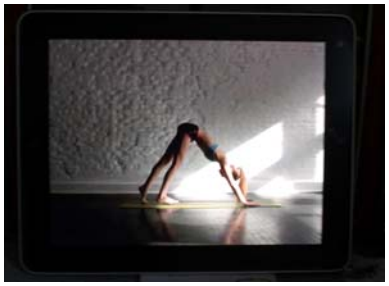
4:3 on the iPad – Full Screen



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Producing 4:3

- Since all HD formats are 16:9, you have to shoot with center cut in mind
  - Most camcorders have a frame assist that helps you do this

Setting the Aspect Ratio Guide

Here are the Guides

Producing 4:3

- Easiest way to edit:
  - Create a 1024x768 sequence setting
  - Zoom video to fit (it will usually start out letterboxed)
  - Output as 1024x768 video with square pixels

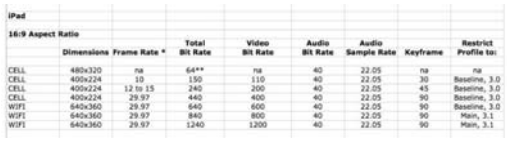
Producing 4:3

Wi-Fi/3G Delivery to the iPad

- Adaptive or single file delivery
  - What's Apple recommend?
- Single file delivery
  - What's the effective throughput for Wi-Fi?
  - What's the effective throughput for 3G?
- Recommendations please

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

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	**Reasonable Quality**	**Lowest Common Denominator (iPhone/iPad)**
Video		
Resolution	640x360	400x224
Frame rate	29.97	15 (assuming 30 fps source)
Profile/Level	Main/3.1	Baseline, 3.0
VBR/CBR	CBR	CBR
CABAC/CAVLC	CABAC	NA
Video data rate	600 kbps	200 kbps
Key frame interval	3 seconds (90 frames)	3 seconds (45 frames)
B-frame interval	1	NA
Reference frames	2	NA

Recommended Encoding Parameters – Static Delivery

Audio	Reasonable Quality	Lowest Common Denominator
Codec	AAC-LC	AAC-LC
Data rate	40 kbps	40 kbps
Channels	Mono	Mono
Sample rate	22.05	22.05
VBR/CBR	CBR	CBR

Comparing the H.264 Codecs

- Test description
  - Apple, Dicas (Episode Pro), Main Concept (Carbon Coder/Squeeze)
  - Two 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

S/be 4:05

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

- All codecs perform well with low motion footage

HD Samples

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

HD Samples

- Jumping further separates the contenders

HD Test Results

	Apple	Episode Dicas	Main Concept
Still Quality	3	2	1
Motion Quality	2	1	1
Smoothness	1	1	1
Total	6	4	3

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HD Test Analysis

- Difference between Dicas and Main Concept is commercially irrelevant
  - Viewers wouldn't notice absent side--by-side comps (which, of course, they never have)
  - Base decision on factors other than quality
- Apple's is much more significant
  - Avoid if seeking highest quality at lowest bitrate
  - At about 2.5 mbps, the quality is nearly the equivalent of the others

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Who Uses What Codec

- Main Concept
  - Adobe Media Encoder
  - Rhozet Carbon Coder
  - Sorenson Squeeze
- Dicas
  - All Telestream products
- Apple
  - Apple Compressor

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SD Comparisons

- Still
- Motion
- Results
- Summary

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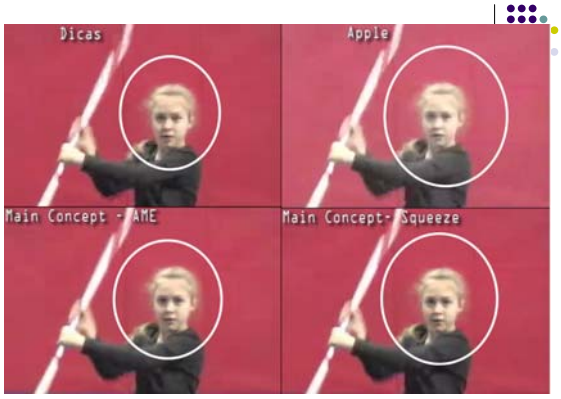

- Taj Kwon Do starts to separate again

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SD Test Results

	Apple	Episode Dicas	AME - Main Concept	Squeeze Main Concept
Still Quality	2	1	1	1
Motion Quality	2	1	1	1
Smoothness	1	1	1	1
Total	6	3	3	3

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SD Test Analysis

- No meaningful difference between Dicas and Main Concept in SD clips
- Apple again lagging
  - Though fine for low volume SD production where data rate isn't critical

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What this means for encoding tools

- Encoding tools follow codec
- Dicas/Main Concept
  - MC slightly better in HD, but the difference isn't commercially significant
  - Nearly identical in SD
- Apple
  - OK choice for SD
  - Avoid for HD when trying to achieve optimal data rate

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What about x264?

- Very competent - quality superior to Apple codec
- http://www.streaminglearningcenter.com/blogs/if-youre-encoding-in-quicktimecompressor-you-gotta-checkout-x264.html
  - I tested an older version of X.264 – will be updating review soon
  - Still, quality very impressive

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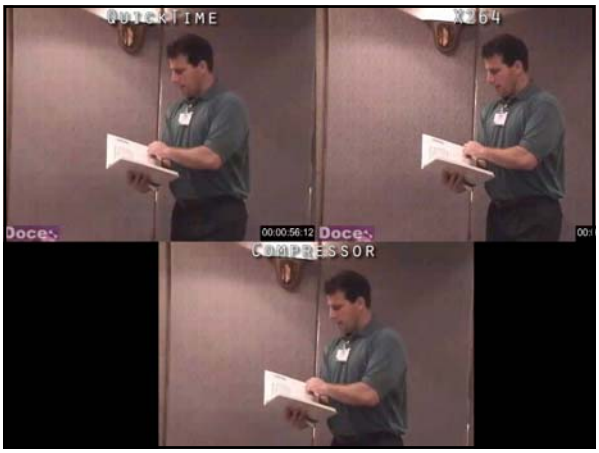

What about x264

- 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

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Wrapping up

- Questions?
- Complete surveys

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