Encoding for iDevices

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Agenda

- What is H.264
- Encoding for the iPad/iPhone
  - Tethered delivery via iTunes
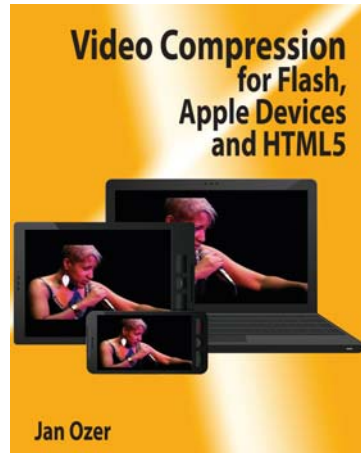 - HTTP Live Streaming

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For Additional Reference

The material in this presentation was derived from Jan Ozer's book, *Video Compression for Flash, Apple Devices and HTML5.*

For further explanation of the concepts presented in this presentation, check out the book at bit.ly/ozerbook1

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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

- HTML5 playback
  - Safari/IE-9 – yes
  - Chrome – for now
  - Firefox/Opera – never
- Reality
  - True HTML5 compatibility is two-codec solution
    - H.264
    - WebM

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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

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Which Profile?

- Critical to know your target profile before encoding
  - Device
    - iPod/iPhone through 4G – Baseline
    - iPod/iPhone 4G+ - 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

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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)

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Which Level

- Varies by Device
  - As you'll see in a moment
- Bottom Line
  - Encoding for iDevices very technical
    - Choose wrong parameters and file won't load
- To succeed
  - Find an encoding tool that you trust
  - Confirm that templates are correct
  - Test files on key target devices

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Producing for iDevices

- Two scenarios
  - Video podcasts
    - Covered next
  - Streaming to iDevices
    - Best done with HTTP Live Streaming, covered later

Encoding for iDevices

	Original iPod (to-5g)	iPod nano/ classic	iPod touch/ iPhone	iPhone 4 /iPod touch 4	iPad 1	iPhone 4S	iPad 2
Device spec							
Screen resolution	320x240	320x240	480x320	960x640	1024x768	960x640	1024x768
Aspect ratio	4:3	4:3	16:9-ish	16:9-ish	4:3	16:9-ish	4:3
Codec spec							
Video codec	H.264	H.264	H.264	H.264	H.264	H.264	H.264
Max video data rate	768 kbps	2.5 Mbps	2.5 Mbps	14 Mbps	14 Mbps	50 Mbps	50 Mbps
Max video resolution	320x240	640x480	640x480	720p	720p	1080p	1080p
Frame rate	30 fps	30 fps	30 fps	30 fps	30 fps	30 fps	30 fps
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	High to Level 4.1	High to Level 4.1
Audio codec	AAC-LC	AAC-LC	AAC-LC	AAC-LC	AAC-LC	AAC-LC	AAC-LC
Max audio data rate	160 kbps	160 kbps	160 kbps	160 kbps	160 kbps	160 kbps	160 kbps
Audio params	48 kHz, stereo	48 kHz, stereo	48 kHz, stereo	48 kHz, stereo	48 kHz, stereo	48 kHz, stereo	48 kHz, stereo

- 1080p playback with adapters only; not on device: use 720p
- These are maximum settings; not recommended settings (we'll get to those)

iPad 2 Specs

- AirPlay Mirroring to Apple TV support at 720p
- Video mirroring and video out support: Up to 1080p with Apple Digital AV Adapter or Apple VGA Adapter (adapters sold separately)
- Video out support at 576p and 480p with Apple Component AV Cable; 576i and 480i with Apple Composite AV Cable (cables sold separately)
- Video formats supported: H.264 video up to 1080p, 30 frames per second, High Profile level 4.1 with AAC–LC audio up to 160 Kbps, 48kHz, stereo audio in .m4v, .mp4, and .mov file formats; MPEG–4 video up to 2.5 Mbps, 640 by 480 pixels, 30 frames per second, Simple Profile with AAC–LC audio up to 160 Kbps per channel, 48kHz, stereo audio in .m4v, .mp4, and .mov file formats; Motion JPEG (M–JPEG) up to 35 Mbps, 1280 by 720 pixels, 30 frames per second, audio in ulaw, PCM stereo audio in .avi file format

- http://www.apple.com/ipad/specs/

Tethered Deliver via iTunes

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

Decision Time

- Decision 1:
  - Should you abandon older iPods that supports only 320x240?
- Decision 2:
  - Should you support post iPod 5GDevices with single max 640x480 stream?
- Decision 3:
  - Should you distribute multiple files?
- Decision 4:
  - Should you distribute 1080p files to iPhone 4S and iPad 2

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iTunes Survey

- 98 files
  - Three letter networks
  - Prominent technology and other popular sites
  - Featured podcasts
  - All FREE downloads
    - Look at paid downloads separately

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Findings

- Should you abandon 320x240?
  - 5 of 98 files were 320x240 or lower
  - 2 shows each from Revision 3 and CNET, one video from Merrill Lynch
- Survey included multiple sites that I thought would support oldest iPods
  - US Government, CNN, AARP, CBS, Fox, NBC
  - All produced at larger than 320x240
- Conclusion: Unless you have a strong reason to support oldest devices, can probably ignore them

Findings

- Should you support post iPod 5G devices with a single stream?
  - 50 of the 98 podcasts were 640x480, or 640x360
  - For most producers, this was the only stream
- Conclusion: Unless you have a strong reason to produce at 720p (compelling content, premium content) a single 640x480/640x360 should be fine

Findings

- Distribute multiple files?
  - 2 scenarios where to consider multiple files
    - Tech site (Revision 3, CNET, TWIT) all used multiple
    - Compelling HD content
      - NASA space sites, etc as opposed to talking head
      - Screencams
  - If you offer a 720p file, you should also offer an SD file unless all you care about are HD viewers
    - 7 of 16 producers who offered a 720p stream also offered a lower resolution stream

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Findings

- Should you encode 1080p video for iPhone 4S and iPad2?
  - Not for native playback (use 720p)
  - Only for playback with external adapters

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Music Videos

Music Videos	Width	Height	Data Rate (kbps)	Frame Rate	Audio DR (kbps)	Channels	Bits per Pixel
Beyonce	640	478	1,538	23.976	256	2	0.210
Britney Spears	640	344	1,552	23.976	256	2	0.294
Enrique Iglesias	640	352	1,537	23.976	235	2	0.285
Justin Bieber	640	352	1,502	23.976	256	2	0.278
Kelly Clarkson	640	478	1,566	23.976	256	2	0.214
LMFAO	640	352	1,524	23.976	256	2	0.282
Totals			**1,537**	**24**	**253**		**0.260**

- All 640x480 or smaller
  - Play on all but the oldest devices, not tuned for new ones
- All 256 kbps audio, exceeding playback specs (but still loading fine)

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HD TV Episodes

HD TV Episodes	Width	Height	Data Rate (kbps)	Frame Rate	Audio DR (kbps)	Channels	Bits per Pixel
American Hoggers	960	720	4,088	29.976	160	2	0.197
Bomb Patrol Afghanistan	960	720	3,955	29.97	160	2	0.191
Californication	1280	720	4,068	23.976	160	2	0.184
Dr. Who	960	720	4,044	25	149	2	0.234
Grimm	960	720	3,941	29.97	151	2	0.190
Luther	960	720	4,018	29.97	139	2	0.194
Mad Fashon	960	720	4,038	29.97	132	2	0.195
Office	960	720	4,023	29.97	160	2	0.194
Secret Circle	1280	720	4,097	23.976	160	2	0.185
The Walking Dead	1280	720	4,063	23.976	160	2	0.184
Countdown to UFC 132	960	720	3,990	29.97	160	2	0.193
Totals			**4,030**	**28**	**154**		**0.195**

- 960x720 files produced at 1.333 aspect ratio and stretched during playback
  - Compressor can do this; not all encoding tools can

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SD TV Episodes

SD TV Episodes	Width	Height	Data Rate (kbps)	Frame Rate	Audio DR (kbps)	Channels	Bits per Pixel
American Hoggers	640	480	1,560	29.97	128	2	0.169
Bomb Patrol Afghanistan	640	480	1,561	29.97	128	2	0.170
Californication	640	480	1,505	23.976	128	2	0.204
Dr. Who	640	478	1,526	25	121	2	0.200
Grimm	640	480	1,370	29.97	121	2	0.149
Luther	640	480	1,321	29.97	110	2	0.143
Mad Fashon	640	480	1,626	29.97	106	2	0.177
Office	640	480	1,649	29.97	128	2	0.179
Secret Circle	640	480	1,358	23.976	128	2	0.184
The Walking Dead	640	480	1,433	23.976	128	2	0.195
Countdown to UFC 132	640	480	1,605	29.97	128	2	0.174
Totals			**1,501**	**28**	**123**		**0.177**

- Buy HD file, get SD automatically – iTunes copies the right file to device
- 640x480 files produced at 1.333 aspect ratio and stretched during playback
  - Compressor can do this; not all encoding tools can
  - Files played fine on 640x480 devices/expanded on iPads

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Here's What It Looks Like

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Encoding Parameters - 320x240

	Survey	Device Maximum
Video codec	H.264 codec, Baseline profile	H.264 codec, Baseline profile
Data rate average/max	528 kbps (average)	768 kbps
Frame rate	match source	30
Audio	AAC Low	AAC Low
Data rate	111 kbps/stereo	128 kbps/stereo
Extension	.mv4	.mv4

- Check your preset
  - Make sure target is around the average
  - Doesn't exceed maximum

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Encoding Parameters - 640x360

	Survey	Device Maximum
Video codec	H.264 codec, Baseline profile	H.264 codec, Baseline profile
Data rate average/max	1.116 mbps	2.5 mbps
Frame rate	match source	30
Audio	AAC Low	AAC Low
Data rate	98 kbps/stereo	128 kbps/stereo
Extension	.mv4	.mv4

- Check your preset
  - Make sure target is around the average
  - Doesn't exceed maximum

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Encoding Parameters - 720p

	Survey	Device Maximum
Video codec	H.264 codec, 8 of 16 are High profile	H.264 codec, Main profile
Data rate average/max	3.011 mbps	14 mbps
Frame rate	match source	30
Audio	AAC Low	AAC Low
Data rate	111 kbps/stereo	160 kbps/stereo
Extension	.mv4	.mv4

- Check your preset
  - Make sure target is around the average
  - Doesn't exceed 2X target (14 mbps is too high)

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Encoding for Adaptive Streaming

- Introduction
- HTTP Live Streaming to iOS/Android
- Transmux strategies

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Adaptive Streaming - Introduction

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

Encoding for Adaptive Streaming

- Optimize playback experience across all served devices and bandwidths
  - How many streams, what resolutions, what data rates
- Work within requirements of adaptive streaming technology
  - Key frame interval, VBR vs. CBR, audio parameters

Apple HTTP Live Streaming

- Primary technology for iOS devices
  - Also supported in Android 3.0
- How it works
- How to customize your encoding

Apple HTTP Live Streaming: How it works

- Encoding
  - Encode as normal, send to segmenter
  - Files chunked, inserted into transport stream (.ts extension)
  - Manifest file (M3U8) created
  - Uploaded to server
- Client
  - Monitors heuristics
  - Changes retrieved file as necessary

15
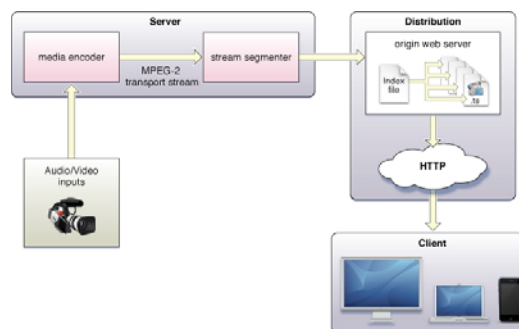
The Manifest File Structure
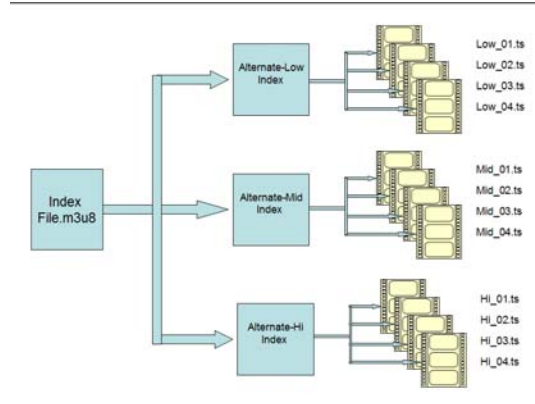
Number of Streams/Config

16:9 Aspect Ratio		Total Bit Rate	Video Bit Rate	Keyframe	Restrict Profile to:	iPod Touch Gens 2, 3, 4 iPhone 3G 3GS	WORKS ON iPhone 4 iPad 1, 2
	Dimensions						
CELL	480x320	64	na	na	na	*	*
CELL	416x234	150	110	30	Baseline, 3.0	*	*
CELL	416x234	240	200	45	Baseline, 3.0	*	*
CELL	416x234	440	400	90	Baseline, 3.0	*	*
WIFI	640x360	640	600	90	Baseline, 3.0	*	*
WIFI	640x360	1240	1200	90	Main, 3.1		*
WIFI	960x540	1840	1800	90	Main, 3.1		*
WIFI	1280x720	2540	2500	90	Main, 3.1		*
WIFI	1280x720	4540	4500	90	Main, 3.1		*

Bit.ly/bestpracticehttplive

How should H.264 encoding parameters change?

- Now we know stream count, resolution and data rate
- How do we customize encoding for adaptive?
  - Key frame settings
  - Bit rate control
  - Audio parameters

Key Frame Interval

- Why important – HTTP technologies - key frame must be first frame of every chunk
  - Key frame interval must divide evenly into chunk duration
    - If 9-sec. chunks, use key frame interval of 3 sec
- Key frame location must be identical in all streams, so:
  - Use same interval in all streams
    - Disable scene change detection

In General - VBR vs CBR

- CBR more conservative
  - Produces smoothest stream, which is easiest to consistently deliver
- But, quality is typically inferior to VBR
  - Sometimes noticeably so
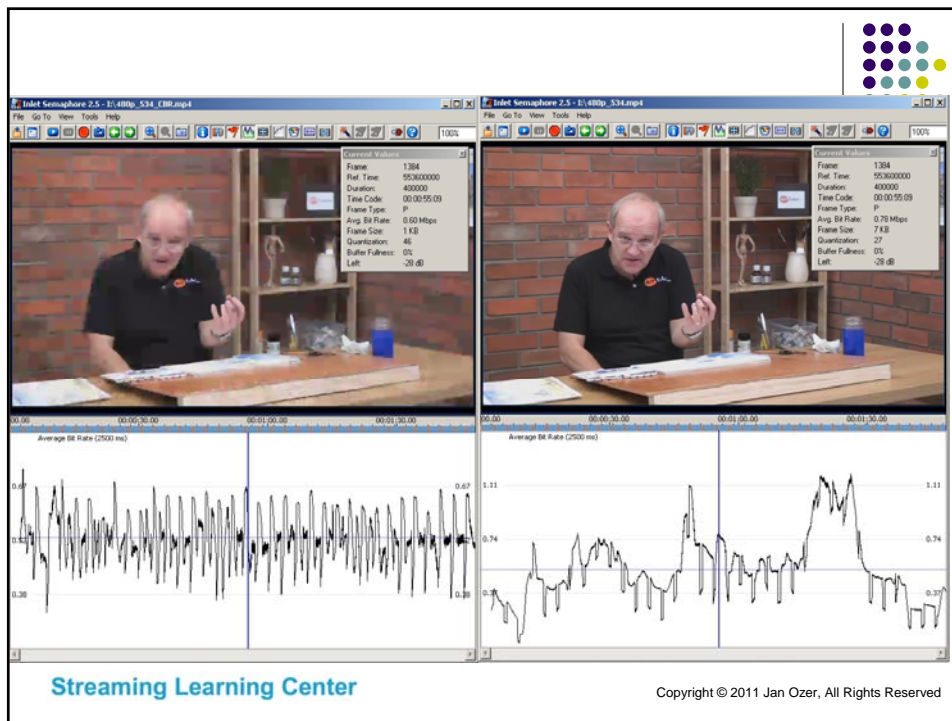
In General - VBR vs CBR

- VBR
  - Variable data rate
  - Could introduce stream switches that relate to bit rate control rather than change in conditions
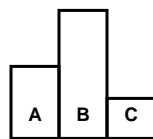 - Too many stream switches degrade perceived quality

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VBR vs CBR
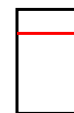
Video bitrate

Player buffer

| A | B | C |

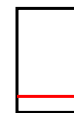med chunk → A → Good delivery → Buffer OK / Status quo / No change

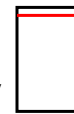large chunk → B → Slow delivery → Ruh, roh! / Buffer too low / Switch to lower bitrate

Small chunk → C → Very fast delivery → Life is good! / Switch to higher bitrate

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What's the Answer?

- Most conservative
  - Use CBR
- Many real world producers
  - Use constrained VBR,
  - Less constrained at high data rates, where difference in bandwidths is great (MTV uses 2X constrained)

In General - Audio Parameters

- Most conservative - use same parameters for all files (Apple recommends)
  - Popping can occur if audio parameters change
  - But, doesn't optimize experience at higher bit rates
- If you do switch audio parameters
  - Switch from stereo to mono at same per channel sampling rate and bit rate
    - From 128 kbps/44 kHz/16-bit/stereo to 64 kbps/44 kHz/16-bit/mono
  - Test to ensure no artifacts when switching streams
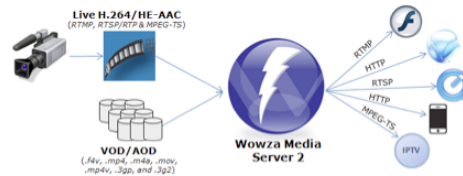
Other H.264 Encoding Parameters

- Adapt H.264 Profile to target device
  - Baseline to older devices
  - Main to newer devices
- As recommended by Apple

Transmuxing Technologies

- Most producers must serve two clients
  - Flash (or Silverlight)
  - iOS (and now Android)
- In the past, that meant two separate encoding and delivery workflows
- Now, multiple technologies for:
  - "Transmuxing" H.264 stream
  - Using correct protocol to distribute to target

Transmuxing Technologies

- Options
  - Technology providers - Wowza, Microsoft, Adobe
  - Service providers - Akamai (in the network repackaging)
- Key point:
  - If serving multiple targets, you must produce using lowest common denominator H.264 encoding parameters

Encoding for HTTP Live Streaming

- Sources
  - Apple Tech Note: "Best Practices for Creating and Deploying HTTP Live Streaming Media for the iPhone and iPad," (bit.ly/bestpracticehttplive)
  - Apple Tech Note: "HTTP Live Streaming Overview," (bit.ly/httpliveoverview)
  - Apple Tech Note: "Using HTTP Live Streaming," (bit.ly/usinghttplive)

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

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Recommended Encoding Parameters – Static Delivery

Encoding Parameters	iPad-Only Stream	iDevice - Mid Quality Stream	iDevice - Low Quality Stream
Video			
Resolution	640x360	400x224	400x224
Frame rate	Full frame rate	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

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Questions?

- Most of the information for this presentation was taken from this book. For more information, check out the book
  - Available on Amazon
  - Bit.ly/ozerbook1

Video Compression for Flash, **Apple Devices** and **HTML5**

Jan Ozer

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