

PRODUCING AND DEPLOYING HEVC

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Agenda

- Point 1: Royalty status is a Mess
- Point 2: Computer playback is nowhere
- Point 3: Encoding side is firming up nicely
- Point 4: Encoding with x265 is straightforward
- Point 5: As is MainConcept

Royalty Status

- What's known: MPEG LA patent group
 - \$0.20/encoder/decoder
 - Shipments in excess of 100,000
 - \$25 million annual maximum (first year only)
 - No HEVC content royalty (even PPV/subscription)

Royalty Status

- What's unknown – HEVC Advance
 - New royalty pool announced on March 24, 2015
 - Includes GE, Technicolor, Dolby, Philips, and Mitsubishi Electric
 - Goal is to offer general terms by Q2 2015, licenses by Q3 2015
 - Nothing is known about plans, including potential for content royalty
- May be other lurkers out there

Implications of New Patent Group?



- Nothing freezes a market like uncertainty (particularly for free content)

Still, the Industry Marches On

- Encoder vendors:
 - Full speed ahead, live and VOD
- Hardware Decoder
 - Most STB and mobile CPU/SOCs are now including HEVC decode
- Content
 - Netflix, Hulu, Amazon, others outputting 4K videos in HEVC

HEVC Delivers the Goods

- Expectation: Same quality as H.264 @ 50% data rate
- My tests
 - 3 files, animation (sintel), movie trailer (TOS), real world video
 - Two HEVC configurations
 - 720p@ 2 mbps
 - 1080p @ 4 mbps
 - Two H.264 configurations
 - 720p@ 4 mbps (200%) and 3 mbps (150%)
 - 1080p@ 8 mbps (200%) and 6 mbps (150%)
 - Assess quality with Moscow University VQMT
 - http://bit.ly/MSU_VQMT

Quality Comparisons

- Results: Video Quality Metric (like PSNR, SSIM, but better)
 - Lower scores better

	x265	Miss %	H.264 @ 2X Data Rate	H.264 @ 1.5X Data Rate
New 1280	0.556	-4.16%	0.579	0.628
New 1920	0.540	-5.59%	0.570	0.610
Sintel 1280	0.748	16.62%	0.624	0.724
Sintel 1920	0.734	6.96%	0.683	0.763
Tears 1280	0.869	-0.28%	0.871	0.973
Tears 1920	0.778	-4.87%	0.816	0.896
			Same quality at 50% data rate	Same quality at 66% data rate

Conclusions

- Now exceeds 50% claim in real world videos/movies
- Animation still running behind
 - X264 has animation tuning; X265 doesn't (yet), or at least the version I used didn't
 - Not sure if this is idiosyncratic to video, but if your content is animation, test early to gauge your results

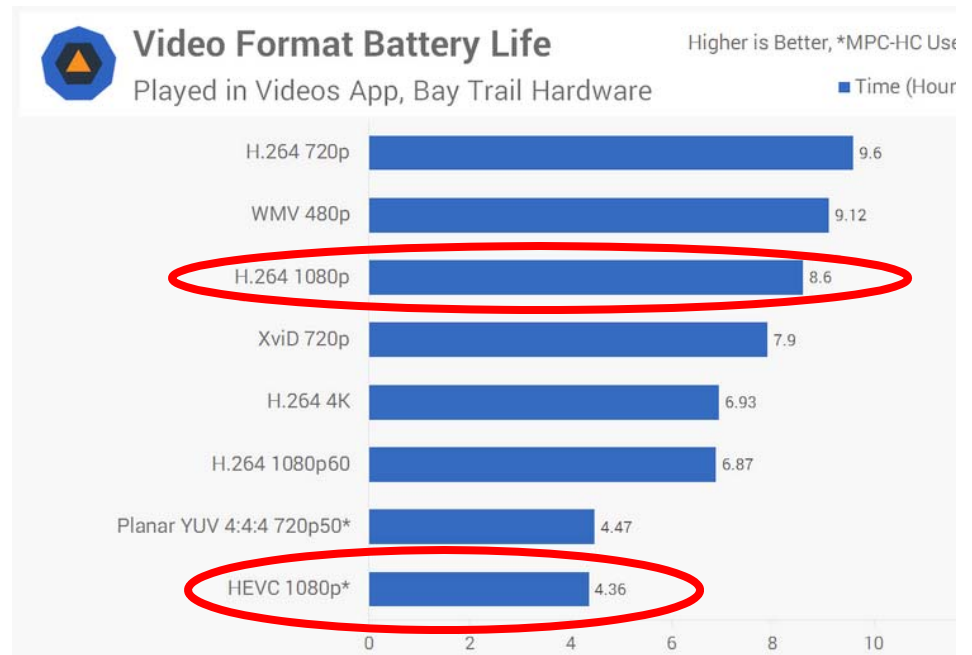
Where Will It Play - Computers

	H264 720p	HEVC 720p	H264 1080p	HEVC 1080p
Dell Precision 390 2.93 GHz Core 2	24%	40%	30%	Fail
Mac 3.06 GHz Core 2 Duo	18%	39%	35%	Fail
HP Elitebook 8760 i7-2820 (4/8 core)	10%	18%	20%	21%

- Limited sample
 - 720p HEVC should play on most 2-core computers
 - 1080p will only play on 4/8 core and above
 - (I'm guessing that) by far, the bulk of video streamed today is 720p or smaller (at least non-OTT)

Caveat: Battery Life

- Techspot: Mobile Playback tests
 - H.264@1080p -- 8.6 hours
 - HEVC@1080p – 4.36 hours
 - While HEVC delivers fantastic quality for the file size, it's impractical for a battery-powered device when it lasts half as long as an equivalent-resolution H.264 file.
 - bit.ly/HEVC_batt



HEVC Software Players

- DivX 10 with HEVC decode shipped – 9/2013
 - Installed base over 10 million
- VLC Player with HEVC – 11/15/2013
- Flash – Adobe to include HEVC decode in Primetime platform in 2015 but not Flash Player
 - Likely never a free, pervasively distributed software plug-in
 - So, it's up to the browser vendors via Media Source Extensions and DASH

What About the Browsers?

- Apple:
 - Added HEVC encode/decoder for FaceTime only in iPhone 6 (http://bit.ly/iphone_HEVC)
 - Not available for general purpose playback on iPhone
 - No word on Safari/Mac
 - Best guess – yes in 2015

What About the Browsers?

- Google:
 - Added software decoder and hooks to HEVC hardware decode in Android 5 (http://bit.ly/iphone_HEVC)
 - Some HEVC capable devices announced (Sony Experia Z3, http://bit.ly/sony_HEVC)
 - No word on Chrome – best guess, yes in 2015

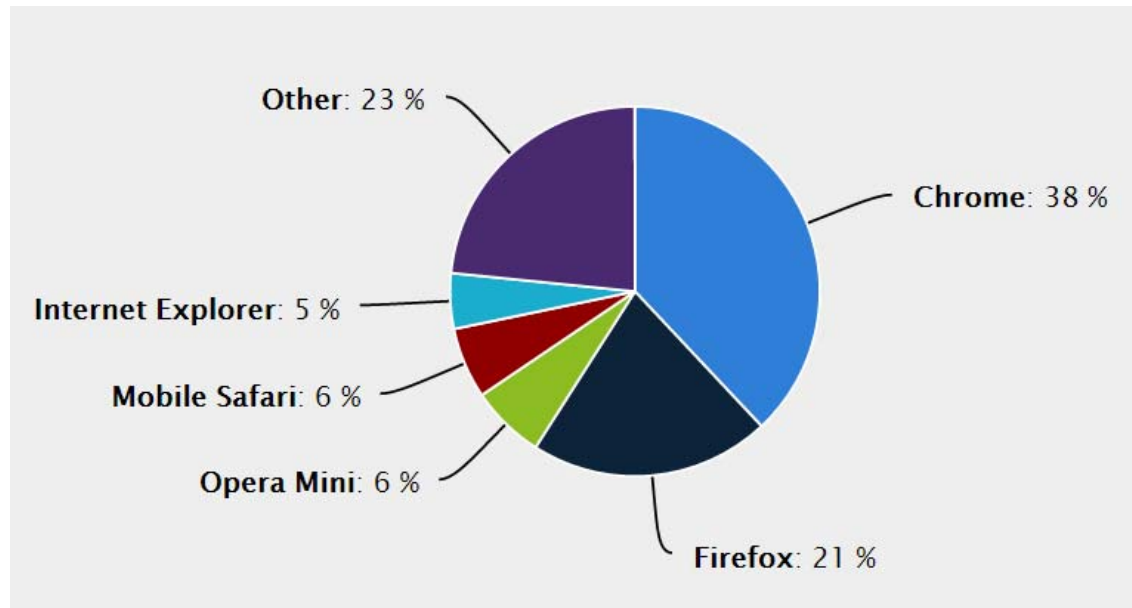
What About the Browsers?

- Microsoft:
 - Will include HEVC decode in Windows 10 in 2015, but will it be backwards compatible with IE? http://bit.ly/iphone_HEVC
 - Would assume not, so installed base of Windows won't have HEVC decode

What About the Browsers?

- Firefox/Opera: ROTFL
 - Will support MSE/VP9 – but feels like direct HEVC support is unlikely
 - Neither company licensed H.265 at 20% of the price

Desktop Browser Share Today



- VP9 capable – at least 59%

- HEVC capable – 0%

<http://www.w3counter.com/stats/browsers/1/top/20/0>

Mobile Support

- 0% HEVC playback natively on iOS
- Android version 5 includes software player
 - Now at about 10%
 - Should grow very quickly
 - Might pressure Apple to open up iPhone6 and other platforms

Version	Codename	API	Distribution
2.2	Froyo	8	0.3%
2.3.3 - 2.3.7	Gingerbread	10	5.7%
4.0.3 - 4.0.4	Ice Cream Sandwich	15	5.3%
4.1.x	Jelly Bean	16	15.6%
4.2.x		17	18.1%
4.3		18	5.5%
4.4	KitKat	19	39.8%
5.0	Lollipop	21	9.0%
5.1		22	0.7%

Data collected during a 7-day period ending on May 4, 2015. Any versions with less than 0.1% distribution are not shown.

<https://developer.android.com/about/dashboards/index.html>

VP9 Deployment

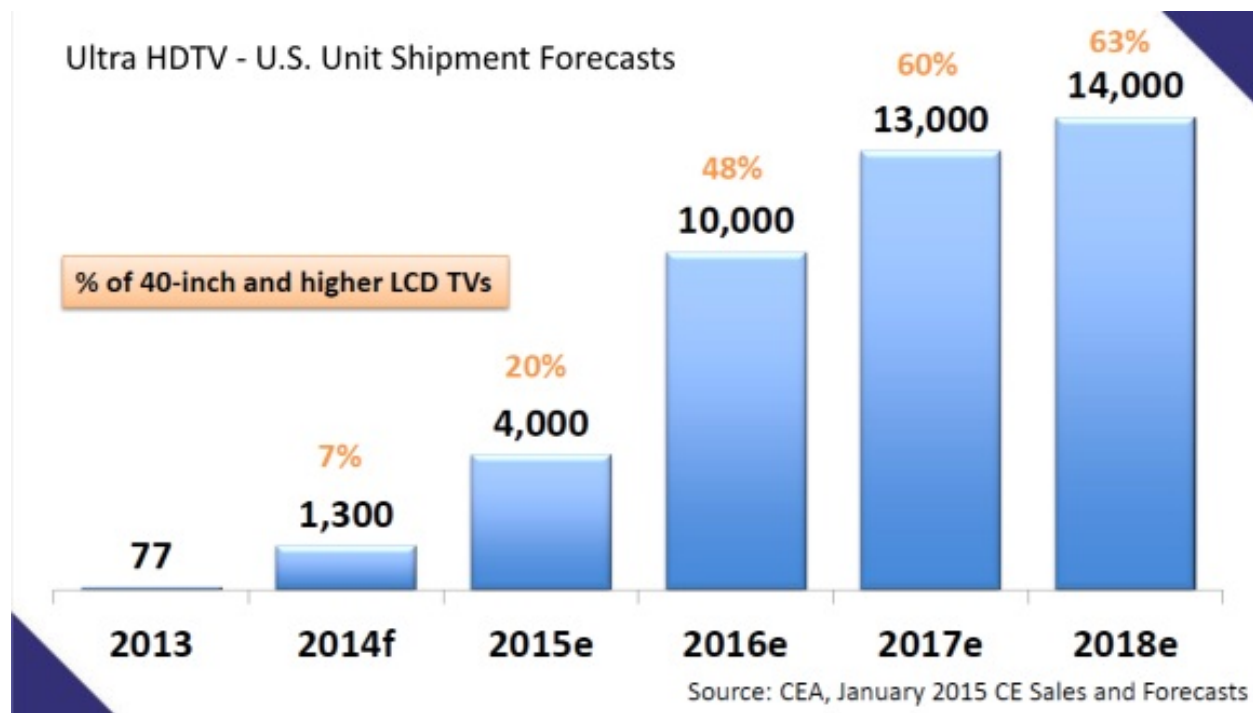


- According to Google, 25 billion hours of VP9 video watched on YouTube
- “VP9 is the most efficient video compression codec in widespread use today”

HEVC on Desktop/Mobile

- Desktop/notebook
 - Files could play; less battery life issues
 - No pervasive player (failure to launch)
- Mobile
 - Battery and power issues
 - Substantial percentage of installed base will never play HEVC
- Overall:
 - Streaming to desktop and mobile devices has seen little progress in last 18 months
 - Could be big year in 2015

OTT – UHD Sales Projections



- Projections are modest
- Most 4K TVs sold prior to 2016 will be obsolete by 2017
- <http://www.nscreenmedia.com/2015-building-ultra-hd-mainstream-3-years-away/>

STB/4K TVs

Why Ultra HD 4K TVs are still stupid

The flood of TVs with higher resolution than 1080p is inevitable, but at typical TV sizes, quadruple the pixels makes no difference in picture quality and are not worth the extra price.

CNET, 11/2014

- Most content upscaled/not enough content
- Have to be really close or get a really large TV

Don't Buy A 4K TV (Right Now)

[+ Comment Now](#) [+ Follow Comments](#)

Don't buy a 4K TV right now. Ignore the deals and bargains, this is *not* a good time to buy a 4K TV. In fact, it's one of the *worst* times to buy a 4K TV. TVs you can buy now won't be able to take advantage of significant next-generation picture quality advancements due out later this year. Some current TVs won't even be *compatible*.

Forbes, 2/2015

- HDR compatibility

Don't Buy a 4K TV Today



Stewart Wolpin

♥ Become a fan ✉ 🐦 👍

Technology Writer and Historian

5 Reasons NOT To Buy a 4K UHD TV - Yet

Posted: 04/14/2015 5:39 pm EDT | Updated: 04/14/2015 7:59 pm EDT

Huffington Post

5. The HDR Conundrum.

UHD is still somewhat a work in progress. This year's models still don't conform to a number of pending, still in development or just announced highly-technical upgrades such as [HEVC](#), [HDCP 2.2](#), [HDR](#) and [HDMI 2.0a](#).

For the average viewer, the subtle differences these H-acronyms upgrades will provide are admittedly hardly earth-shaking or even noticeable, with the singular exception of HDR, High Dynamic Range.

HDR brings a demonstrably higher degree of color, both in intensity and the number of colors and how accurately they're displayed. You can see the difference HDR makes on photos you snap on an iPhone with HDR switched on or off.

Looming Obsolescence

- Many 4K TVs will be obsolete in the short term
 - Potential big deal for consumers
- Much of the content encoded prior to 2016 will have to be reencoded to leverage HDR
 - Not such a big deal for publishers
 - About \$25/hour to encode to HEVC
 - http://bit.ly/uhd_encodecost
 - Netflix has about 8,000 movies – assume 90 minute average - \$300K
 - Amazon – 40K titles – assume 45 minutes each - \$750K

Deliverability Issues

Can I stream Netflix in Ultra HD?

Ultra HD streaming is available on Netflix!

What do I need to stream Ultra HD?

- A TV compatible with Ultra HD streaming from Netflix. See below for more details.
- A plan that supports streaming in Ultra HD. You can check which plan you're currently on at www.netflix.com/ChangePlan.
- A steady Internet connection speed of 25 megabits per second or higher. See below for more details.
- Streaming quality set to "**High**." More information about video quality settings can be found in our [Playback Settings](#) article.

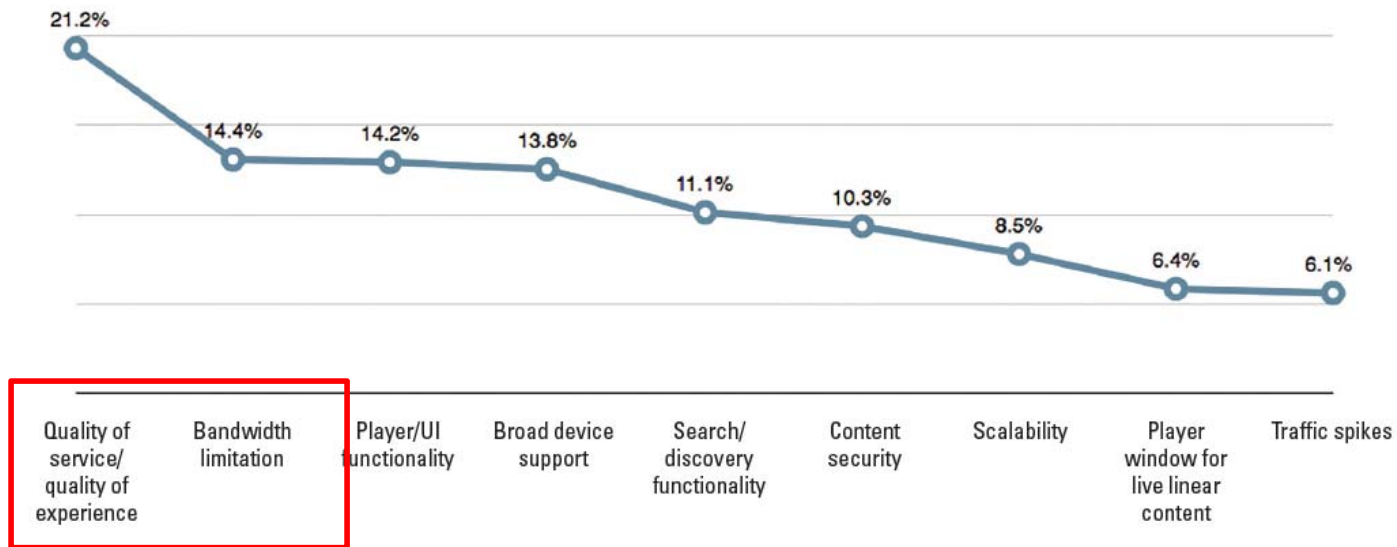
Steady internet connection speed of 25 Mbps

Akamai State of the Internet

Global Rank	Country/Region	Q4 '14 Avg. Mbps	QoQ Change	YoY Change
16	United States	11.1	-3.7%	15%
20	Canada	10.7	3.9%	19%

Unisphere Research: OTT Video Delivery

Chart 06: What are the most significant technical challenges for your business in offering OTT services today?



QOS/Bandwidth biggest issues

http://bit.ly/OTT_video

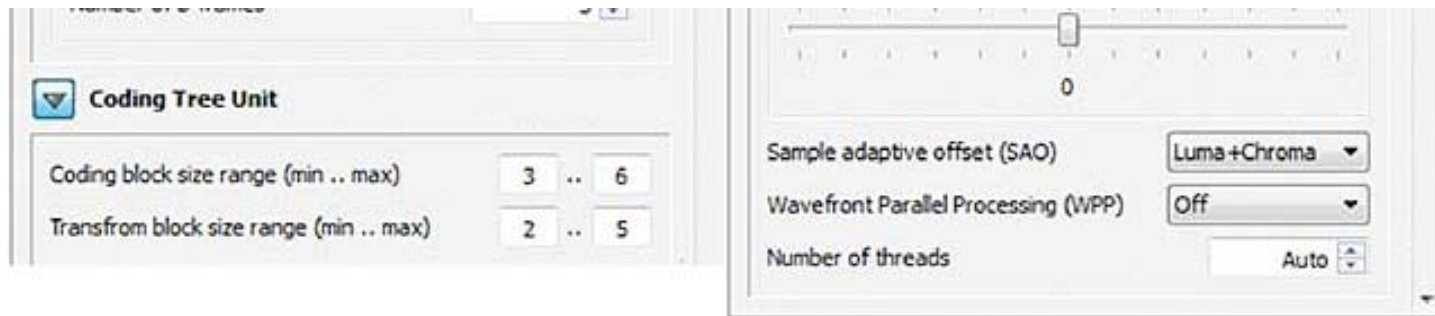
OTT Summary

- Market fundamentals aren't great
 - Not that many 4K sets
 - Substantial likelihood that many will be obsolete once HDR and other advances come through
 - Deliverability issues exist in many regions
 - Very little 4K content through broadcasters
 - News, sports, other non – Netflix-type content
- All that said, clearly lots of HEVC content being streamed to these devices

Producing HEVC


- Overview
- X265
 - Bitrate
 - Preset
 - Keyframe interval
- MainConcept
 - P/Q Value
 - Wavefront Parallel Processing
- Sample Adaptive Offset

HEVC Configuration Options - MainConcept



- Will vary by vendor
- MainConcept – access to profile, level, etc, plus:
 - Coding tree unit configuration
 - Sample adaptive offset
 - Wavefront Parallel Processing
 - Use case documentation to come with final product

Introduction to Moscow State U VQMT

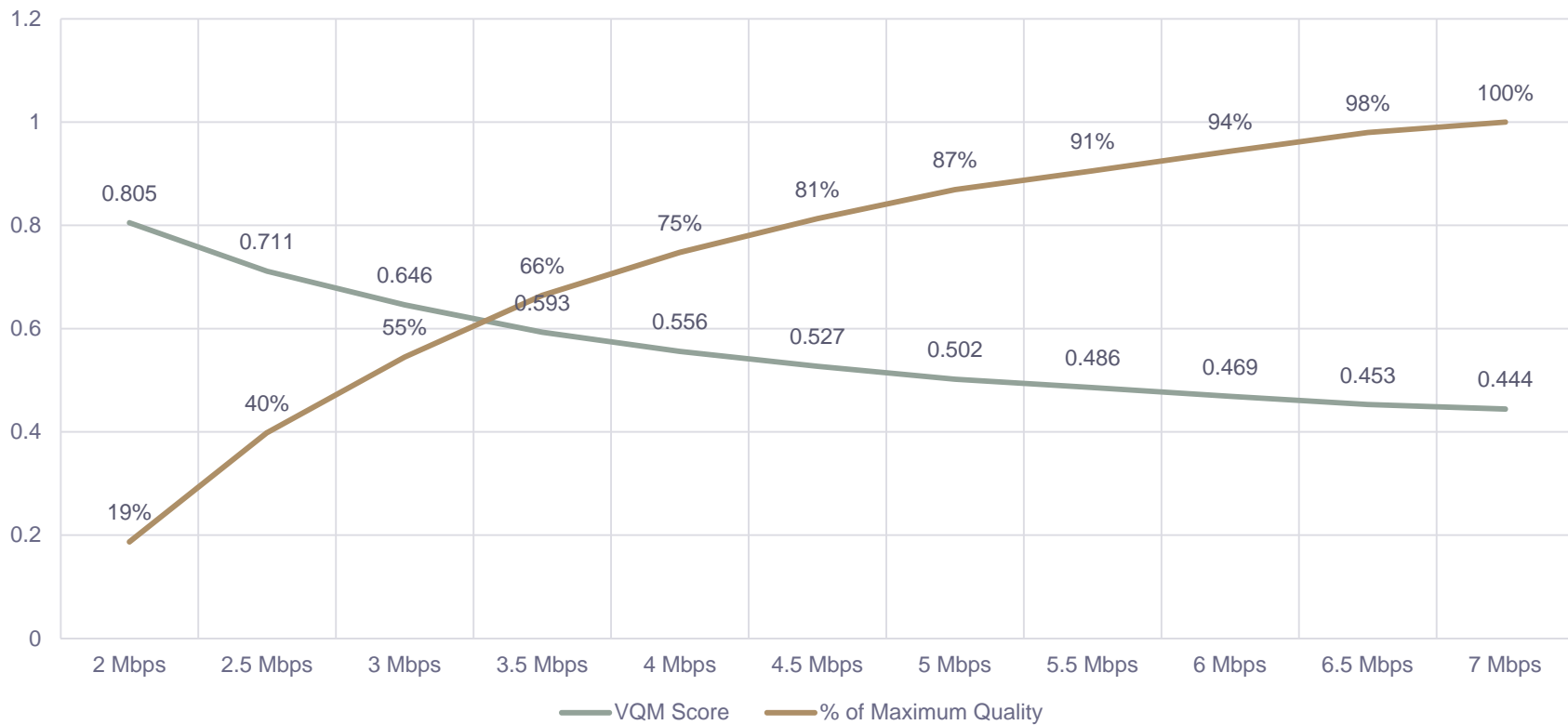
- Video Quality Measurement Tool
 - Input compressed file and original
 - Tool outputs various quality measures
 - Peak Signal to Noise (PSNR)
 - Structured Similarity (SSIM)
 - Video Quality Metric (VQM) 
- Can objectify previously subjective analysis
- Can compare alternatives numerically and visually

Affect of Data Rate on File Quality

Data Rate (Mbps)	VQM Score	% of Maximum Quality
2 Mbps	0.805	19%
2.5 Mbps	0.711	40%
3 Mbps	0.646	55%
3.5 Mbps	0.593	66%
4 Mbps	0.556	75%
4.5 Mbps	0.527	81%
5 Mbps	0.502	87%
5.5 Mbps	0.486	91%
6 Mbps	0.469	94%
6.5 Mbps	0.453	98%
7 Mbps	0.444	100%

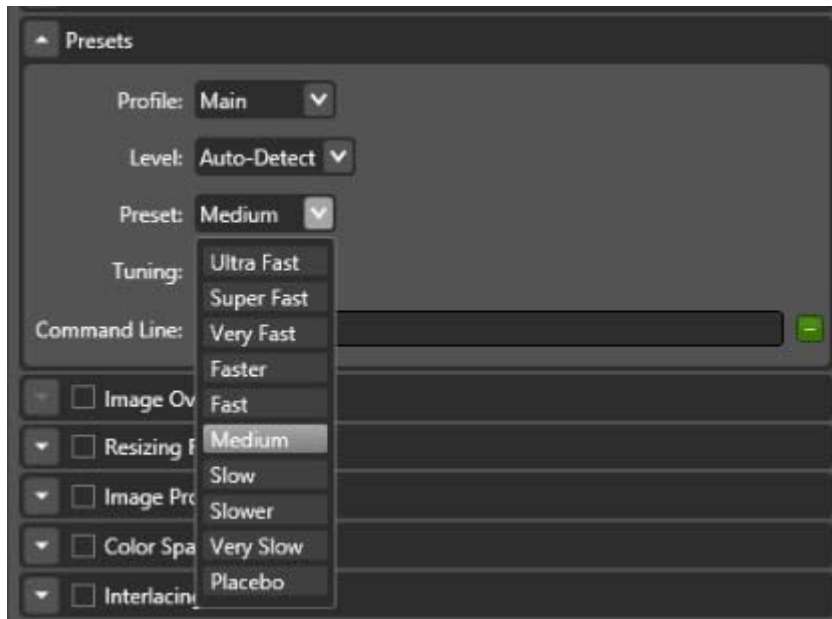
Affect of Data Rate on File Quality

Data Rate, VQM Score and % of Maximum Quality



Choosing a Preset

- What's a Preset?
 - Controls a range of parameters
 - Enables tradeoff between quality and encoding time



X265 Presets

- Presets
- Parameters
- The big issues are how much quality, how much encoding time?

	ultrafast	superfast	veryfast	faster	fast	medium	slow	slk
ctu	32	32	32	64	64	64	64	64
min-cu-size	16	8	8	8	8	8	8	8
bframes	3	3	4	4	4	4	4	8
b-adapt	0	0	0	0	0	2	2	2
rc-lookahead	5	10	15	15	15	20	25	30
scenecut	0	40	40	40	40	40	40	40
refs	1	1	1	1	2	3	3	3
me	dia	hex	hex	hex	hex	hex	star	star
merange	57	57	57	57	57	57	57	57
subme	0	1	1	2	2	2	3	3
rect	0	0	0	0	0	0	1	1
amp	0	0	0	0	0	0	0	1
max-merge	2	2	2	2	2	2	3	3
early-skip	1	1	1	1	0	0	0	0
fast-intra	1	1	1	1	1	0	0	0
b-intra	0	0	0	0	0	0	0	1
sao	0	0	1	1	1	1	1	1
signhide	0	1	1	1	1	1	1	1
weightp	0	0	1	1	1	1	1	1
weightb	0	0	0	0	0	0	0	1
aq-mode	0	0	1	1	1	1	1	1
cuTree	0	0	0	0	1	1	1	1
rdLevel	2	2	2	2	2	3	4	6

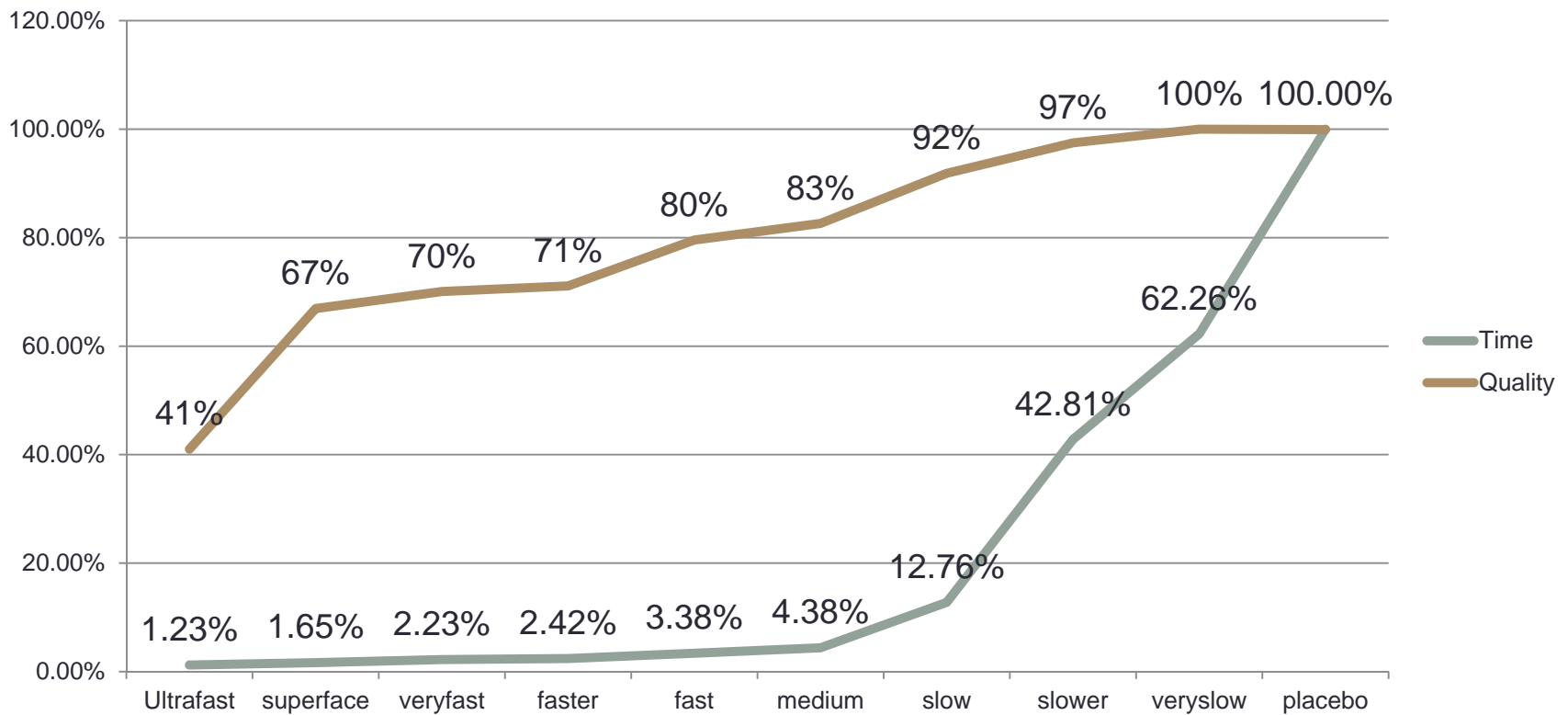
http://bit.ly/x265_presets

Choosing an x265 Preset

Preset	Time	Quality
Ultrafast	1.23%	41%
superfast	1.65%	67%
veryfast	2.23%	70%
faster	2.42%	71%
fast	3.38%	80%
medium	4.38%	83%
slow	12.76%	92%
slower	42.81%	97%
veryslow	62.26%	100%
placebo	100.00%	100%

Choosing an x265 Preset

Preset Quality and Encoding Time (normalized to 100%)



Affect of Key Frame Interval on Quality

HEVC

Key Frame Interval	VQM Score	Delta
15	0.93660	
30	0.90034	4%
60	0.79722	11%
90*	0.86318	-8%
120*	0.86501	0%
* Gotta be mistakes		

H.264

Key Frame Interval	360p @ 600 kbps	Delta
1 second	0.83159	
2 seconds	0.77519	6.78%
3 seconds	0.72899	5.96%
10 seconds	0.71163	2.38%

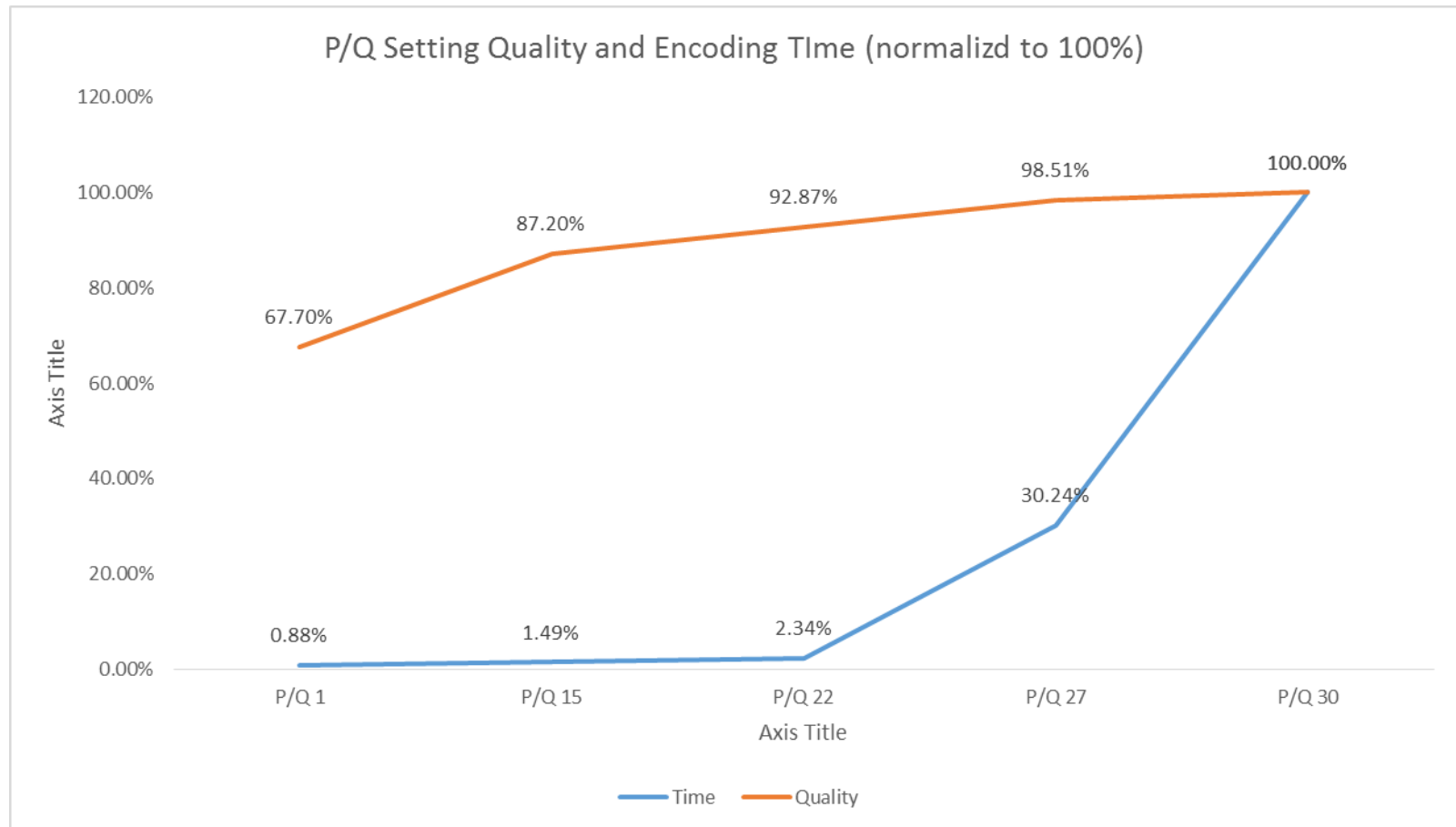
- Got new build Friday AM
- Didn't have time to check work
- Will update tests by Monday 5/18

Main Concept – P/Q Values

- Same concept
- Single switch that controls a number of configs trading off quality and encoding time

Preset	Average Encoding Time	Increase in Encoding Time	Average VQM Score (lower is better)	Quality Change
P/Q 1	2.7		1.38	
P/Q 15	4.6	68%	1.17	15%
P/Q 22	7.3	58%	1.12	5%
P/Q 27	94.0	1190%	1.06	5%
P/Q 30	310.7	231%	1.04	1%
Total Difference		1547%		27%

Main Concept – P/Q



Wavefront Parallel Processing

- What is it?
 - Feature that improves encoding speed and decode efficiency with a slight potential cost in quality
 - Worked differently in MainConcept and x266

Wavefront Parallel Processing - MainConcept

Encoding Time	Content	No WPP	WPP	Delta
Jan at desk	Talking head	90.9	113.6	24.97%
Ballet	Ballet	92.9	120.1	29.28%
Jan getting boxes	Moderate motion	96	119.6	24.58%
Food City - lift rising	Detail extreme motion	106.5	126	18.31%
Liquor store	Detail low motion	89.2	106.2	19.06%
Recycling center - forklift	Detail and motion	89.4	108.4	21.25%
Down street view	Detail and motion	96.2	116.7	21.31%
				22.68%
WPP - VQM	Content	27	27 - WPP	
Jan at desk	Talking head	0.57891	0.57918	-0.05%
Ballet	Ballet	1.0498	1.04554	0.41%
Jan getting boxes	Moderate motion	0.83415	0.83128	0.34%
Food City - lift rising	Detail extreme motion	2.36758	2.35165	0.67%
Liquor store	Detail low motion	0.67693	0.67517	0.26%
Recycling center - forklift	Detail and motion	1.1462	1.14397	0.19%
Down street view	Detail and motion	0.74676	0.74993	-0.42%
				0.20%

- 23% longer encoding time
- Slightly lower quality
- Not meaningful on any clips
- Disabled in MainConcept by default

Wavefront Parallel Processing – x265

Encoding Time	Content	No WPP	WPP	Delta
Jan at desk	Talking head	355.68	131.8	-62.94%
Ballet	Ballet	448.02	158.18	-64.69%
Jan getting boxes	Moderate motion	402.8	146.87	-63.54%
Food City - lift rising	Detail extreme motion	429.96	143.07	-66.72%
Liquor store	Detail low motion	243.93	88.73	-63.62%
Recycling center - forklift	Detail and motion	351.08	128.76	-63.32%
Down street view	Detail and motion	367.51	116.22	-68.38%
				-64.75%
VQM	Content	No WPP	WPP	Delta
Jan at desk	Talking head	0.61584	0.59346	3.63%
Ballet	Ballet	1.06225	1.03683	2.39%
Jan getting boxes	Moderate motion	0.83606	0.80828	3.32%
Food City - lift rising	Detail extreme motion	2.46366	2.42097	1.73%
Liquor store	Detail low motion	0.72949	0.68933	5.51%
Recycling center - forklift	Detail and motion	1.14793	1.12742	1.79%
Down street view	Detail and motion	0.85136	0.79311	6.84%
				3.60%

- WPP dropped encoding time by 65%
- Increase quality by 3.6%
- Enabled in MainConcept by default

Sample Adaptive Offset

- What is it?
 - Sample Adaptive Offset (SAO) is a filter applied after the standard deblocking filter
 - Designed to increase picture quality and reduce banding and ringing artifacts at some cost of encoding speed.
 - On by default in both codecs

Sample Adaptive Offset- MainConcept

Encoding Time	Content	On	SAO Off	Delta
Jan at desk	Talking head	90.9	93.8	3.19%
Ballet	Ballet	92.9	92.6	-0.32%
Jan getting boxes	Moderate motion	96	93	-3.13%
Food City - lift rising	Detail extreme motion	106.5	104.1	-2.25%
Liquor store	Detail low motion	89.2	98.4	10.31%
Recycling center - forklift	Detail and motion	89.4	87.8	-1.79%
Down street view	Detail and motion	96.2	96.6	0.42%
				0.92%
VQM Score	Content	On	SAO Off	Delta
Jan at desk	Talking head	0.58	0.65772	-13.61%
Ballet	Ballet	1.05	1.07459	-2.36%
Jan getting boxes	Moderate motion	0.83	0.84974	-1.87%
Food City - lift rising	Detail extreme motion	2.37	2.43589	-2.89%
Liquor store	Detail low motion	0.68	0.97413	-43.90%
Recycling center - forklift	Detail and motion	1.15	1.17489	-2.50%
Down street view	Detail and motion	0.75	0.94983	-27.19%
				-13.48%

- Encoding time about the same
- Quality significantly better with enabled
 - Funky concentration
 - One clip talking head
 - One high detail/low motion
 - One high detail and motion

Sample Adaptive Offset– x265

Encoding Time	Content	On	Off	Delta
Jan at desk	Talking head	129.99	129.71	-0.22%
Ballet	Ballet	155.93	155.04	-0.57%
Jan getting boxes	Moderate motion	144.08	159.9	10.98%
Food City - lift rising	Detail extreme motion	138.24	137.91	-0.24%
Liquor store	Detail low motion	89.87	89.1	-0.86%
Recycling center - forklift	Detail and motion	128.68	127.89	-0.61%
Down street view	Detail and motion	115.78	116.02	0.21%
				1.24%
VQM	Content	On	Off	Delta
Jan at desk	Talking head	0.597	0.586	1.76%
Ballet	Ballet	1.042	1.043	-0.14%
Jan getting boxes	Moderate motion	0.820	0.830	-1.28%
Food City - lift rising	Detail extreme motion	2.440	2.420	0.83%
Liquor store	Detail low motion	0.859	0.696	19.06%
Recycling center - forklift	Detail and motion	1.141	1.147	-0.52%
Down street view	Detail and motion	0.907	0.786	13.37%
				4.73%

- Very little difference in encoding time
- Overall minor difference, though big in some clips



Questions