NETINT

VVC Playback

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Marketing

NETINT

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Agenda

- Overview
- Desktop
- Mobile
- Living room

Overview

- From a publisher’s perspective, a codec is unusable until a critical mass of players exists in the relevant target markets
- There are two ways to playback compressed video, software or hardware:

Software vs. Hardware Playback

Software Playback

- How: Host CPU decodes and plays
- Pros:
  - No upgrade needed so faster deployment
  - AV1 was deployed in Chrome and Firefox in August, 2018, within months of release
- Cons
  - Playback may not be full framerate
    - AV1 playback on Android is not
  - Playback may consume excessive power (and shorten battery life)

Hardware Playback

- How: Hardware decode on CPU or GPU
- Pros:
  - Ensures full frame rate playback
  - Preserves battery life
- Cons
  - Longer deployment cycle

Overview

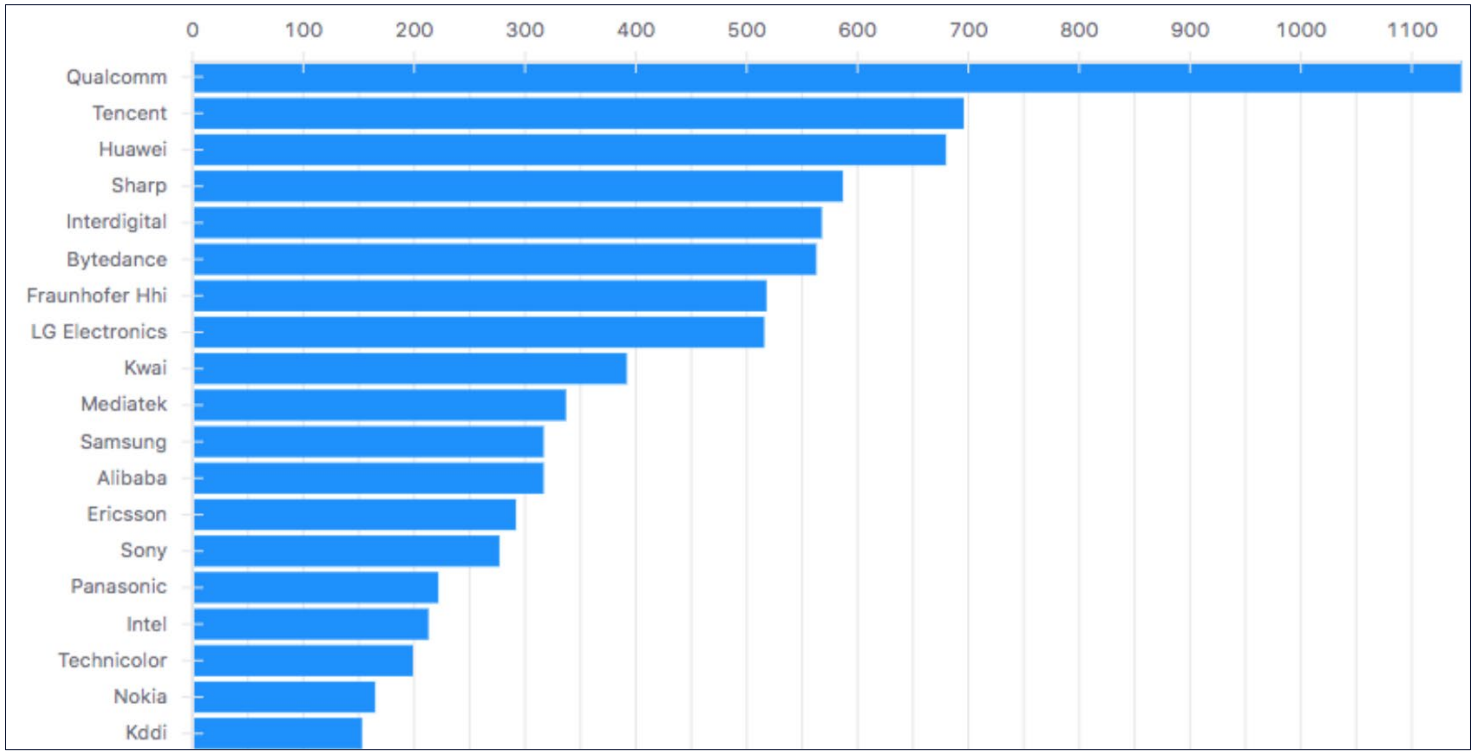
- From a publisher's perspective, a codec is unusable until a critical mass of players exists in the relevant target markets
- Two types of playback, software or hardware
- In both cases, licensing and playback are different issues
  - Distributing a VVC player is likely a royalty-bearing event
- Distributing a codec always incorporates two questions
  - Can the platform play the video at full frame rate without significantly degrading battery life?
  - Is the licensing side easily manageable?

Desktop Overview

- Desktop are the most optimal platform for software-based playback, as CPUs are relatively powerful
- That said, the lack of browser support makes licensing a significant challenge

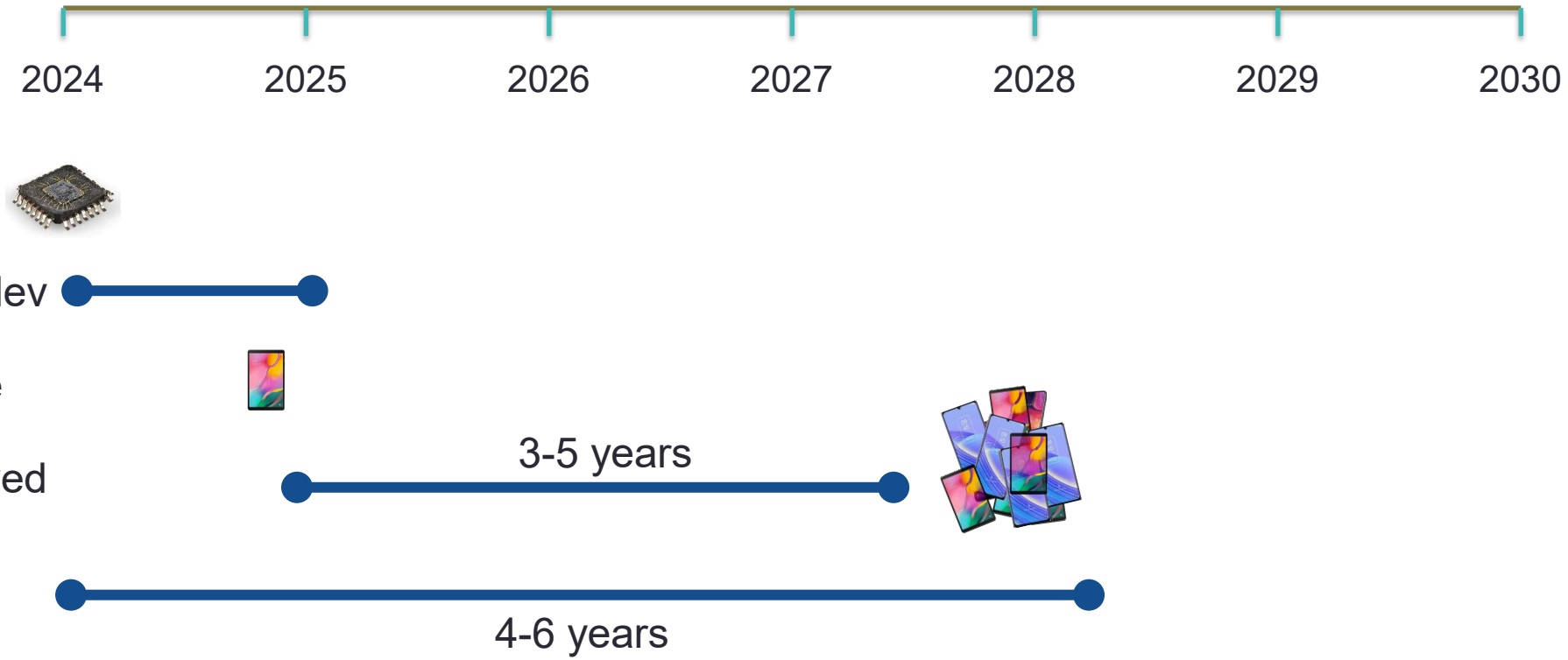
What About Desktop Hardware?

- No CPUs or GPUs announced at this time
  - Intel – major IP contributor (and in MC-IF)
    - Presumably first
  - Not listed
    - AMD (CPU/GPU)
    - NVIDIA



https://bit.ly/VVC_POs_Unified

Codec Deployment – Hardware / Best Case



When to Expect VVC Decode at Scale (FDIS – July 2020)

- HEVC – standardized April 2013
  - Intel – 6th gen Intel Core with HEVC decode (8-bit) – August 2015 – 2 years 1 month
  - AMD – Q1/2017 – 3 years 10 months
- VVC – at 2 years 10 months, no announcement
- Best guess – 2028 or so, relevant share of installed base will have VVC hardware decode

Desktop Overview

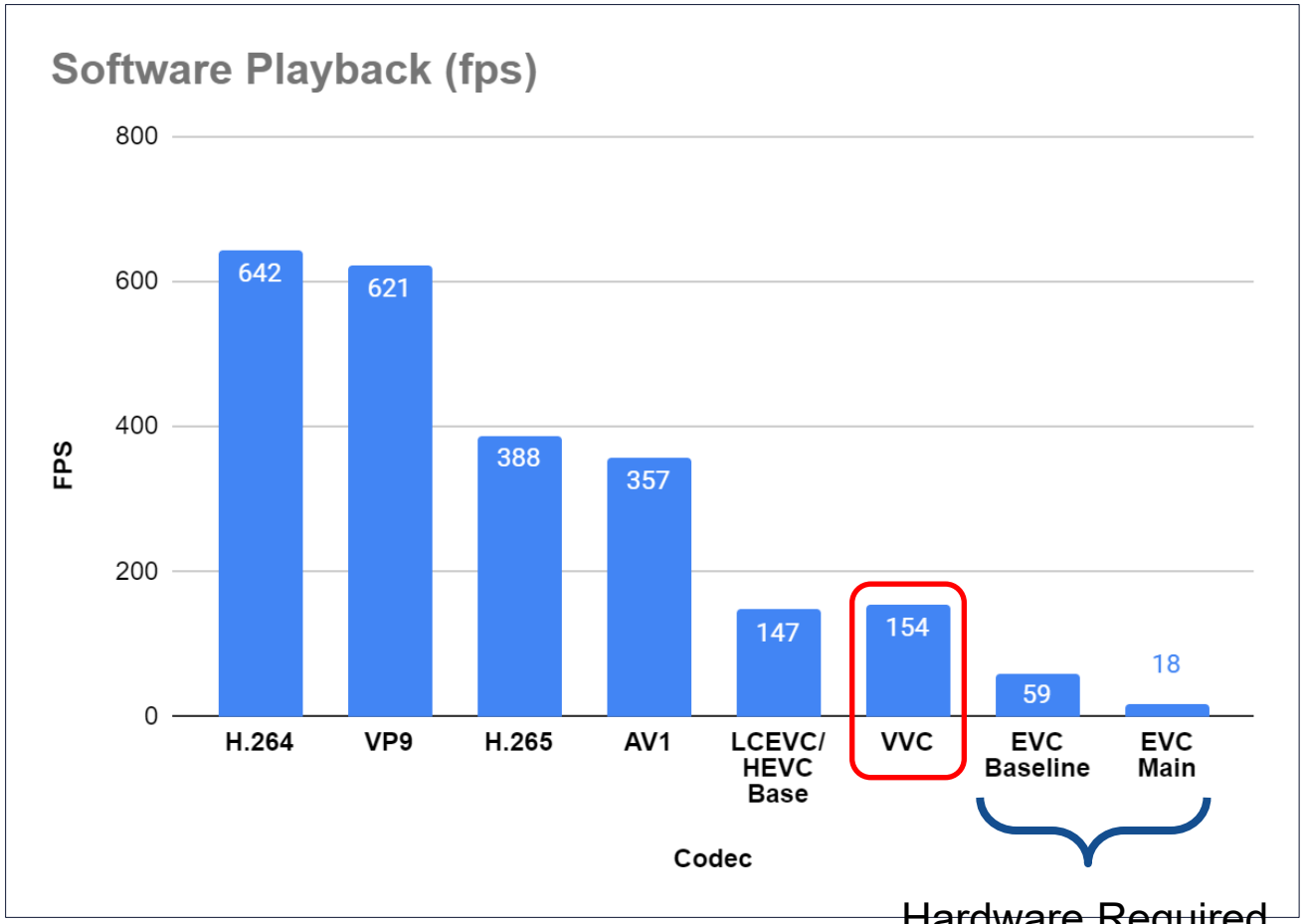
- Desktop are the most optimal platform for software-based playback, as CPUs are relatively powerful
- That said, the lack of browser support makes licensing a significant challenge

Playability - Performance

- Where can the codec play?
  - VVC plays at 5x 1080p frame rate on a 13-year-old desktop CPU

Device specifications

Device name	DESKTOP-E13MMP4
Processor	Intel(R) Core(TM) i7-3770 CPU @ 3.40GHz 3.40 GHz
Installed RAM	16.0 GB (15.9 GB usable)



Experimental Setup

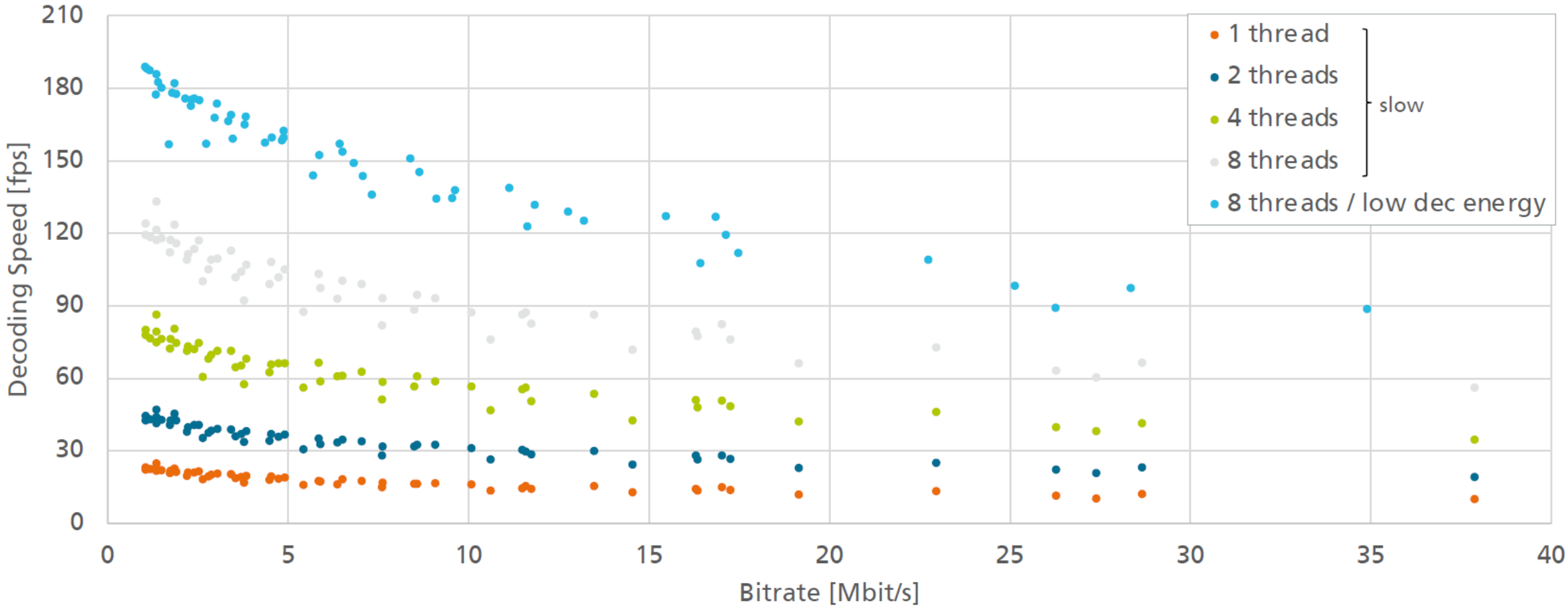
Systems

	Workstation		Laptop		Mobile
CPU	M1 Ultra	Xeon 6348	M1 Max	i9-12900H	Snapdragon 865+
Cores*	16P @ 3.2 GHz 4E @ 2.06 GHz	28 @ 2.6 GHz	8P @ 3.2 GHz 2E @ 2.06 GHz	6P @ 5.0 GHz 8E @ 3.4 GHz	1/3P @ 3.09/2.4 GHz 4E @ 1.9 GHz
Threads**	20	56	10	20	8
OS	MacOS 13.2	Ubuntu 22.04	MacOS 13.2	Ubuntu 22.04	Android 12
Compiler	clang 14.0.0	gcc 11.3.0	clang 14.0.0	gcc 11.3.0	clang 14.0.6
SIMD	NEON	AVX512	NEON	AVX2	NEON

* P = performance core, E = efficiency core, **including hyper-threading

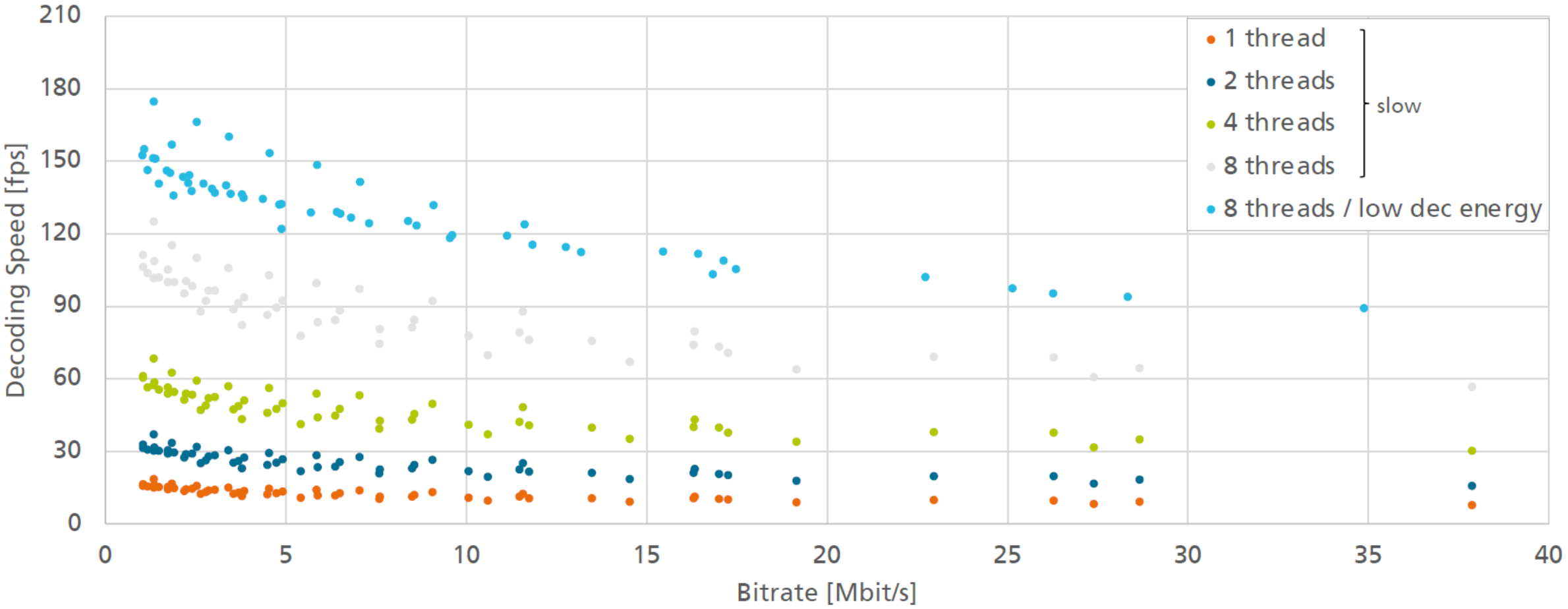
VVdeC Decoder Runtime

Laptop – UHD – x86



VVdeC Decoder Runtime

Laptop – UHD – ARM



Tencent Software Player - https://bit.ly/TC_VVC_Play

Sequence	QP	Frames	Bitrate [Mbps]	VTM [fps]	O266 Thread 1 [fps]	O266 Thread 2 [fps]	O266 Thread 4 [fps]	O266 Thread 8 [fps]
Tango	22	294	27.86	2.03	6.74	13.02	23.82	41.86
	27	294	7.54	2.48	8.21	15.62	28.48	50.33
	32	294	3.62	2.72	9.11	17.33	31.34	55.48
	37	294	1.97	3.04	10.59	20.11	36.64	64.11
FoodMarket	22	300	16.98	2.11	7.02	13.43	24.85	44.47
	27	300	7.58	2.40	7.92	15.16	27.98	48.62
	32	300	3.91	2.66	8.96	17.07	31.41	56.37
	37	300	2.06	2.95	10.21	19.5	35.92	63.58
Campfire	22	300	59.03	1.35	4.23	8.33	15.93	29.01
	27	300	15.33	2.09	7.16	13.76	24.43	46.12
	32	300	6.93	2.54	8.79	16.69	30.51	54.96
	37	300	3.50	2.91	10.07	19.07	34.71	59.05
CatRobot	22	300	33.71	1.86	6.13	11.81	21.77	38.27
	27	300	8.68	2.45	7.98	15.31	28.39	50.36
	32	300	4.11	2.79	9.29	17.81	32.94	57.57
	37	300	2.14	3.06	10.65	20.34	37.75	66.46
DaylightRoad	22	300	58.71	1.62	5.23	10.17	18.77	32.75
	27	300	10.23	2.27	7.41	14.21	26.1	47.68
	32	300	4.12	2.62	8.61	16.35	30.07	54.04
	37	300	2.06	2.96	10.08	19.16	35.32	51.98
ParkRunning	22	300	108.17	1.17	3.57	6.99	13.53	24.75
	27	300	41.64	1.46	4.72	9.17	17.35	31.82
	32	300	18.47	1.76	5.83	11.19	20.96	38.49
	37	300	8.01	2.22	7.27	13.86	25.43	45.64
Average			**19.02**	**2.31**	**7.74**	**14.81**	**27.27**	**48.07**

Table I: decoding speed comparison among VTM and Tencent O266 decoders, 4K CTC streams

Table II: decoding speed comparison among VTM and Tencent O266 decoders, 2K CTC streams

Sequence	QP	Frames	Bitrate [Mbps]	VTM [fps]	O266 Thread 1 [fps]	O266 Thread 2 [fps]	O266 Thread 4 [fps]	O266 Thread 8 [fps]
MarketPlace	22	600	14.39	6.74	21.02	40.06	73.13	129.63
	27	600	5.12	8.54	26.84	50.78	91.12	162.95
	32	600	2.26	10.12	32.66	61.53	108.68	192.03
	37	600	1.00	11.6	38.92	73.51	127.79	219.38
RitualDance	22	600	9.22	7.13	23.12	43.74	79.37	143.36
	27	600	4.57	8.78	28.79	54.21	97.84	166.05
	32	600	2.43	10.35	34.23	64.29	114.96	201.47
	37	600	1.27	11.84	40.17	75.27	132.6	233.2
Cactus	22	500	14.09	6.65	21.22	40.24	71.09	120.21
	27	500	4.12	9.66	32.18	60.24	107.48	184.36
	32	500	1.89	11.43	39.33	73.27	128.41	216.78
	37	500	0.93	12.99	47.11	88.1	152.03	257.45
BasketballDrive	22	500	14.44	6.2	19.56	37.34	67.16	117.78
	27	500	4.69	8.3	26.44	49.81	88.79	158.62
	32	500	2.16	9.76	31.53	58.8	103.19	182.4
	37	500	1.07	11.02	35.66	66.12	115.14	207.01
BBQTerrace	22	600	34.07	4.65	14.38	27.91	52.19	93.8
	27	600	5.47	9.75	31.75	59.04	101.57	174.95
	32	600	1.69	12.16	39.79	73.26	126.24	223.15
	37	600	0.75	13.46	45.14	83.49	143	254.02
Average			**6.28**	**9.56**	**31.49**	**59.05**	**104.09**	**181.93**

*CTC bitstreams is generated by VTM-10 encoder

*Tested on Windows Desktop i7-9700@3.0G platform

Spin Digital Player – Includes Decoder

Spin Digital VVC Media Player (Spin Player VVC) enables real-time decoding and playback of VVC/H.266 UHD (4K, 8K) video and MPEG-H Audio on PC-based systems.

Spin Player VVC is addressed to innovative and demanding playback systems in broadcast, video streaming, large screen display, and virtual reality, and screen content coding.

spin player vvc

Spin Digital VVC Media Player

VVC/H.266 software media player for 4K-UHD and 8K-UHD video with NGA audio, enabling next-generation applications in broadcast, immersive media, and large screen visualization.

Product Highlights

- VVC decoding up to 8Kp120 on a single PC
- Support for VVC Multilayer profile (spatial scalability)
- Advanced renderer with SDI and GPU outputs
- 8K HDR with HDMI 2.1 interface
- Color conversion and tone mapping
- TS-over-IP live streaming: UDP, RTP, SRT, RIST, Zixi
- HTTP streaming: HLS, DASH
- Next Generation Audio (NGA): MPEG-H Audio

RECOMMEND SYSTEMS FOR HIGH-END PLAYBACK

8K 60 Hz

Use case	Format	Platform
Distribution GPU output	8Kp60 4:2:0 10-bit	CPU: Intel Core i9-13900K (8+16 cores) Memory: 16 GB (2x 8 GB, DDR5-5600) GPU: NVIDIA GeForce RTX 3060, or Intel Arc A770
Distribution SDI output	8Kp60 4:2:0 10-bit	CPU: Intel Xeon Gold 6330 (28 cores) Memory: 64 GB (8x 8 GB, DDR4-3200) 12G-SDI: AJA Kona 5, Corvid 44 12G, or Blackmagic DecLink 8K Pro

8K 120 Hz

Use case	Format	Platform
High frame rate	8Kp120 4:2:0 10-bit	CPU: 2x Intel Xeon Gold 6338 (2x 32 cores) Memory: 128 GB (16x 8 GB, DDR4-3200) 12G-SDI: 2x AJA Kona 5, 2x AJA Corvid 44, or 2x Blackmagic DeckLink 8K Pro

Playability – Compatibility - Computer and Mobile Browser Support

	HEVC	VP9	AV1	VVC	LCEVC	EVC Baseline	EVC Main
Playability	388 fps	621 fps	357 fps	154 fps	147fps +	59 fps	18 fps
- Browser support	87.51	97.95	70.79%	Not listed	Not listed	Not listed	Not listed
- Browser workaround	No	NA	NA	No	**Yes**	No	No

- CanIUse shows compatibility percentage
  - VVC not yet listed
  - Any company distributing VVC-encoded video will have to distribute player as well and pay any associated royalty
  - This is complicated since few computer users will install a player for desktop video

https://caniuse.com/?search=VVC

Computer – Summary

- Pervasive hardware support won't be available before 2028 or so
- VVC can play today on most relatively modern computers (1080p)
- The lack of browser support means that publishers will have to distribute and pay for a player
- The likelihood of browser support improved once Chrome enabled HEVC playback
  - But: Chrome only plays HEVC when an HEVC player exists on system (so Google is not distributing a player)
  - Schema requires existing software or hardware support for HEVC; right now that number is at zero for VVC

Mobile

- Overview
- Hardware status
- Software playback

Mobile Overview

- Mobile apps make it easier to distribute video encoded with VVC
- But: Mobile users are less tolerant of software decoding because:
  - Lower performing CPUs mean that video may not play at full frame rate
  - Video playback will degrade battery life
- AOM members (particularly Meta) ignored these negatives and shipped video for software decoding anyway
- This likely will be the case with several major VVC IP owners
  - Tencent
  - Kwai
  - ByteDance
- Presumably, most unaffiliated patent owners will wait for hardware decode

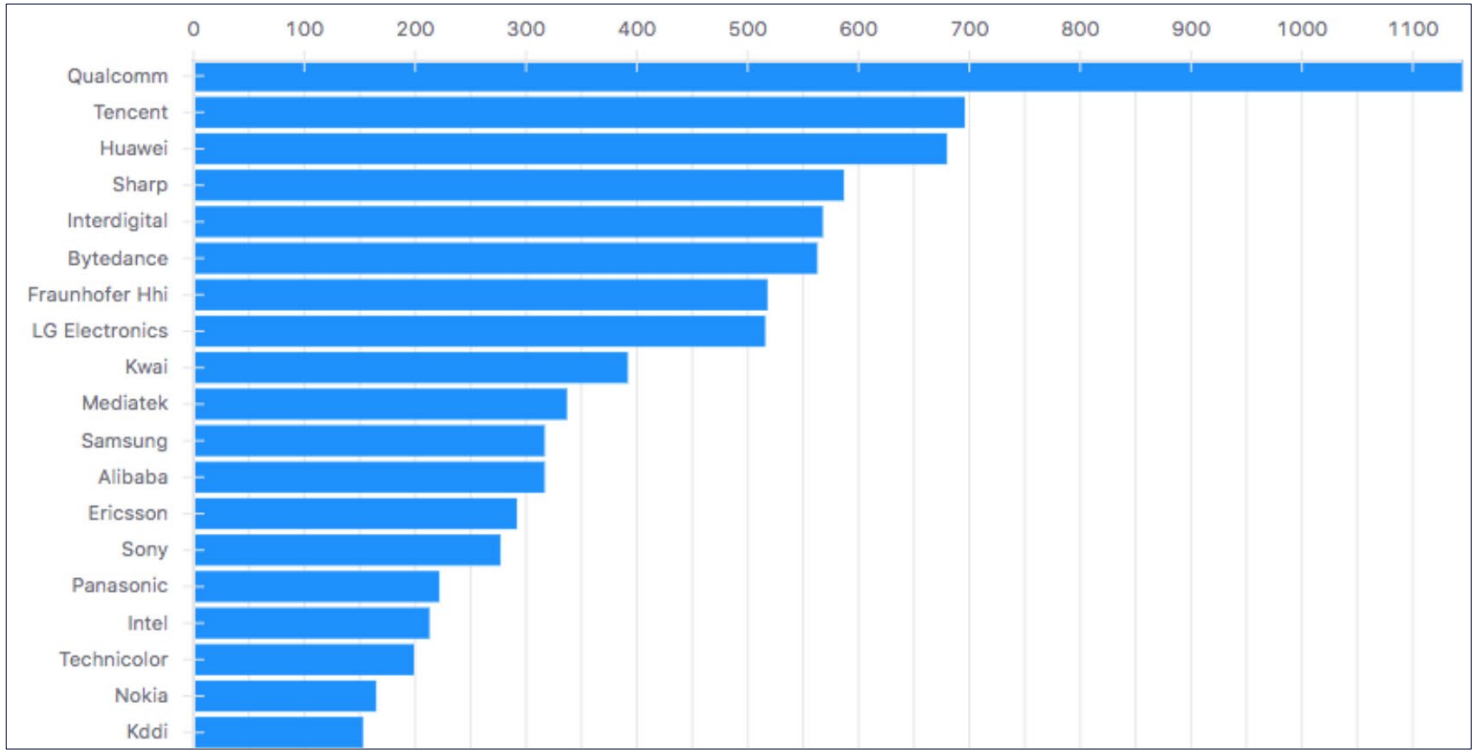
What About Mobile Hardware?

- No CPUs or GPUs announced at this time
  - Intel – major IP contributor (and in MC-IF)
  - Apple – also a contributor

https://bit.ly/VVC_POs_Unified

What About Desktop Hardware?

- No CPUs or GPUs announced at this time
  - Intel – major IP contributor (and in MC-IF)
    - Presumably first
  - Not listed
    - AMD (CPU/GPU)
    - NVIDIA



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Software Playback Appears Acceptable on High End Phones

- At least on premium phones

Experimental Setup

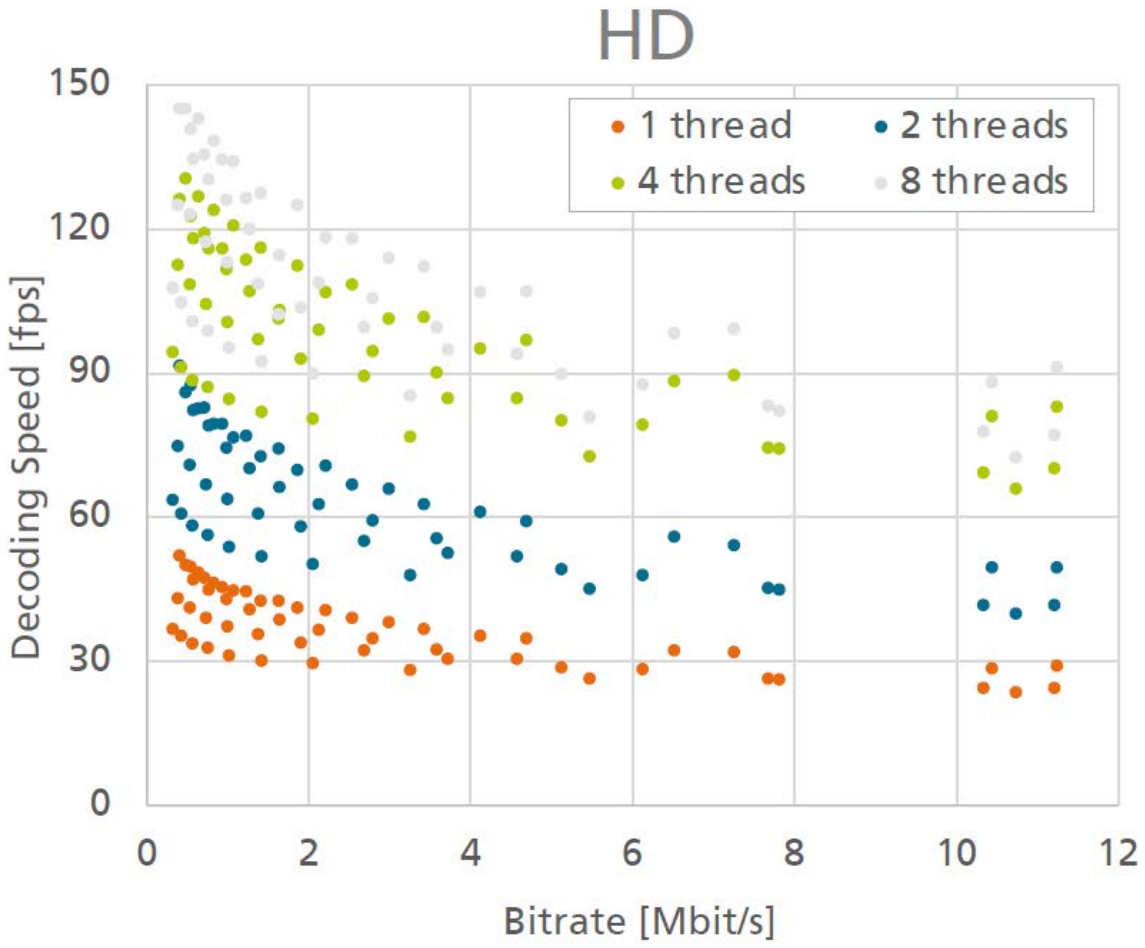
Systems

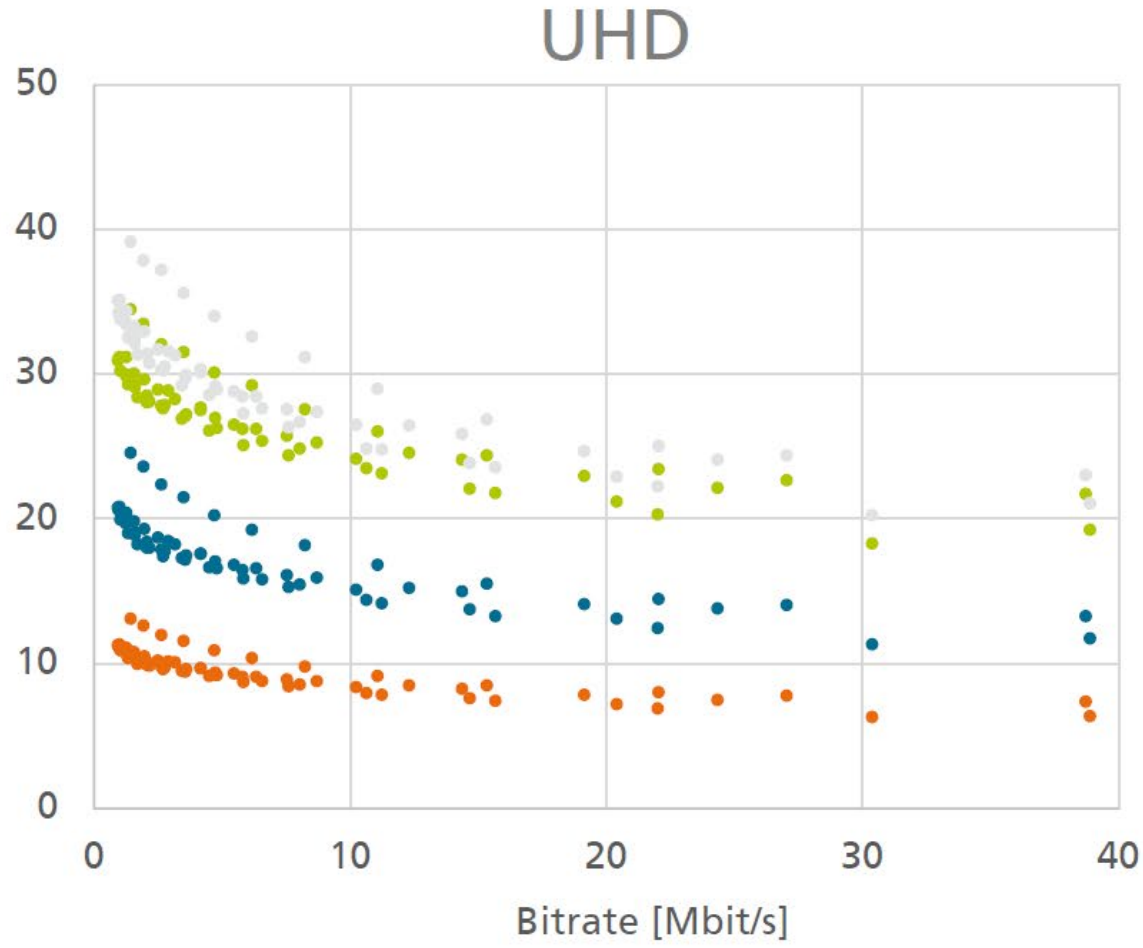
	Workstation		Laptop		Mobile
CPU	M1 Ultra	Xeon 6348	M1 Max	i9-12900H	Snapdragon 865+
Cores*	16P @ 3.2 GHz 4E @ 2.06 GHz	28 @ 2.6 GHz	8P @ 3.2 GHz 2E @ 2.06 GHz	6P @ 5.0 GHz 8E @ 3.4 GHz	1/3P @ 3.09/2.4 GHz 4E @ 1.9 GHz
Threads**	20	56	10	20	8
OS	MacOS 13.2	Ubuntu 22.04	MacOS 13.2	Ubuntu 22.04	Android 12
Compiler	clang 14.0.0	gcc 11.3.0	clang 14.0.0	gcc 11.3.0	clang 14.0.6
SIMD	NEON	AVX512	NEON	AVX2	NEON

* P = performance core, E = efficiency core, **including hyper-threading

VVdeC Decoder Runtime

Mobile – Low Decoding Energy Preset – ARM





VVC Trials – VVC Stakeholders

Results for Android Platform

- Kwai UGC Sequences

	VTM-11.0	K266Dec				Speedup			
# threads	1	1	2	4	8	1	2	4	8
Huawei P40	26.66	97.49	173.85	270.26	178.75	4.82	8.59	13.35	8.83
Oppo R17	10.59	40.95	78.40	100.52	116.97	5.17	9.89	12.68	14.76
VIVO Y93s	5.82	19.06	35.28	60.10	56.63	4.39	8.12	13.83	13.03

link

Performance on iPhone13

	BVC (CPU+GPU) vs. VTM-11.0						
	RA						
	VTM-11.0 (fps)	BVC (CPU+GPU)(fps)			Speedup ratio		
		T-1	T-2	T-4	T-1	T-2	T-4
class A1	2.2	39.5	60.7	67.7	17.6	27.2	30.3
class A2	2.0	30.8	48.8	54.1	15.3	24.2	26.8
class B	9.8	144.3	205.0	217.7	14.8	21.0	22.3
class C	53.5	473.3	563.7	630.3	8.9	10.5	11.8
class D	206.6	970.5	1043.5	1074.2	4.7	5.1	5.2
class F	43.6	444.1	527.6	616.0	10.2	12.1	14.1

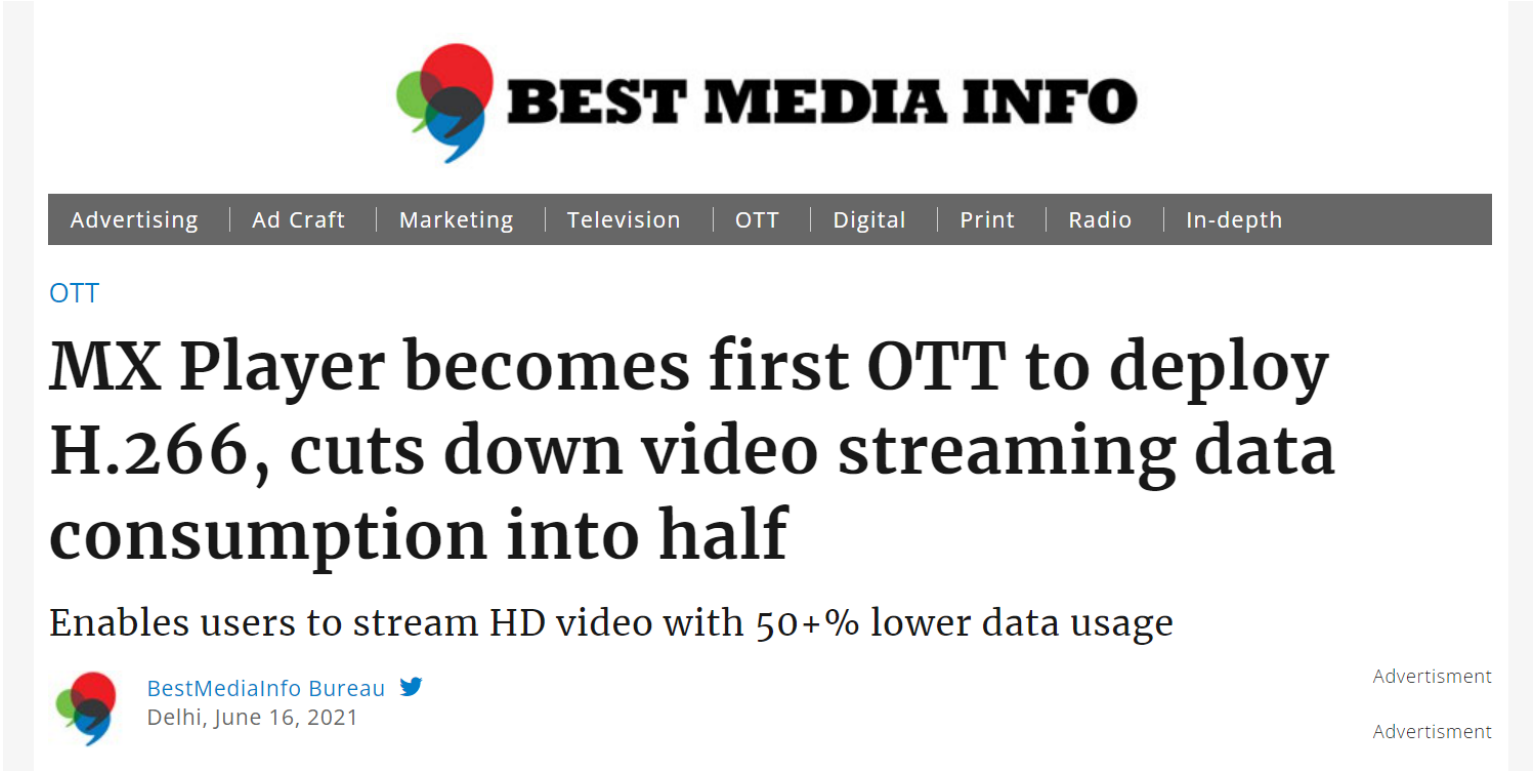
- For 4K 8-bit CTC bitstreams
  - *Achieve 35 fps with single thread on average*
  - *15x faster than the VTM11.0 reference decoder with single thread*

link

ByteDance 字节跳动

- As with AV1, stakeholders could deploy VVC much earlier than a third-party company
  - This will prime the pump, accelerating hardware/software support and additional deployments

MX Player (Largely Serves India)



BEST MEDIA INFO

Advertising | Ad Craft | Marketing | Television | OTT | Digital | Print | Radio | In-depth

OTT

MX Player becomes first OTT to deploy H.266, cuts down video streaming data consumption into half

Enables users to stream HD video with 50+% lower data usage

BestMediaInfo Bureau
Delhi, June 16, 2021

Mobile Distribution

- Bottom line
  - Most mainstream publishers won’t distribute VVC to phones without hardware players
  - This likely won’t happen until 2028 (or so)
- This may change if IP owners like Tencent, ByteDance, and Kwai prove the value proposition for software playback

Living Room

- Overview
- Hardware support

Living Room Overview

- The living room includes Smart TVs and OTT dongles
  - No software playback
- Much more progress made here than in computers/mobile
  - Makes sense: VVC is a premium content experience codec
  - The living room is where most premium content is veiwed

Hardware Support

Company	Chip / Architecture	Type	Throughput	Ref
Allegro DVT	AL-D320	Decoder IP core	8K@120	[31][32]
MediaTek	Pentonic 2000	Decoder	8K@144	[33]
	Pentonic 1000	Decoder	4K@144	[34]
	Pentonic 700	Decoder	4K@144	[35]
Realtek	RTD1319D	Set-top box SoC	4K@60	[36]
VeriSilicon	Hantro VC9000D	Decoder	8K@120	[37]

November 2021 (TV)

November 2022 (TV)

August 2022 (TV)

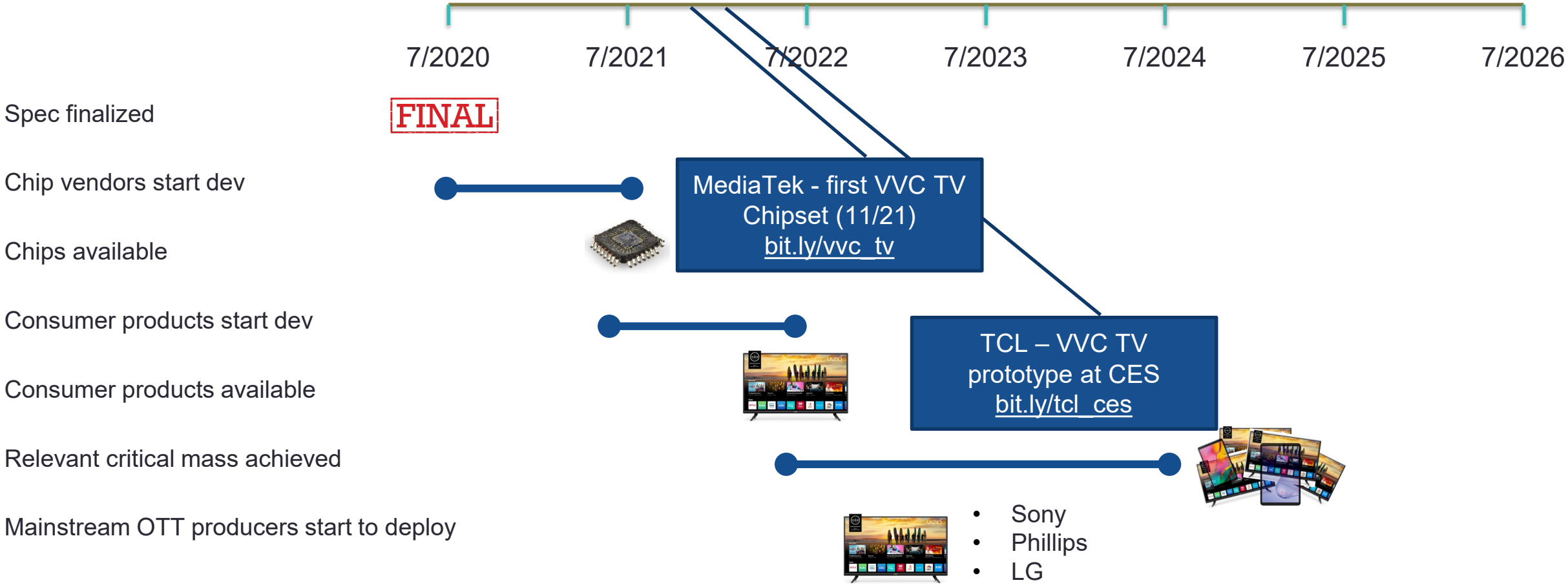
August 2022 (TV)

March 2023 (TV, phones, other)

Television Sets

- Philips - **all** 2023 **OLED models** will support VVC
- Sony – **some** 2023 sets will support VVC
- LG’s webOS TV now supports VVC for 8K Ultra HD TVs

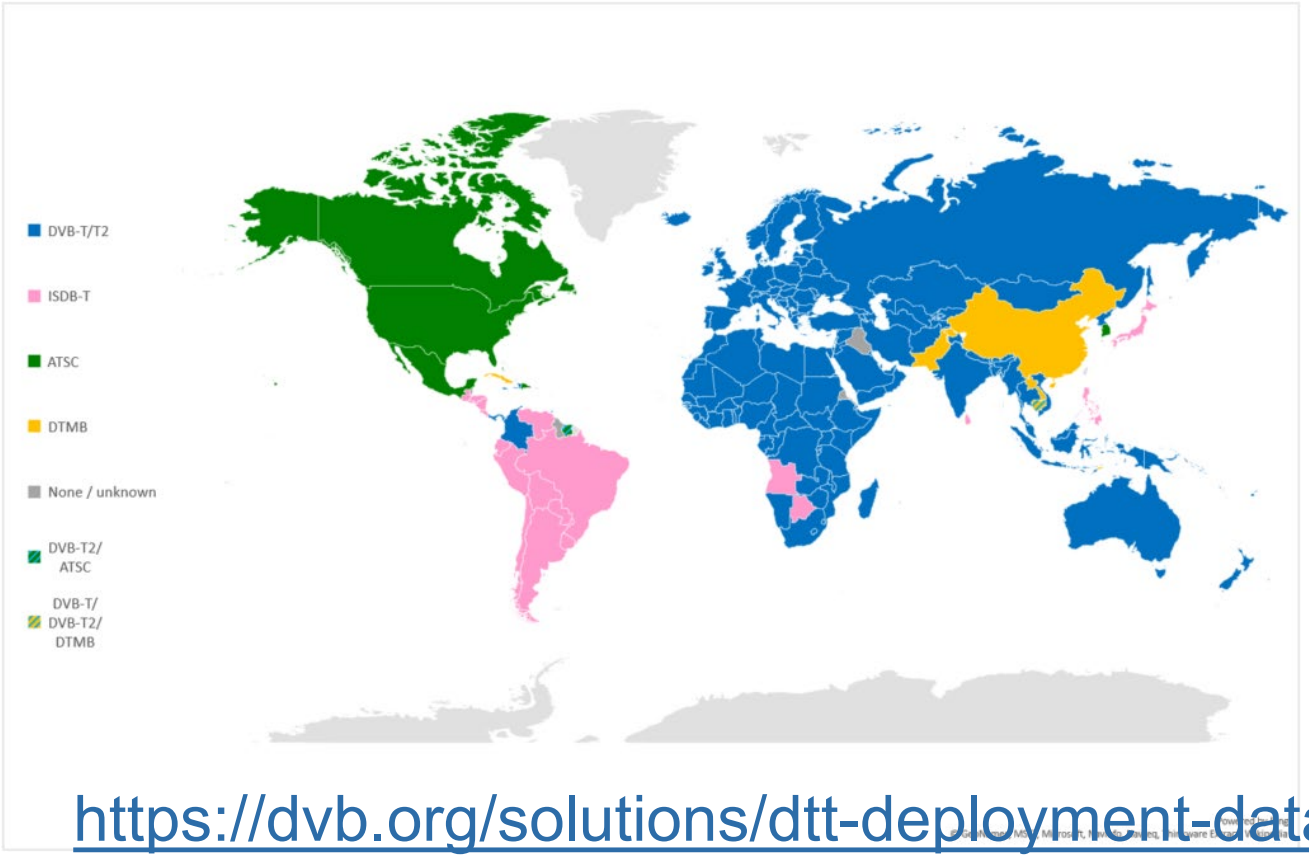
Codec Deployment – VVC – TV/Mobile Hardware



Other Factors

bit.ly/DVB_VVC2

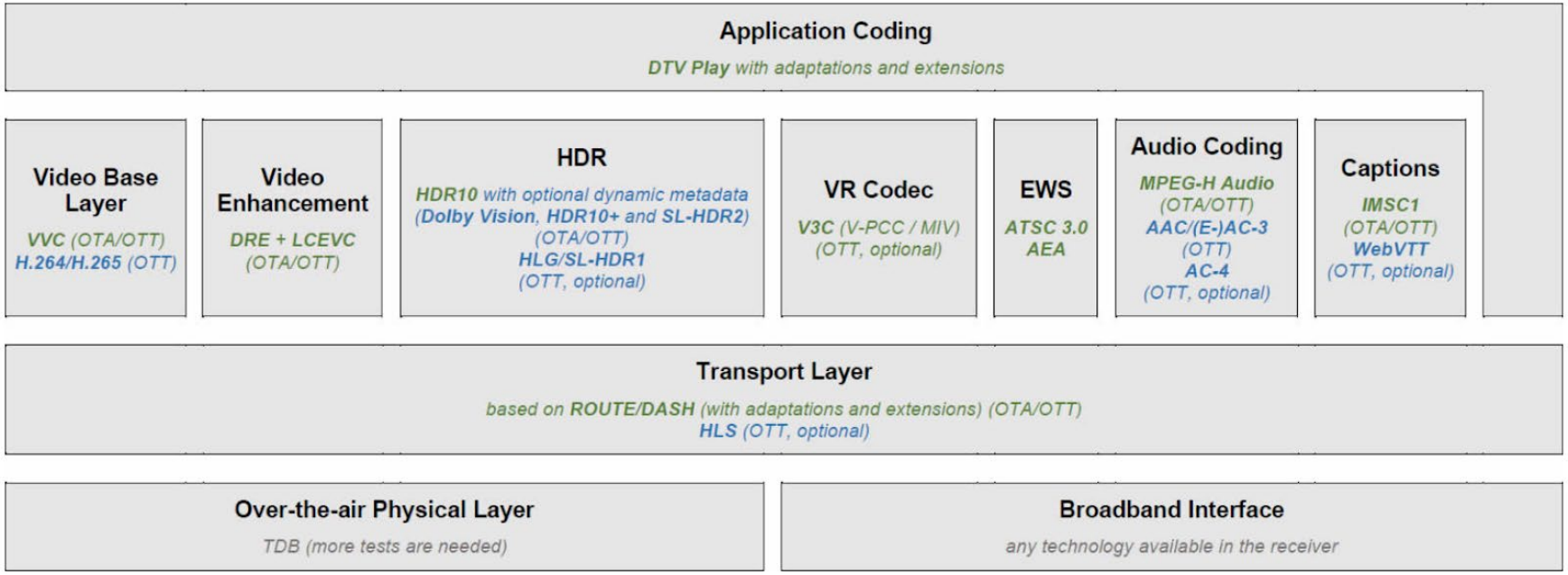
- VVC added to DVB tuner specification



https://dvb.org/solutions/dtt-deployment-data/

- From the press release – “Having completed the addition of VVC on schedule, the group is continuing to work intensively, with the AVS3 codec as the current focus and **AV1 next in line for evaluation.”**

Other Factors

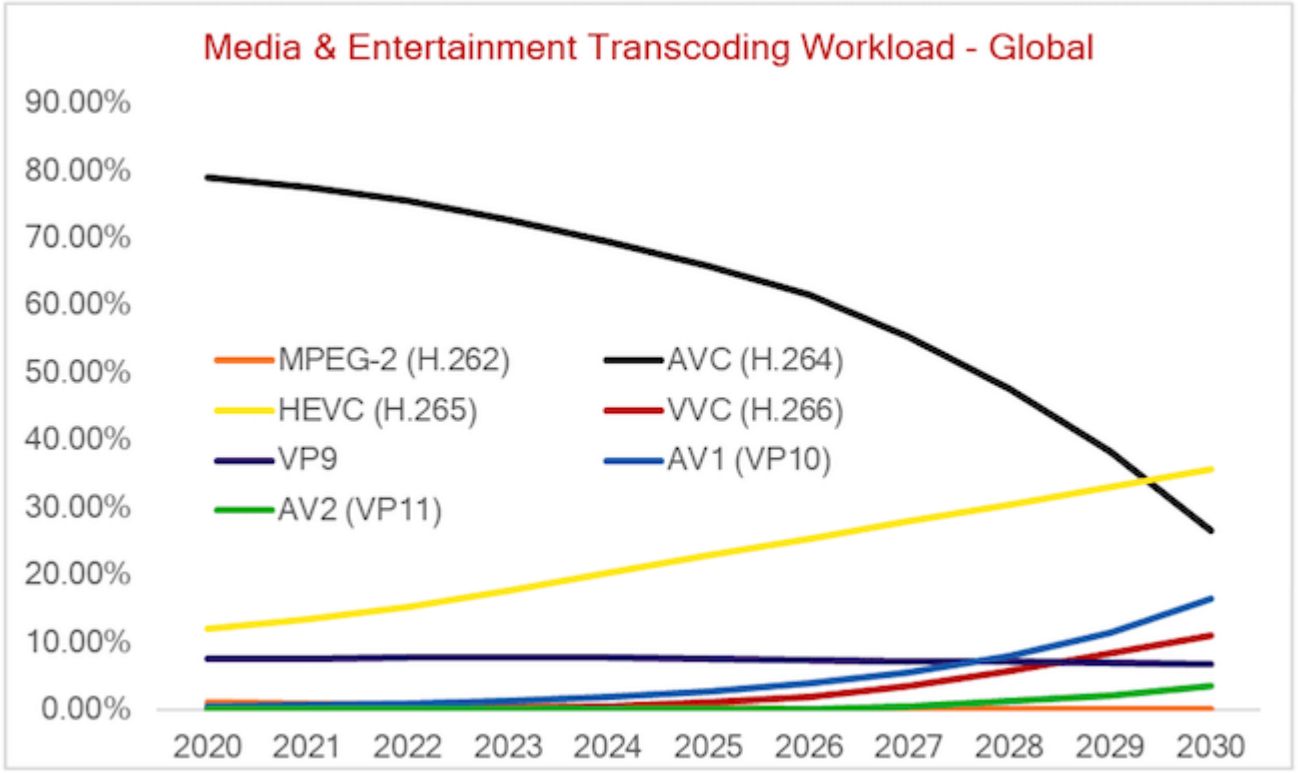


- VVC and LCEVC were included in Brazil's recent TV 3.0 project (Above)
- Should advance adoption of both codecs

Living Room Analysis

- With chips available for set top boxes and smart TVs, and smart TVs shipping, the living room is ahead of mobile and desktop computers
- The living room can also be very effectively targeted for greenfield IPTV progress with VVC set top boxes
- This market presents the most short-term opportunity for VVC

When Hardware Playback on Significant Share of Desktop/Notebooks?



Summary