WAVE

WEB APPLICATION VIDEO ECOSYSTEM

Streamlining Streaming: Interoperability via the WAVE Project

April 11, 2018

2018 NAB Show | Las Vegas, NV

Consumer Technology Association™

AGENDA

- Introduction to WAVE – Paul Hearty, Sony Electronics
- Presentations:
  - WAVE Technical Overview – Will Law, Akamai
  - WAVE Content Specification – John Simmons, Microsoft
  - WAVE Applications Environment – Mark Vickers, Comcast
- Panel Discussion/Audience Q&A/Wrap-up
  - Paul Hearty, Moderator

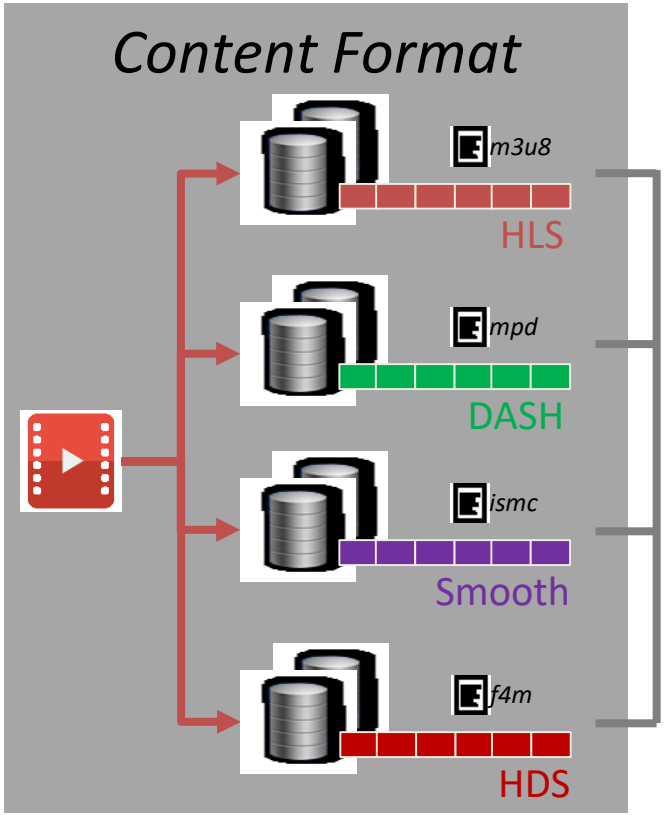
Overview of the WAVE Project

Paul Hearty / Sony Electronics, Inc.

Introduction to WAVE

- What are the problems WAVE is addressing?
- What are the WAVE solutions?
- WAVE participating companies
- WAVE work structure

Problem: Commercial OTT Video Content Format Issues



Each “asset” copied to multiple media formats

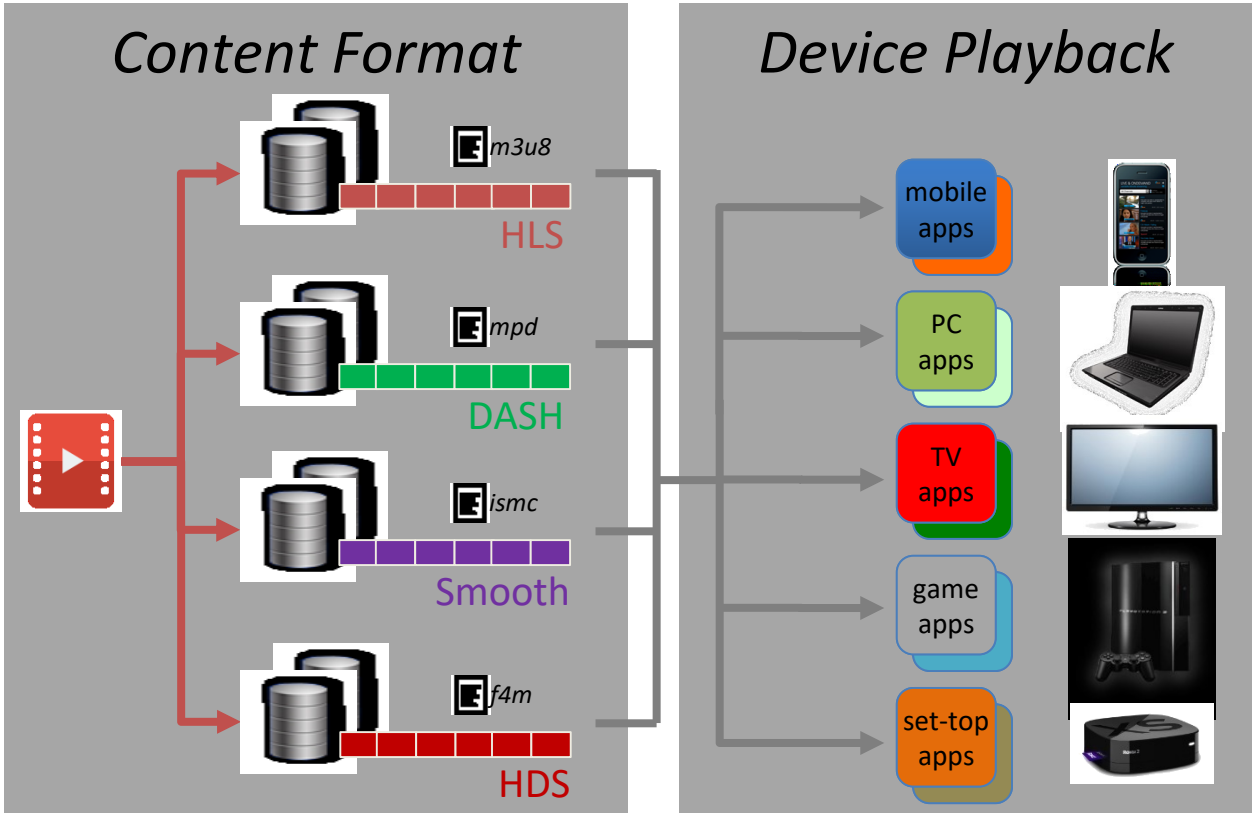
- different video codecs
- different audio codecs
- Regional frame rates

Cost to content creators and distributors

Inefficiencies in content delivery networks (CDNs)

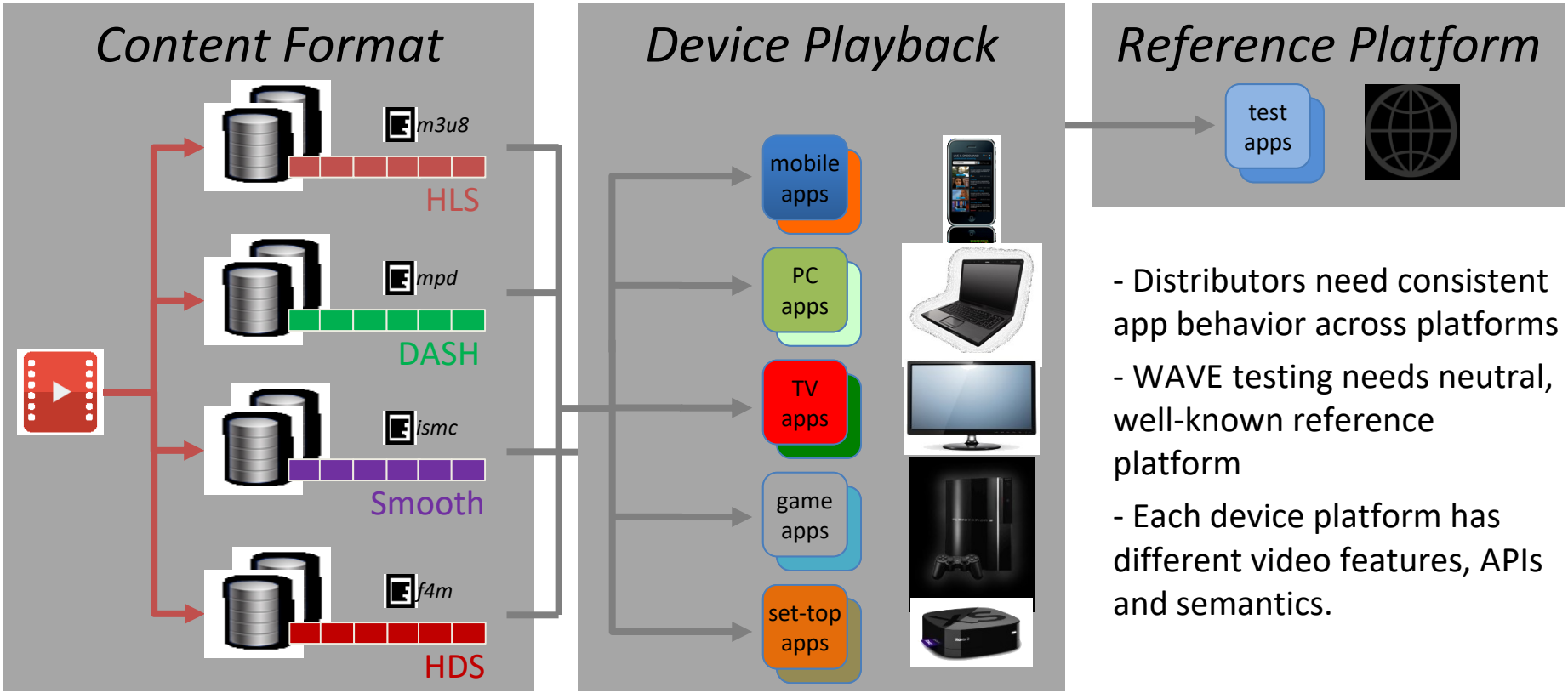
Storage costs

Problem: Commercial OTT Video Device Playback Issues



- Switching bitrate glitches
- Codec incompatibility
- Scaling display issues
- Partial profile support
- Long-term playback instability
- Audio discontinuities
- Request protocol deficiencies
- Memory problems
- CPU weakness
- Variable HDR support
- Unknown capabilities
- Ad splicing problems

Problem: Commercial OTT Video Reference Platform Issues



- Distributors need consistent app behavior across platforms
- WAVE testing needs neutral, well-known reference platform
- Each device platform has different video features, APIs and semantics.

Commercial OTT Video Issues: WAVE Solution

Content

Content Specification

- Based on MPEG Common Media Application Format (CMAF)
- Compatible with DASH and HLS.

Device Playback Capabilities

Testable requirements

- covering most common playback interoperability issues.

HTML5 Reference Platform

Reference application framework

- Based on HTML5
- Provides functional guidelines for playback interoperability.

WAVE Test Suite

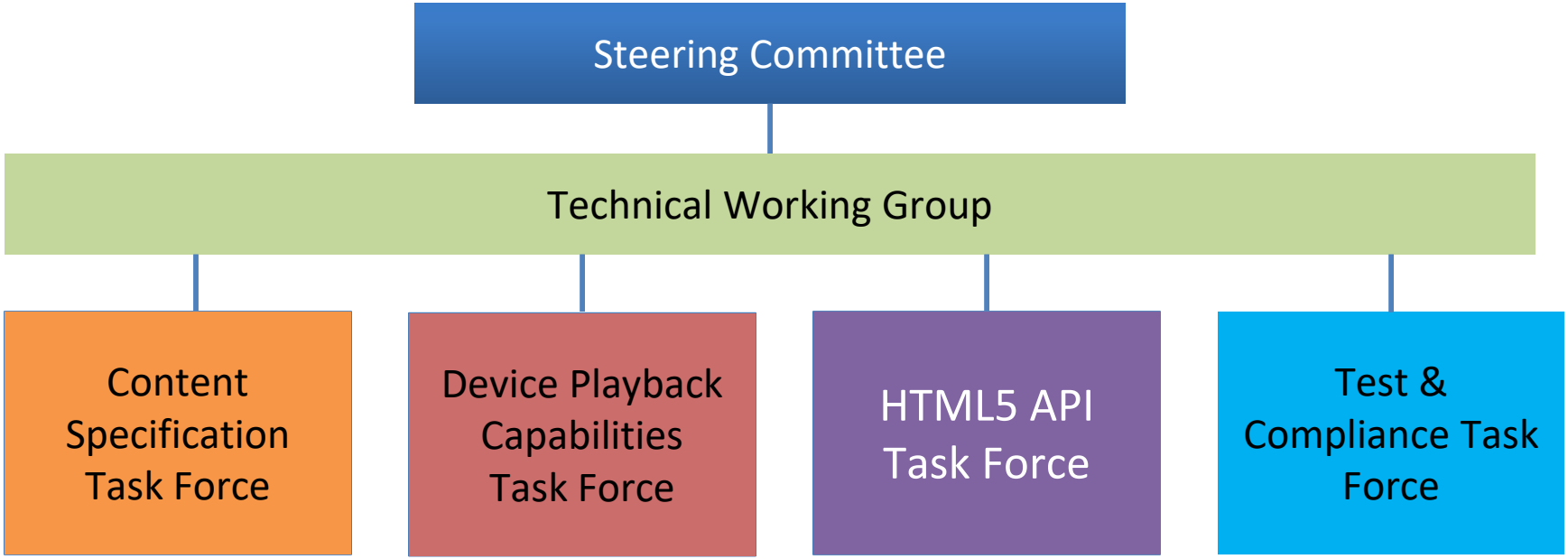
Current WAVE Membership

Adobe Systems
AGP
Akamai
Amazon.com
Apple
AT&T
AwoX
BAMTECH Media
BBC Research & Dev.
BitRouter
Brazilian Soc. of TV Eng.
BrightCove
Cable Television Labs
castLabs
CBS Interactive
Charter Communications
Cisco Systems
Comcast Cable
Cox Communications
Discovery Communications
Disney/ABC/ESPN
Dolby Laboratories
Ericsson
Eurofins Digital Testing
Facebook
Fraunhofer
Google
Home Box Office (HBO)
Huawei Device Co.
Intel Corporation
JR Consulting
JW Player
LG Electronics
Martin Freeman Consulting
Microsoft Corporation
MPAA
Motion Picture Laboratories
Mux
Nagravision
Nathan Zerbe LLC
Nat'l Assoc. of Broadcasters
Netflix
Nevelex Corporation
Opera Software
P Thomsen Consulting
Qualcomm Incorporated
RK Entertainment Technology Consulting
Samsung Electronics
Showtime Networks
Sky
Solekai Systems
Sony Electronics
SpireSpark International
Starz
Streaming Video Alliance
TBT
Toshiba
TP Vision
Turner Broadcasting System
UltraViolet / DECE
Verance Corporation
Verimatrix
Verizon
Viacom
Vizio
WJR Consulting
World Wide Web Consortium
WWE
Xperi/DTS

Updated 2018-04-02

*Company names in **bold** are members of the WAVE Steering Committee.*

WAVE Work Structure



WAVE Technical Overview

Will Law / Akamai

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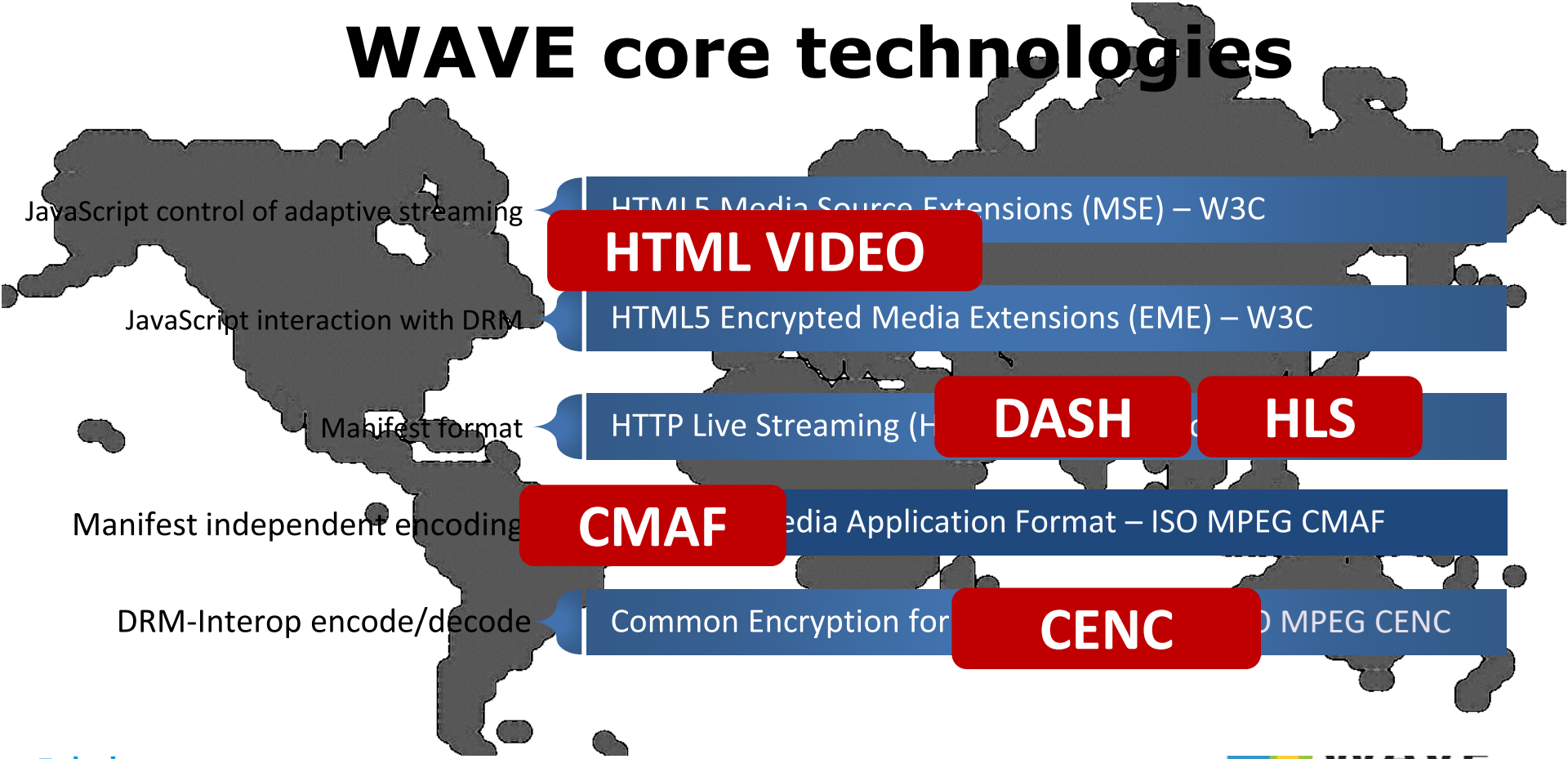
WAVE core technologies



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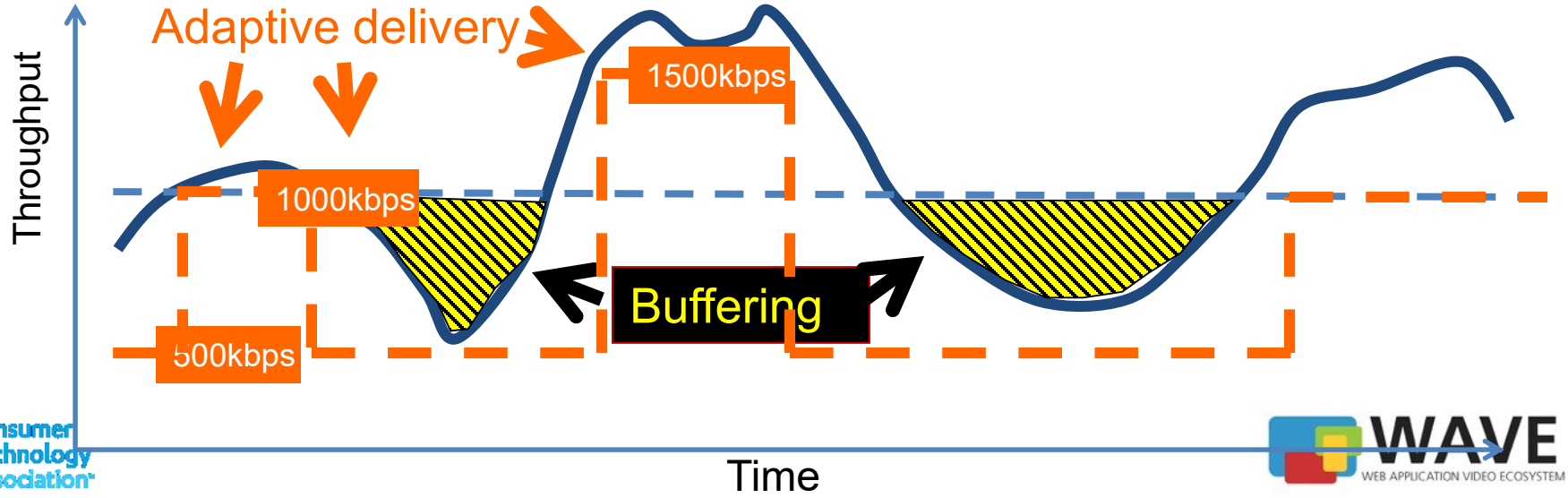
Adaptive Segmented Media

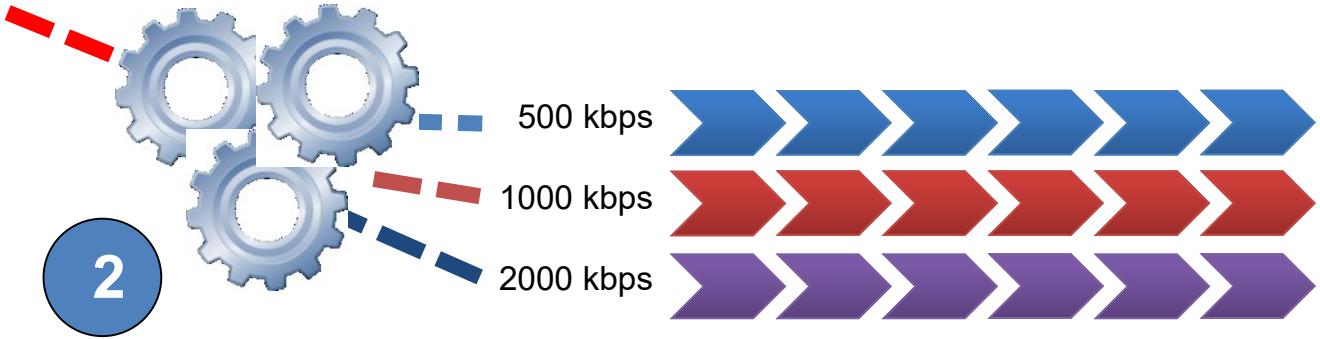
- The internet does not offer a fixed QoS. Throughput (goodput) fluctuates constantly over the timescale of video content delivery
- Ideally we would like to switch bitrates constantly to always give the user the highest quality they can sustain at any point in time.



How does segmentation work?

1 Incoming video

2 is split by an encoder

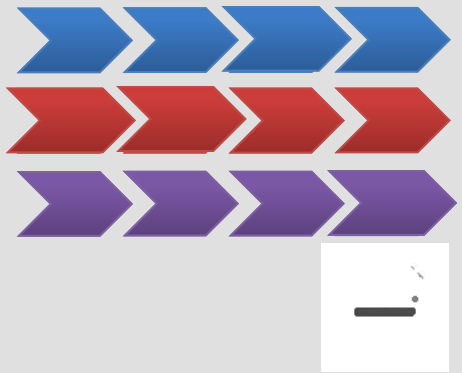


3 into multiple short blocks. Each block holds the same section of video, encoded at a different size and bitrate.

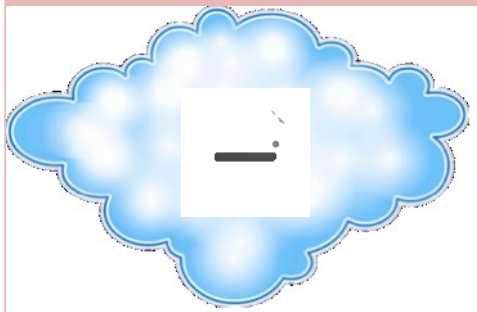
How does adaptive delivery work?

The segmented video is stored on a server, along with a text file which describes the names of each segment. This text file is called a **manifest**.

A player downloads the manifest and then begins requesting individual segments of video.



SERVER



CLOUD

It makes its choice based on bandwidth conditions, grabbing the best quality it can at the time.

PLAYER

Adaptive Segmented Media Formats

MOVE Networks - 2007

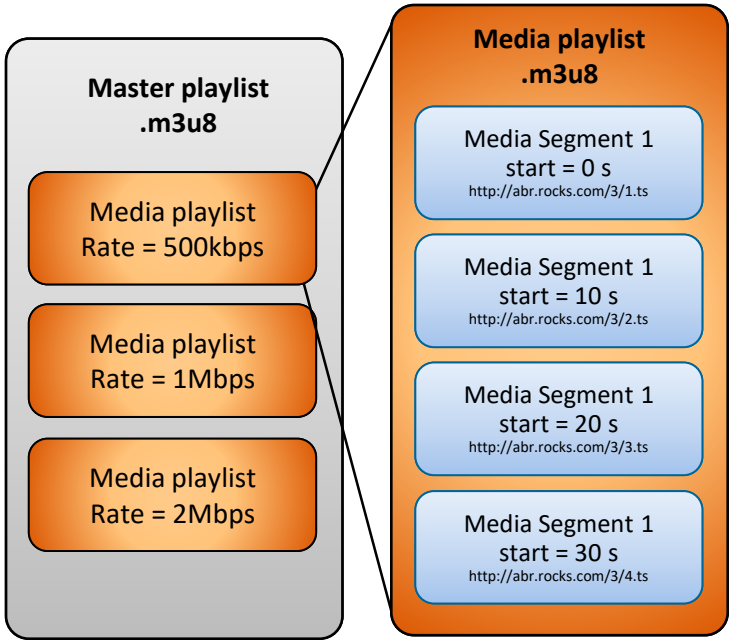
Microsoft Smooth Streaming - 2008

Apple HTTP Live Streaming (HLS) - 2009

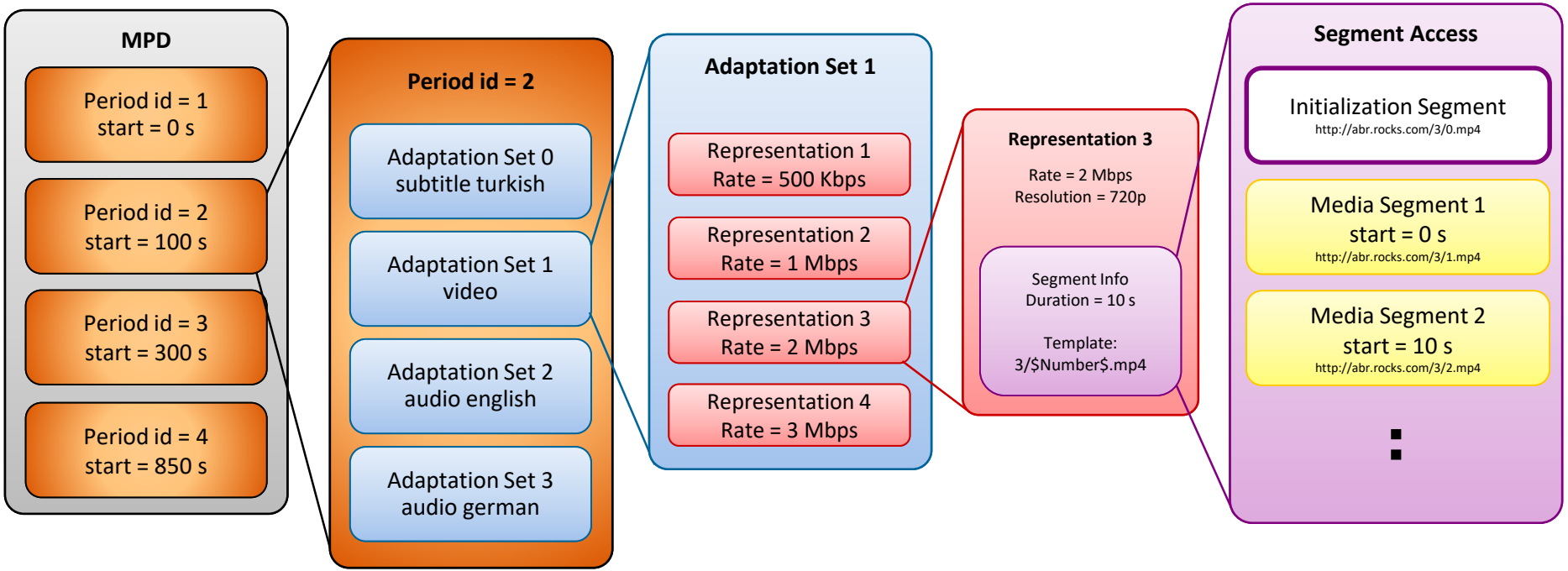
Adobe HDS - 2010

MPEG DASH - 2012

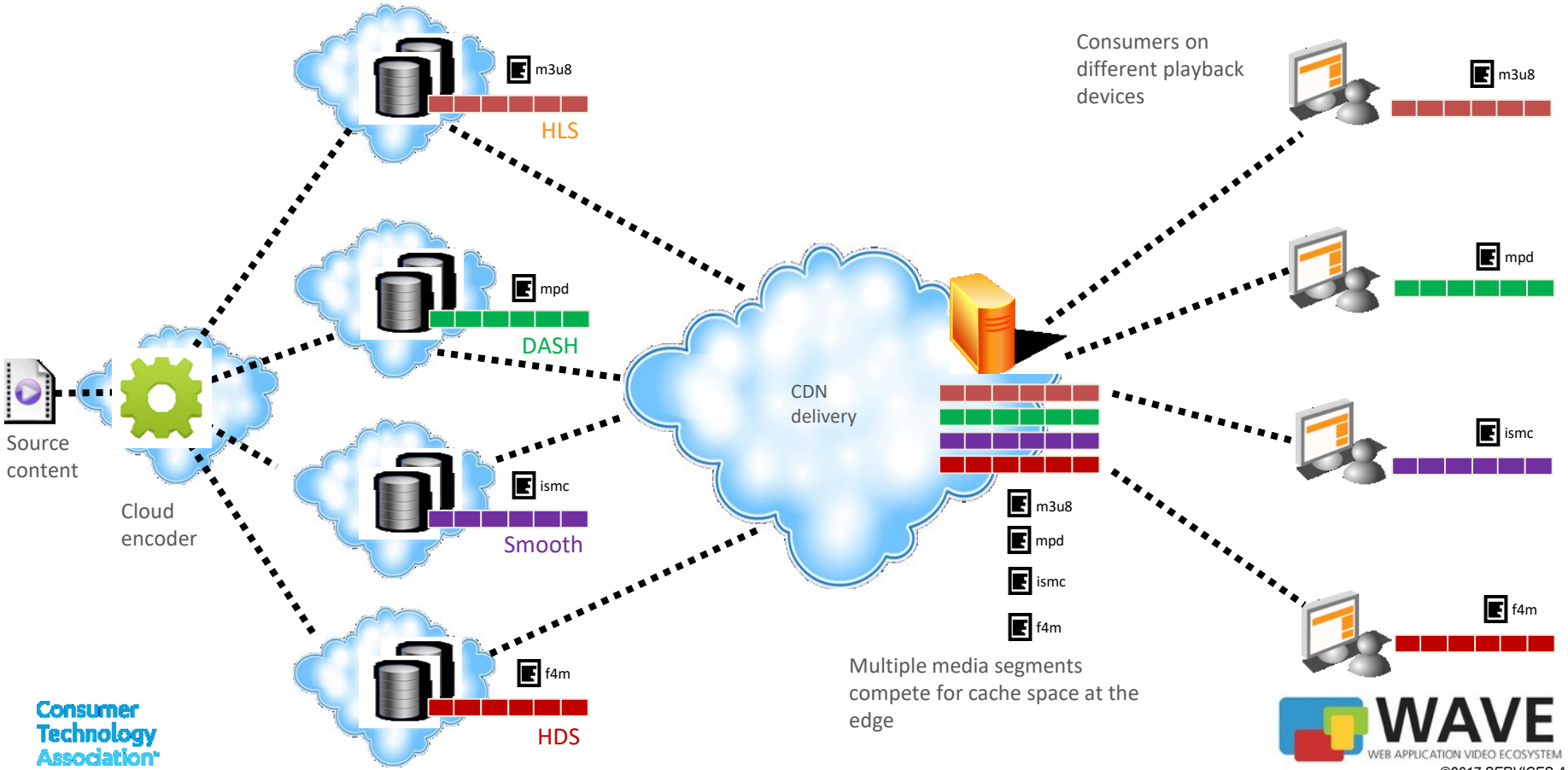
HLS– object hierarchy



MPEG DASH – object hierarchy



CMAF – Multi-platform OTT workflow today



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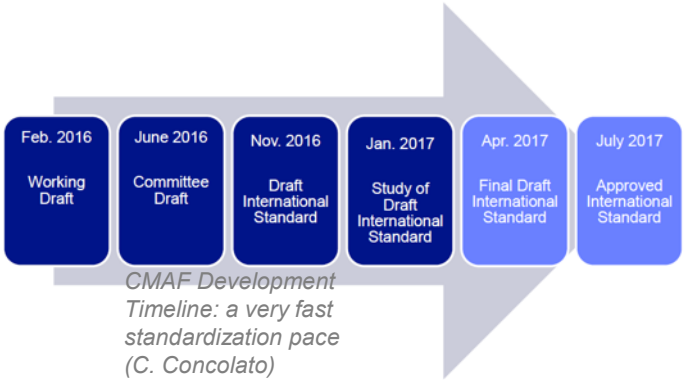
CMAF History and Roadmap

- In January 2015, **Microsoft and Apple** had individual meetings with 8 companies and proposed a new media format which would be common between HLS and DASH.
- Held conf calls and meetings to discuss the format.



CMAF Development Timeline: a very fast standardization pace (C. Concolato)

- Proposed at MPEG's 114th meeting in San Diego in Feb 2016.
- Requirement proposal presented: Adobe, Akamai, Apple, BBC, Cisco, Comcast, DTG, Ericsson, Fraunhofer, iStreamPlanet, LG Electronics, Microsoft, MLBAM, Qualcomm, Samsung, Starz, Telecom Italia, Turner, Verimatrix, WWE.
- Draft specification presented: Apple, Microsoft, MLBAM, Cisco, Akamai and Comcast.
- MPEG approved the establishment of a new standard:

ISO/IEC 23000-19 - Common Media Application Format

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CMAF Scope

The Common Media Application Format defines the container that holds the audio and video content. It is not another presentation format itself.

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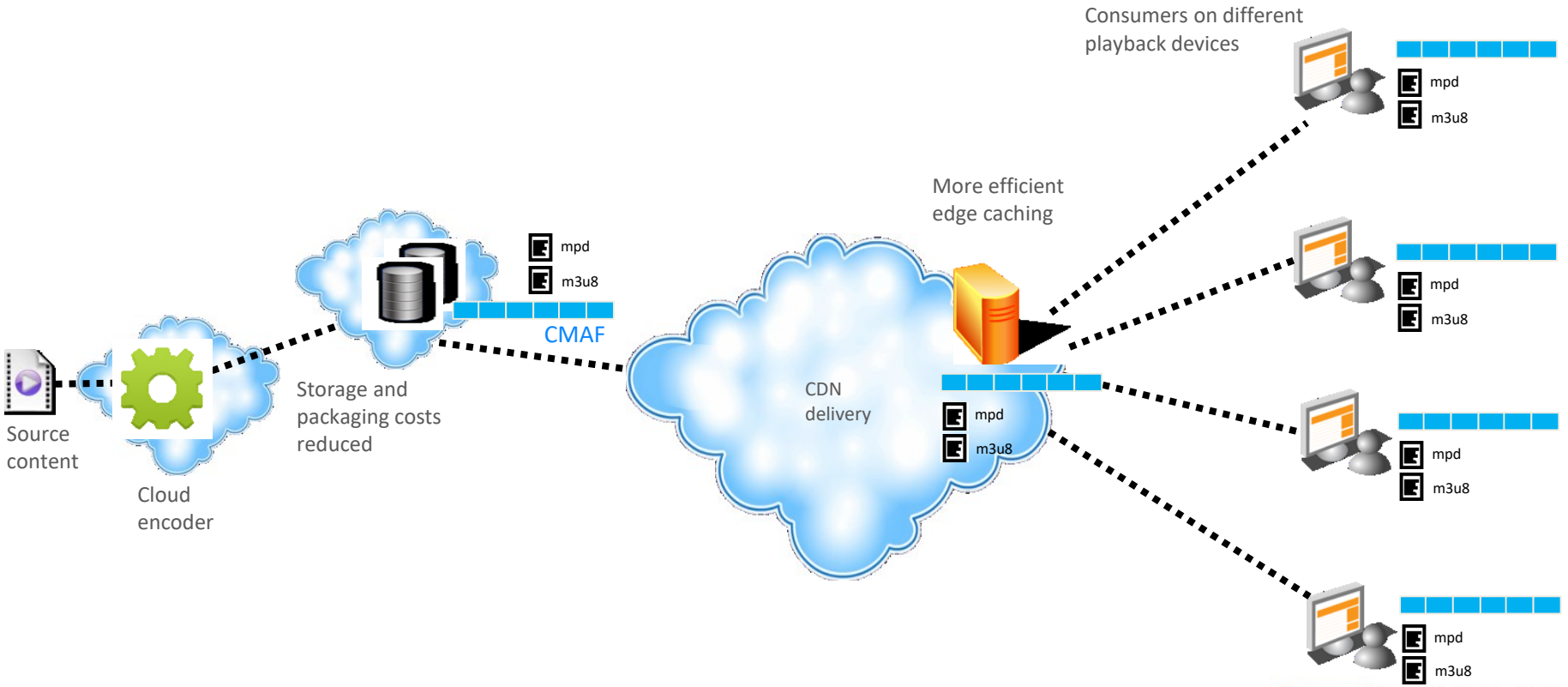
Multi-platform OTT workflow with CMAF



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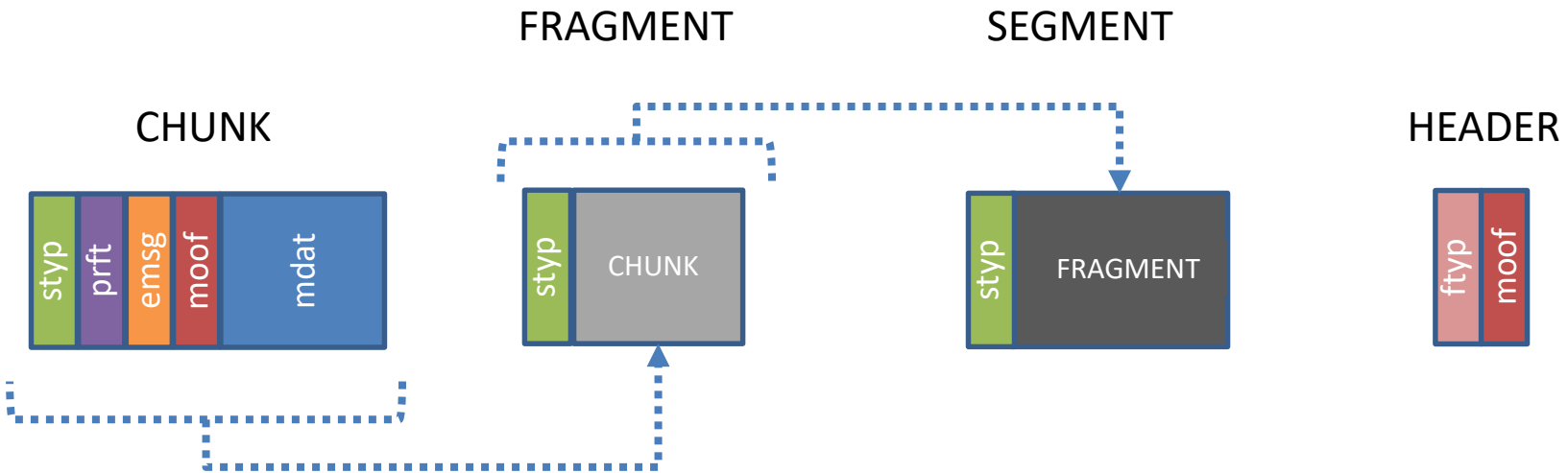
Core Technologies

- **ISOBMFF**, fMP4 container, specifically ISO/IEC 14496-12:201
- Common Encryption (**CENC**) - ISO/IEC 23001-7: 2016
  - Allows “cenc”, “cbcs”, “cens” and “cbc1” modes of operation

- Supports the MPEG codec suite of **AVC** (ISO/IEC 14496-10), **AAC** (ISO/IEC 14496-3) and **HEVC** (ISO/IEC 23008-2) codecs in a baseline interoperability but allow other audio and video codecs (such as VP9 or Dolby AC4) to be signaled.

- Supports captioning and subtitles: **TTML IMSC1, WebVTT (CEAx08 allowed)**

Media Object Box Tables - Components



Logical Media Objects for delivery

TRACK FILE

SERIES OF SEGMENTS

CHUNKS

CMAF Defined brands

Brand	Location	Conformance Requirements
'cmfc'	FileTypeBox and SegmentTypeBox	CMAF Header CMAF Track Format
'cmfs'	SegmentTypeBox	CMAF Segments
'cmfl'	SegmentTypeBox	CMAF Chunks
'cmff'	SegmentTypeBox	CMAF Fragment (containing the first samples of the CMAF Fragment)

CMAF Presentation Profiles

urn:mpeg:cmaf:presentation_profile:cmfhd:2017

- At least ‘cfhd’ (HD video)
- At least ‘caac’ (AAC core audio)
- At least ‘im1t’ (IMSC1 Text subtitles)
- Not encrypted

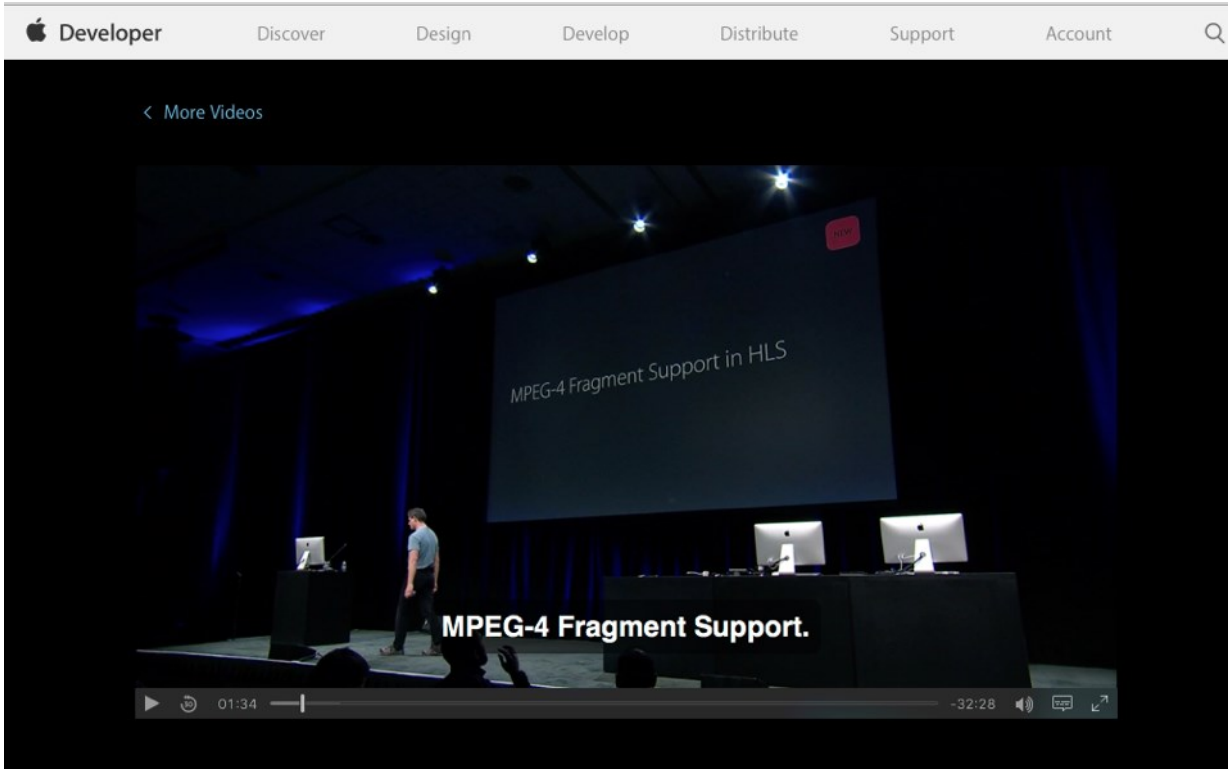
urn:mpeg:cmaf:presentation_profile:cmfhdc:2017

- CMFHD but with at least one ‘cenc’ encrypted media

urn:mpeg:cmaf:presentation_profile:cmfhds:2017

- CMFHD but with at least one ‘cbcs’ encrypted media

Apple Support



Apple announced on June 15th 2016 at their WWDC "*that Fragmented MPEG-4 (fMP4) will be added as a Segment format to the HLS spec, and that it will be supported on all Apple HLS clients.*"

Compatibility to CMAF and DASH ISO BMFF segment formats is available with the following software releases: macOS 10.12, iOS 10, tvOS 10 which were released on September 13th 2016

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HLS and DASH with CMAF

HLS/TS

m3u8

.ts .ts
.ts .ts
.ts .ts
.ts .ts

DASH/ISO

mpd

.mp4 .mp4
.mp4 .mp4
.mp4 .mp4
.mp4 .mp4

DASH/HLS/CMAF

mpd m3u8

.mp4 .mp4
.mp4 .mp4
.mp4 .mp4
.mp4 .mp4

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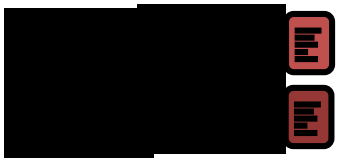
Live vs ondemand for DASH/HLS/CMAF

LIVE

mpd m3u8



.mp4 .mp4
.mp4 .mp4
.mp4 .mp4
.mp4 .mp4

ONDEMAND

Track files

mpd m3u8

.mp4
.mp4

OR

Separate segments

mpd m3u8

.mp4 .mp4
.mp4 .mp4
.mp4 .mp4
.mp4 .mp4

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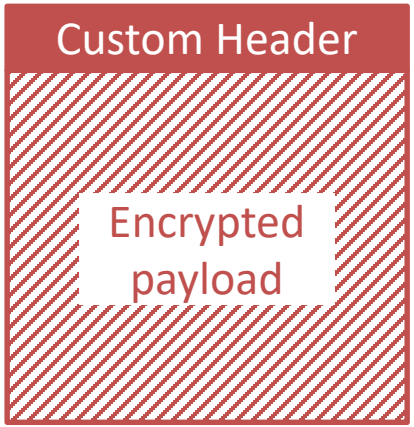
Common Encryption ISO/IEC 23001-7:2016

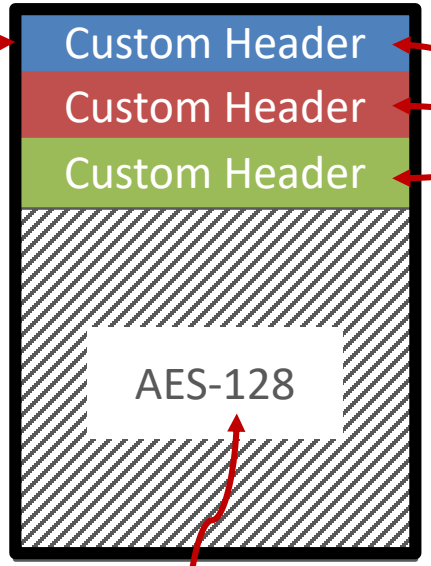
DRM “A” DRM “B” DRM “C”

Common Encryption ISO/IEC 23001-7:2016



Common Encryption ISO/IEC 23001-7:2016

Single ISOBMFF container



Multiple concurrent DRM header information

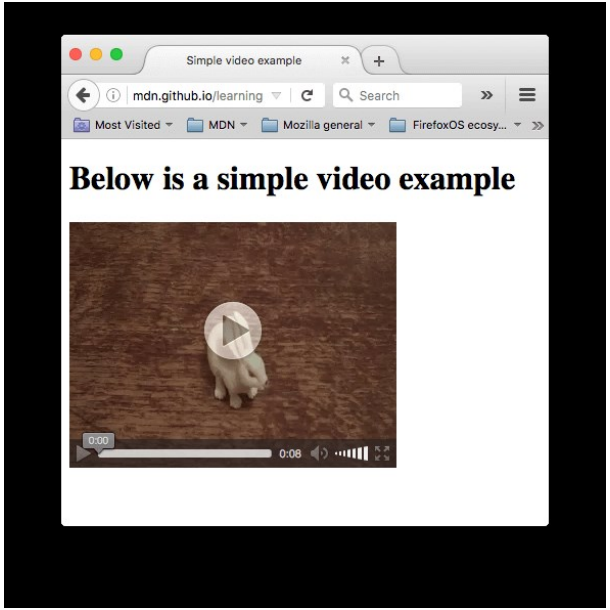
AES-128 commonly encrypted audio or video payload

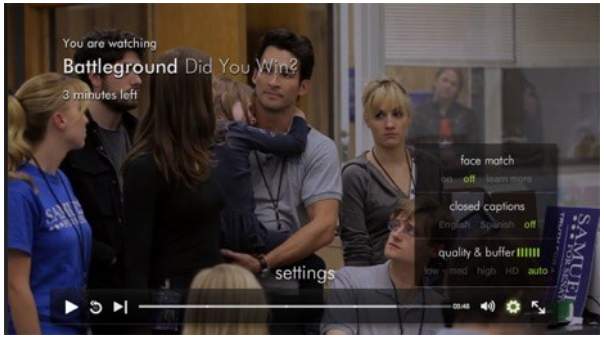
Common Encryption ISO/IEC 23001-7:2016

Unfortunately, there are 4 versions of AES-128 encryption that are allowed:

- **CENC AES-CTR** or **cenc**: CENC Protection Scheme using AES 128-bit keys in Counter Mode (AES-128 CTR)
- **CENC AES-CBC** or **cbc1**: CENC Protection Scheme using AES 128-bit keys in Cipher-block chaining mode (AES-128 CBC)
- **CENC AES-CTR Pattern** or **cens**: CENC Protection Scheme using AES 128-bit keys in Counter Mode (AES-128 CTR) using pattern of unencrypted/encrypted bytes
- **CENC AES-CBC Pattern** or **cbcs**: CENC Protection Scheme using AES 128-bit keys in Cipher-block chaining mode (AES-128 CBC) using pattern of unencrypted/encrypted bytes

HTML Video





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Media Source Extensions (MSE)

1. https://www.w3.org/TR/media-source/
2. This specification extends HTMLMediaElement to allow JavaScript to generate media streams for playback.
3. Allows the creation of <audio>, <video> and <text> source buffers.
4. Delivery is format agnostic.

Encrypted Media Extensions (EME)

1. W3C standard https://www.w3.org/TR/encrypted-media/
2. This proposal extends HTMLMediaElement providing APIs to control playback of protected content.
3. The API supports use cases ranging from simple clear key decryption to high value video (given an appropriate user agent implementation). License/key exchange is controlled by the application, facilitating the development of robust playback applications supporting a range of content decryption and protection technologies.

Which browser code bases support MSE today?

Media Source Extensions - CR

API allowing media data to be accessed from HTML **video** and **audio** elements.

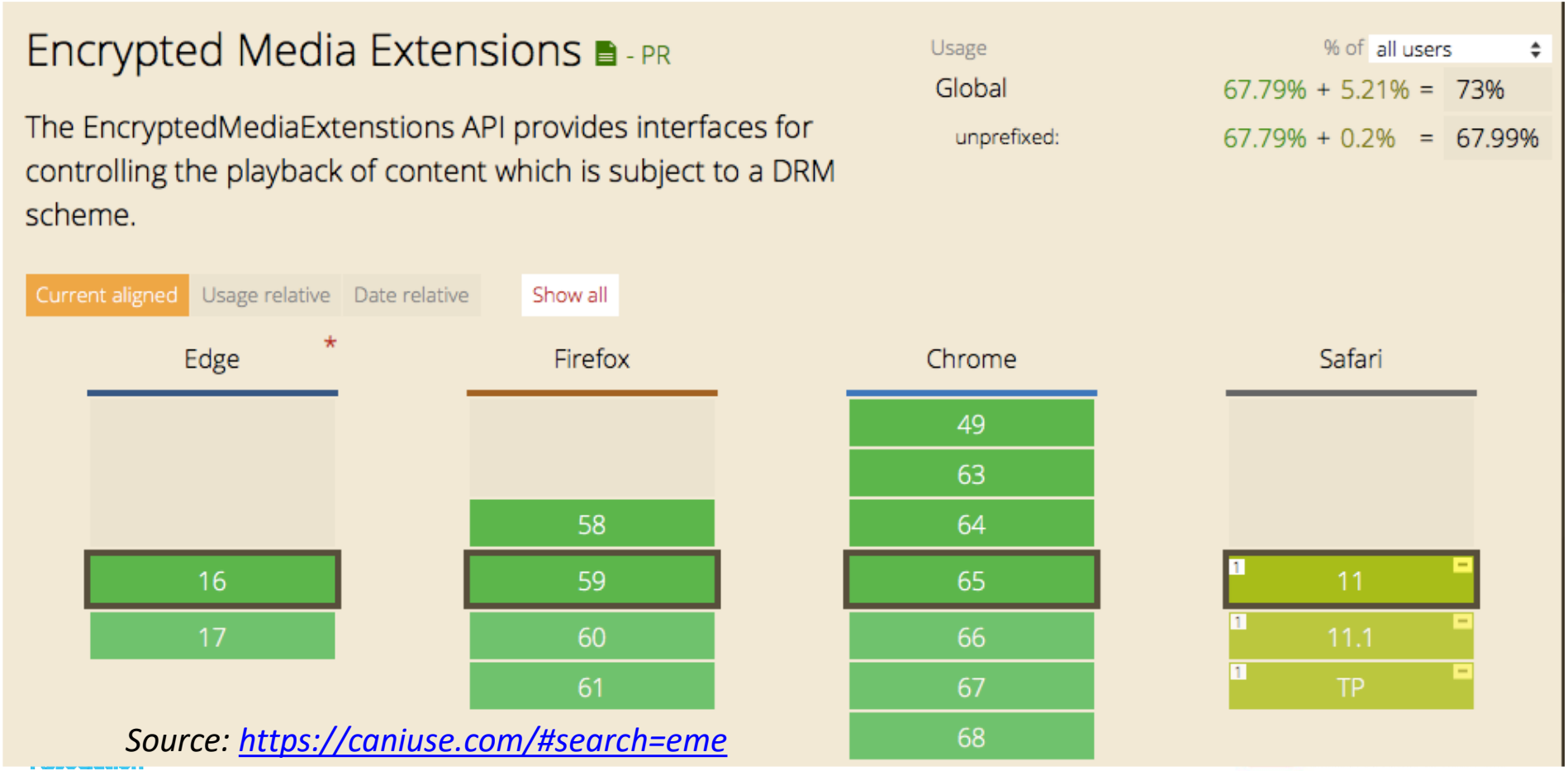
Usage	% of all users		
Global	79%	+ 2.76% =	81.76%
unprefixed:	78.56%	+ 2.76% =	81.32%

Current aligned | Usage relative | Date relative | Show all

Edge *	Firefox	Chrome	Safari
		49	
		63	
	58	64	
16	59	65	11
17	60	66	11.1
	61	67	TP
		68	

Source: https://caniuse.com/#search=mse

Which browser code bases support EME today?



Source: https://caniuse.com/#search=eme

HTML5 players....many choices!

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Content Specification

Device Playback Requirements

HTML5 Reference Platform

CONTENT SPECIFICATION TASK FORCE

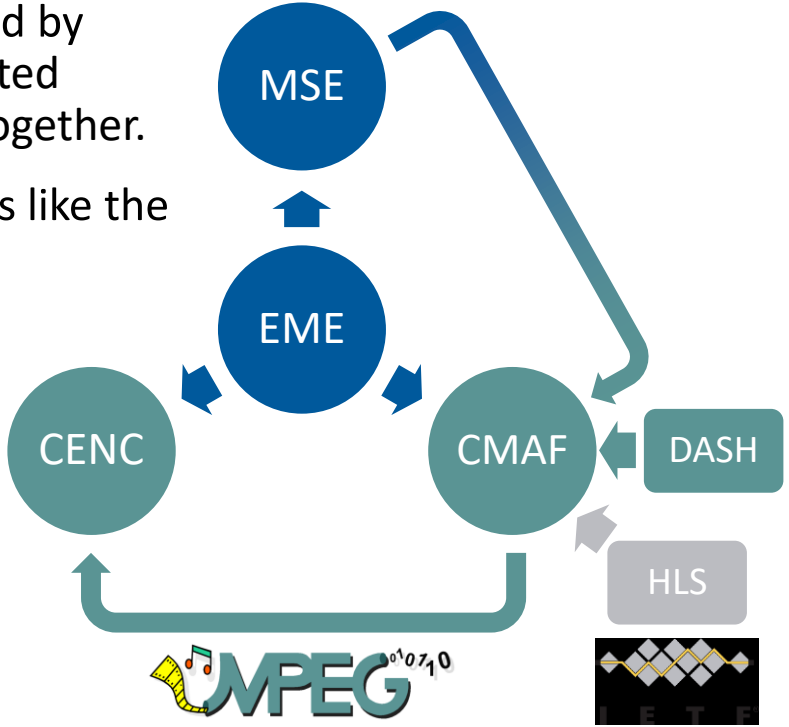
WAVE Content in Context

Cross-platform commercial media web apps are enabled by the HTML5 Media Source Extensions (MSE) and Encrypted Media Extensions (EME), which are designed to work together.

MSE is designed to work with segmented media formats like the MPEG Common Media Application Format (CMAF).

CMAF supports DRM-interop using the MPEG Common Encryption (CENC) specification, and both CMAF and CENC are designed to work with EME.

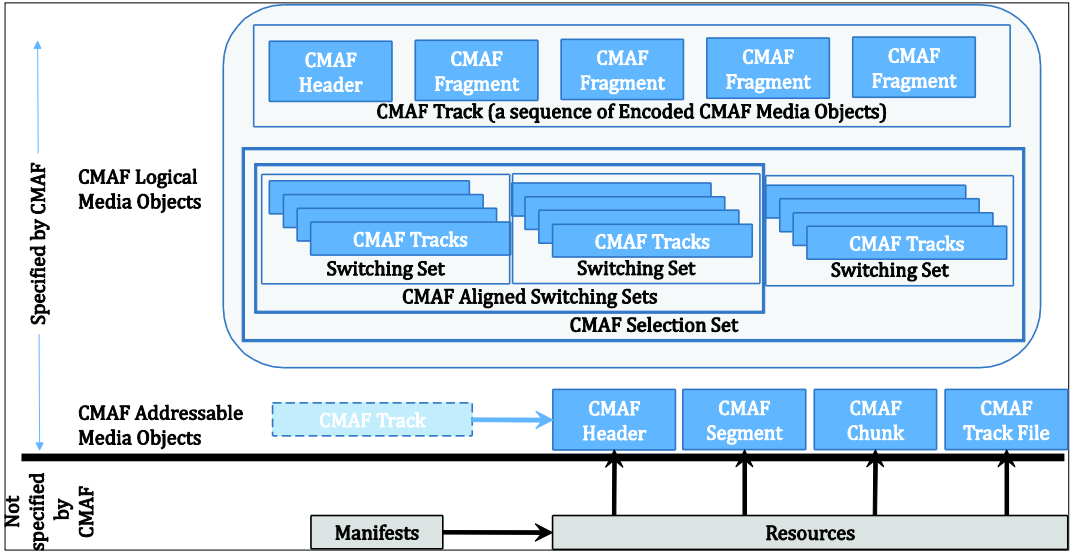
Media presentations can be described using either MPEG Dynamic Adaptive Streaming over HTTP (DASH) or Apple's IETF-published HTTP Live Streaming (HLS), both of which now work with CMAF.



WAVE is predicated on the belief that the well-coordinated, global adoption of these standards can transform both the broadcast and Internet industries.

What is the Common Media Application Format (CMAF)?

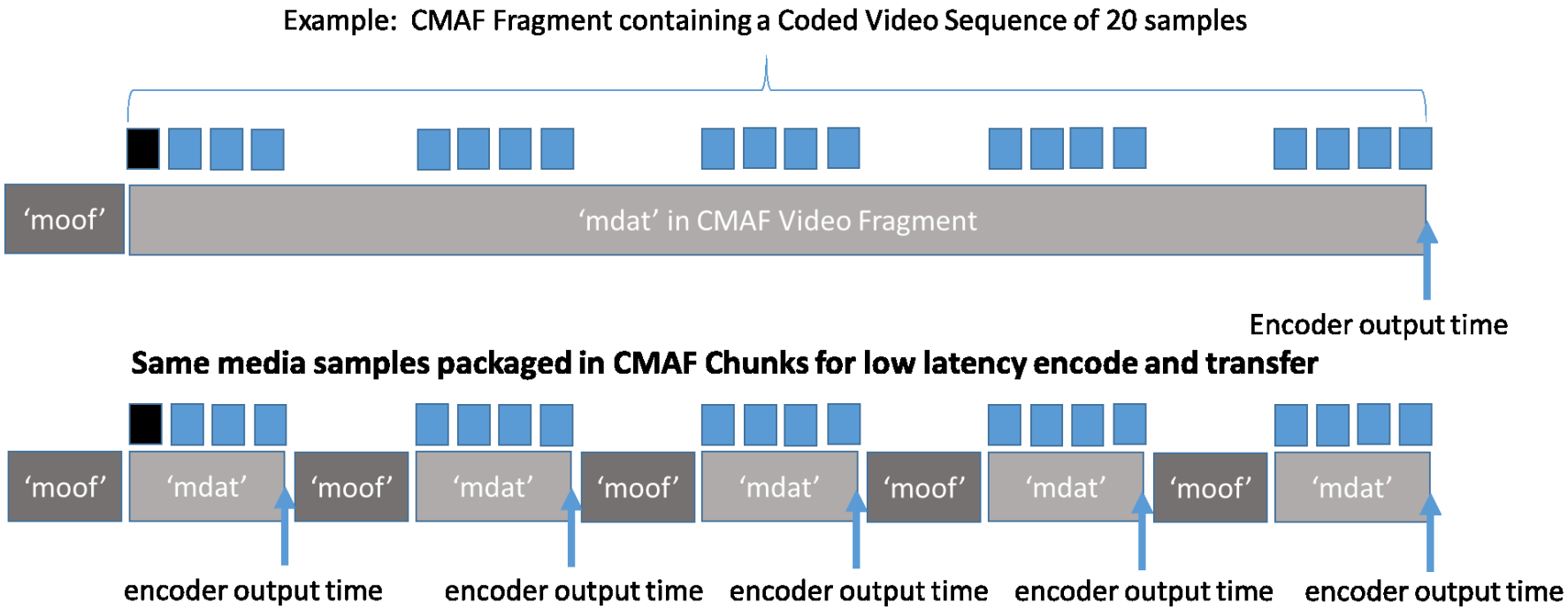
- CMAF is a standardization and codification of existing best practices for fragmented MP4 delivery in common use with DASH – with some enhancements for low latency delivery.
- CMAF began as a collaboration of Apple and Microsoft in 2015 which grew into a series of discussions across the industry.
- In 2016 requirements for what would become CMAF were submitted to MPEG by Apple, BAMTech, BBC, Cisco, Comcast, DTG, Ericsson, Fraunhofer, iStreamPlanet, LG Electronics, Microsoft, Qualcomm, Samsung, Starz, Telecom Italia, Turner, Verimatrix and the WWE.



ISO/IEC 23000-19, Information technology — Coding of audio-visual objects — Part 19: Common media application format (CMAF) for segmented media.
https://www.iso.org/standard/71975.html

- CMAF was published as ISO/IEC spec January 2018, but companies across the industry had began efforts to adopt CMAF early in 2017.

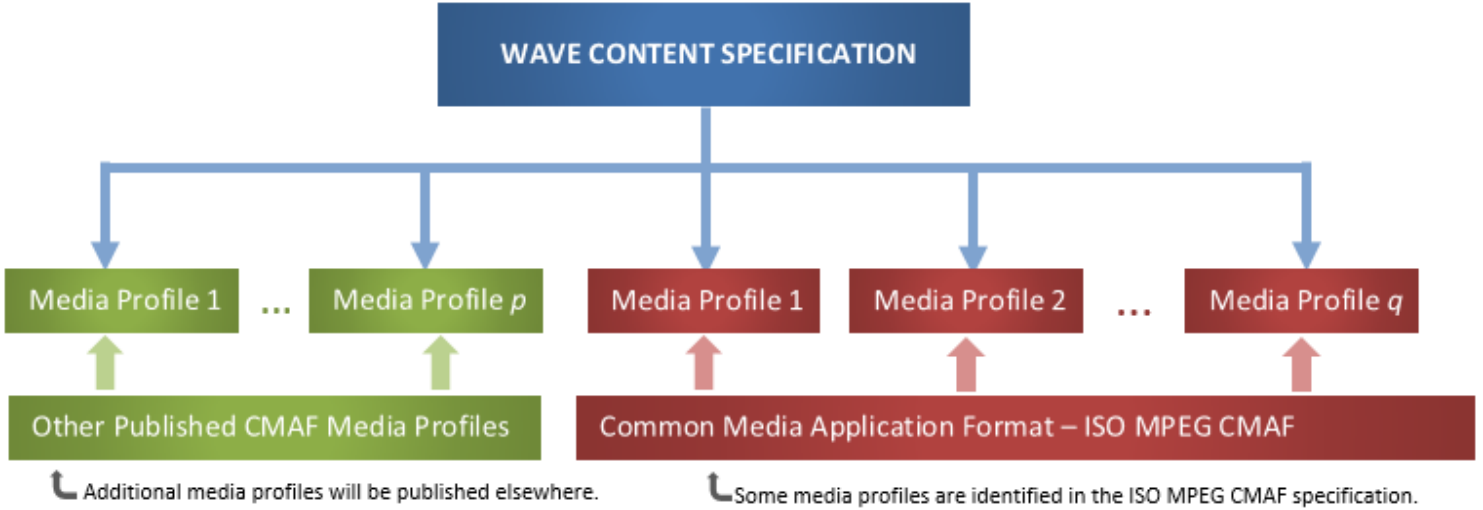
CMAF Packaging for Low Latency encode and transfer



Web Application Video Ecosystem – Content Specification

2018 Edition
April 6, 2018

WAVE Content Spec and Published CMAF Media Profiles



- CMAF presentations can be constructed from a variety of codecs – the binding to the CMAF container format is called a "Media Profiles".
- The MPEG CMAF specification defines CMAF bindings for a variety of MPEG codecs, but it also includes an extensibility mechanism for defining bindings outside of MPEG.
- WAVE developed an objective process to qualify Media Profiles to be included in the WAVE Content Specification, based on market relevance, MSE compatibility and the schedule for availability of test tools and test content. This is an ongoing process.

WAVE Content Specification 2018 - Video Profiles

Media Profile Name	*Informative* Codec	*Informative* Profile	*Informative* Level	*Informative* Color primaries & matrix coefficients	*Informative* Transfer Characteristics	*Informative* 'codecs' MIME subparameters	NORMATIVE CMAF Brand	NORMATIVE Normative Reference
HD	AVC	High	4.0	1 (BT.709)	1 (BT.709 OETF)	avc1.640028 avc3.640028	'cfhd'	[CMAF] Table A.1
HHD10	HEVC	Main10 MainTier	4.1	1 (BT.709)	1 (BT.709)	hev1.2.4.L123.B0 hvc1.2.4.L123.B0	'chh1'	[CMAF] Table B.1
UHD10	HEVC	Main10 MainTier 10-bit	5.1	1 (BT.709) 9 (BT.2020)	1 (BT.709 OETF) 14 (BT.2020 OETF)	hev1.2.4.L153.B0 hvc1.2.4.L153.B0	'cud1'	[CMAF] Table B.1
HLG10	HEVC	Main10 MainTier 10-bit	5.1	9 (BT-2020)	18 (BT.2100 Table 5 HLG OETF) 14 (BT.2020 OETF)	hev1.2.4.L153.B0 hvc1.2.4.L153.B0	'clg1'	[CMAF] Table B.1
HDR10	HEVC	Main10 MainTier 10-bit	5.1	9 (BT.2020)	16 (BT.2100 Table 4 PQ EOTF)	hev1.2.4.L153.B0 hvc1.2.4.L153.B0	'chd1'	[CMAF] Table B.1

The 2018 Edition of the WAVE Content Specification includes the following video Media Profiles. Additional media profiles are likely to be added in an amendment prior to the 2019 edition of the WAVE Content Specification.

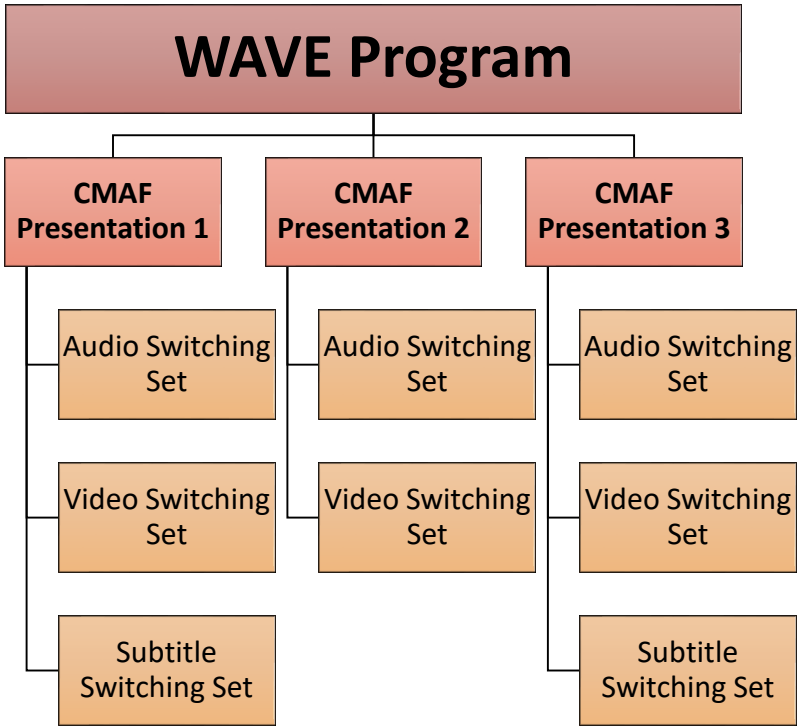
WAVE Content Spec 2018 - Audio Profiles

- Some organizations outside MPEG have begun publishing bindings specifications for CMAF.
- The first of these organizations is ETSI, which is publishing CMAF bindings specifications for both Dolby and DTS audio codecs.
- Other organization have suggested they will publish CMAF bindings in 2018.
- The WAVE content specification also includes both IMSC1 Text and Image CMAF bindings.

Media Profile Name	*INFORMATIVE* Codec Family	*INFORMATIVE* Allowed Codecs or Profiles	*INFORMATIVE* Level	*INFORMATIVE* 'codecs' MIME subparameter	NORMATIVE CMAF Brand	NORMATIVE Normative Reference
AAC Core	AAC	AAC-LC, HE-AAC or HE-AAC v2	2	mp4a.40.2 mp4a.40.5 mp4a.40.29	'caac'	[CMAF] Table A.2
Adaptive AAC Core	AAC	AAC-LC, HE-AAC or HE-AAC v2	2	mp4a.40.2 mp4a.40.5 mp4a.40.29	'caaa'	[CMAF] Table A.2
AAC Multichannel	AAC	AAC-LC, HE-AAC	6	mp4a.40.2 mp4a.40.5 mp4a.40.29	'camc'	[CMAF A1] Table i.2
Enhanced AC-3, including AC-3	AC-3 EAC-3	AC-3 EAC-3	n.a.	ec-3	'ceac'	[EAC3]
AC-4, Single Stream	AC-4	AC-4	3	ac-4.02.01.03	'ca4s'	[AC4]
MPEG-H, Single Stream	MPEG-H	Low Complexity (LC)	3	mhm1.0x0B mhm1.0x0C mhm1.0x0D	'cmhs'	[CMAF A1] Table j.2

WAVE Programs and Live Linear Content

- Live linear content with ad insertions may require delivering not one but a sequence of CMAF Presentations.
- To address this likelihood, the WAVE content spec defines a WAVE programs, which is a sequence of one or more CMAF Presentations.
- When a WAVE Program includes more than one CMAF presentations, it can optionally conform to a WAVE Splice Constraint Profile.
- The 2018 Edition of the WAVE Content Spec defines a Baseline Splice Constraint Profile, encoding constraints intended to allow continuous rendering of Sequential Switching Sets in WAVE Programs on most existing adaptive streaming Players in the market today.
- We anticipate that as new devices enter the market, the more advanced Splice Constraint Profiles will be published by WAVE.



Continuous Rendering for a continuous user experience

The WAVE Content Specification – via the CTA store

Download WAVE specifications in PDF format at:

members.cta.tech/ctaWAVE

*This is a **free** download. You can use a CTA member account or create a free guest account.*

Web Application Video Ecosystem – Content Specification

This Web Application Video Ecosystem Content Specification (WAVE Content Spec) is derived from the ISO/IEC standard, "Common Media Application Format for Segmented Media" [CMAF].

Learn More | Buy Now

Content Specification

Device Playback Requirements

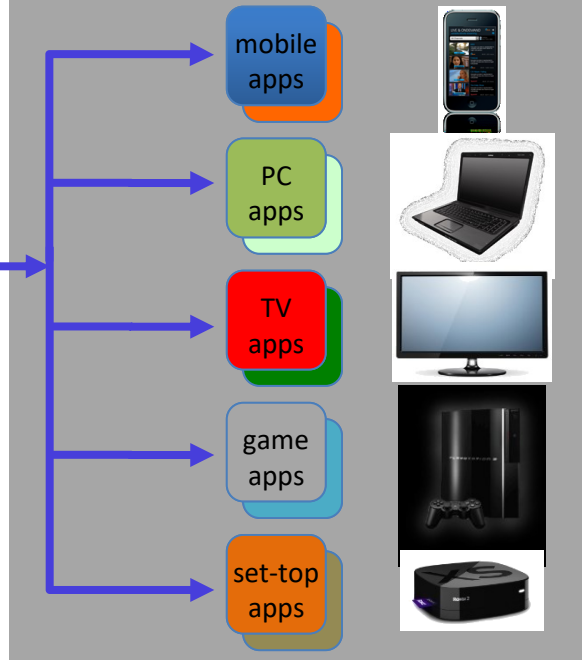
HTML5 Reference Platform

HTML5 API TASK FORCE

HTML5 API Task Force: Reference Platform

One Content Format...

...but multiple devices



Reference Platform

HTML5 tests

Write reference tests in HTML5…

… then port tests to device platforms.

(HTML5 platforms run tests directly.)

HTM5 API Task Force: Work Plan

Web Media API Community Group:

w3.org/community/webmediaapi/

1. **Annual Web Media API spec**
   define baseline web APIs to support media web apps.
2. **Guidelines for media web app developers**
3. **Guidelines for device makers**
4. **Identify gaps in current web APIs**
   work with W3C Working Groups to update web standards.

Web Media API Snapshot 2017

W3C Community Group Final Report

Web Media API Snapshot 2017

Final Community Group Report 20 December 2017

Latest editor's draft:
https://w3c.github.io/webmediaapi/

Editors:
David Evans, British Broadcasting Corporation
Mark Vickers, Comcast

Participate:
GitHub w3c/webmediaapi
File a bug
Commit history

Abstract

This specification lists the Web APIs to support media web apps that are supported across all four of the most widely used user agent code bases at the time of publication. This specification should be updated at least annually to keep pace with the evolving Web platform. We encourage manufacturers to develop products that support the APIs in the most recent version of Web Media API Snapshot. This specification is comprised of references to existing specifications in W3C and other specification groups. The target devices will include any device that runs a modern HTML user agent, including televisions, game machines, set-top boxes, mobile devices and personal computers.

The goal of this Web Media API Community Group specification is to transition to the W3C Recommendation Track for standards development.

First annual API Snapshot published 20 December 2017:
https://www.w3.org/2017/12/webmediaapi.html

- Lists key APIs supported in 2017 in all major HTML code bases.
- CTA-W3C agreement to co-publish this spec.
- Plan to propose Community Group spec as a W3C standards track spec
- CTA WAVE issued RFP to create a test suite for all listed APIs based on W3C API tests.
- Test suite will enable manufacturers to test that their HTML support is up-to-date!

The WAVE Web Media API Snapshot 2017 – via CTA

Download WAVE specifications in PDF format at:

members.cta.tech/ctaWAVE

*This is a **free** download. You can use a CTA member account or create a free guest account.*

Web Application Video Ecosystem – Web Media API Snapshot 2017

The Web Application Video Ecosystem (WAVE) Project is an open process, cross-industry engineering effort to identify a standards-based solution to audio-video application interoperability.

Learn More | Buy Now

Content Specification

Device Playback Requirements

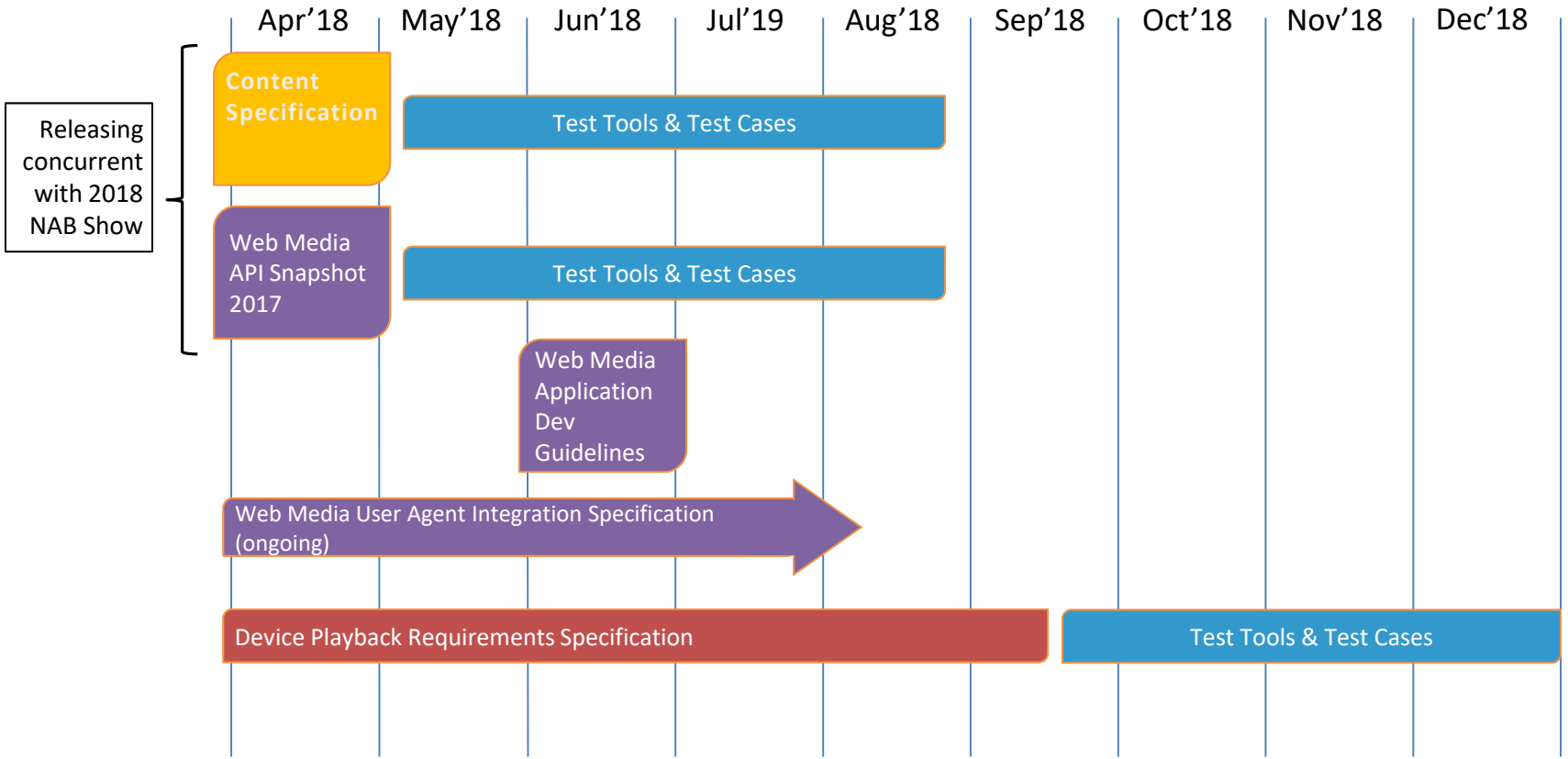
HTML5 Reference Platform

Wrap-up

About WAVE

- WAVE is global in scope, not just North American. WAVE welcomes increased global participation.
- “Devices” in WAVE are desktop-browser-based (laptops, phones, tablets) and embedded-browser-based (smart TVs, media sticks, STBs)
- HTML5 APIs are the basis for the preferred common video application environment, but other environments are supported.
- The MPEG Common Media Application Format (CMAF) is the basis for content preparation.

WAVE Output Plan



How to Get Involved

WAVE Specifications – free PDF download

members.cta.tech/ctaWAVE

This slide deck: CTA.tech/WAVE

Join the WAVE Project:

standards@CTA.tech *Or:* Mike Bergman mbergman@CTA.tech