Technology & Standards Forum
Produced by Consumer Technology Association™

October 1-5, 2018 | The Loews Hollywood Hotel | Los Angeles, CA
Thank You to Our Sponsors
AGENDA

• Introduction to WAVE – Paul Hearty, Sony Electronics

• Presentations:
  • WAVE Technical Overview – Will Law, Akamai
  • WAVE Content Specification – Mike Bergman, CTA
  • WAVE Applications Environment – Mark Vickers, Comcast
  • WAVE Device Playback Capabilities – Mike Bergman, CTA
  • WAVE Test Suites – Mike Bergman, CTA

• 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
Fragmentation is Expensive
Supporting a fragmented OTT world

• Fragmentation impacts content providers and device makers:
  • Multiple streaming formats (HLS, HDS, DASH, Smooth)
  • Multiple device types from laptops to phones to gaming consoles
  • Inconsistent device performance capabilities
  • Inconsistent device compliance to industry specifications

• The result:
  • Content providers: Increased cost to prepare, store and support OTT
  • Device makers: Increased test and support costs for devices
Commercial OTT Video Issues: WAVE Solution

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

Testable requirements
- covering most common playback interoperability issues.

Reference application framework
- Based on HTML5
- Provides functional guidelines for playback interoperability.

WAVE Test Suite
WAVE bridges media standards & web standards

WAVE Device Playback Capabilities Spec

WAVE Content Spec

WAVE Web Media API spec

RFC 6381
HLS
AC-3/4
DTS
MPEG Audio
CENC
AVC
HEVC
BMFF
DASH
CMAF
IMSC1
HTML5
MSE
EME
CSS
Fetch
XHR
JavaScript
WebGL

IETF
ETSI
MPEG
W3C
WHATWG
ECMA
Khronos
# Current WAVE Membership

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

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

Steering Committee

Technical Working Group

WAVE Device Playback Capabilities Spec

WAVE Content Spec

WAVE Web Media API spec
WAVE Technical Overview

Will Law / Akamai
WAVE core technologies

- HTML VIDEO
- DASH
- HLS
- CMAF
- CENC

JavaScript control of adaptive stream
JavaScript interaction with DRM
Manifest format
Manifest independent encoding
DRM-Interop encode/decode

HTML5 Encrypted Media Extensions (EME) – W3C
HTTP Live Stream – IETF
Media Application Format – ISO MPEG CMAF
Common Encryption (CENC) – ISO MPEG CENC

October 1-5, 2018 | The Loews Hollywood Hotel | Los Angeles, CA
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.

- 500 kbps
- 1000 kbps
- 2000 kbps
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.

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

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

MOVE Networks - 2007

Microsoft Smooth Streaming - 2008

Apple HTTP Live Streaming (HLS) - 2009

Adobe HDS - 2010

MPEG DASH - 2012
Adaptive Segmented Media Formats

Apple HTTP Live Streaming (HLS) - 2009

MPEG DASH - 2012
HLS—object hierarchy

- **Master playlist** .m3u8
  - Media playlist Rate = 500kbps
  - Media playlist Rate = 1Mbps
  - Media playlist Rate = 2Mbps

- **Media playlist .m3u8**
  - Media Segment 1 start = 0 s
    - http://abr.rocks.com/3/1.ts
  - Media Segment 1 start = 10 s
    - http://abr.rocks.com/3/2.ts
  - Media Segment 1 start = 20 s
  - Media Segment 1 start = 30 s
MPEG DASH – object hierarchy

MPD
- Period id = 1
  start = 0 s
- Period id = 2
  start = 100 s
- Period id = 3
  start = 300 s
- Period id = 4
  start = 850 s

Period id = 2
- Adaptation Set 0
  subtitle turkish
- Adaptation Set 1
  video
- Adaptation Set 2
  audio english
- Adaptation Set 3
  audio german

Adaptation Set 1
- Representation 1
  Rate = 500 Kbps
- Representation 2
  Rate = 1 Mbps
- Representation 3
  Rate = 2 Mbps
- Representation 4
  Rate = 3 Mbps

Adaptation Set 2
- Representation 2
  Rate = 1 Mbps
- Representation 3
  Rate = 2 Mbps

Adaptation Set 3
- Representation 3
  Rate = 2 Mbps
  Resolution = 720p

Segment Info
- Duration = 10 s
- Template: 3/$Number$.mp4

Segment Access
- Initialization Segment
  http://abr.rocks.com/3/0.mp4
- Media Segment 1
  start = 0 s
  http://abr.rocks.com/3/1.mp4
- Media Segment 2
  start = 10 s
  http://abr.rocks.com/3/2.mp4

October 1-5, 2018 | The Loews Hollywood Hotel | Los Angeles, CA
CMAF – Multi-platform OTT workflow today

Consumers on different playback devices

Multiple media segments compete for cache space at the edge
CMAF Development Timeline: a very fast standardization pace (C. Concolato)

• In January 2015, **Microsoft and Apple** proposed a new media format which would be common between HLS and DASH.
• Worked with other companies to develop the format.

• Proposed Feb 2016 at MPEG’s 114th meeting.
• “Requirement Proposal” presented by:
  • 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 by:
  • Apple, Microsoft, MLBAM, Cisco, Akamai and Comcast.
• MPEG approved the establishment of a new standard:

**ISO/IEC 23000-19 - Common Media Application Format**
The Common Media Application Format defines the **container that holds the audio and video content**. It is not another presentation format itself.
Multi-platform OTT workflow with CMAF

Consumers on different playback devices

More efficient edge caching

Multiple media segments compete for cache space at the edge

Source content
Cloud encoder

Storage and packaging costs reduced

Cloud CDN delivery

Consumers on different playback devices

More efficient edge caching

Multiple media segments compete for cache space at the edge

Cloud encoder

Storage and packaging costs reduced

Cloud CDN delivery

Consumers on different playback devices

More efficient edge caching

Multiple media segments compete for cache space at the edge
Multi-platform OTT workflow with CMAF

- Source content
- Cloud encoder: Storage and packaging costs reduced
- CMAF
- CDN delivery
- Consumers on different playback devices
- More efficient edge caching
Core Technologies

- **ISO BMFF**, fMP4 container, specifically ISO/IEC 14496-12:201
  - 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 allows 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

CHUNK

FRAGMENT

SEGMENT

HEADER
Logical Media Objects for delivery

TRACK FILE
- HEADER
- SIDX
- FRAGMENT
- FRAGMENT
- FRAGMENT
- FRAGMENT

SERIES OF SEGMENTS
- HEADER
- SEGMENT
- SEGMENT
- SEGMENT
- SEGMENT

CHUNKS
- CHUNK
## CMAF Defined brands

<table>
<thead>
<tr>
<th>Brand</th>
<th>Location</th>
<th>Conformance Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>cmfc</code></td>
<td>FileTypeBox and SegmentTypeBox</td>
<td>CMAF Header</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CMAF Track Format</td>
</tr>
<tr>
<td><code>cmfs</code></td>
<td>SegmentTypeBox</td>
<td>CMAF Segments</td>
</tr>
<tr>
<td><code>cmfl</code></td>
<td>SegmentTypeBox</td>
<td>CMAF Chunks</td>
</tr>
<tr>
<td><code>cmff</code></td>
<td>SegmentTypeBox</td>
<td>CMAF Fragment (containing the first samples of the CMAF Fragment)</td>
</tr>
</tbody>
</table>
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:cmfhrs:2017
- CMFHD but with at least one ‘cbcs’ encrypted media
Apple Support

Apple @ WWDC, June 2016: “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 beginning with the following software releases: macOS 10.12, iOS 10, tvOS 10 (released September 13th 2016)
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
Live vs ondemand for DASH/HLS/CMAF

**LIVE**

- mpd
- m3u8
- .mp4
- .mp4
- .mp4
- .mp4
- .mp4
- .mp4

**ONDEMAND**

- Track files
  - mpd
  - m3u8
  - .mp4
  - .mp4
  - .mp4
  - .mp4
  - .mp4
  - .mp4
  - .mp4

- Separate segments
  - mpd
  - m3u8
  - .mp4
  - .mp4
  - .mp4
  - .mp4
  - .mp4
  - .mp4
  - .mp4

DRM “A”

Custom Header

Encrypted payload

DRM “B”

Custom Header

Custom Header

AES-128

Custom Header

Encrypted payload

DRM “C”

AES-128 commonly encrypted audio or video payload

Single ISO BMFF container

Multiple concurrent DRM header information

AES-128
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

…but only two versions are allowed in WAVE.
HTML Video

Below is a simple video example
Media Source Extensions (MSE)

1. [https://www.w3.org/TR/media-source/](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/](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](https://caniuse.com/#search=mse)

**Source:** [https://caniuse.com/#search=mse](https://caniuse.com/#search=mse)
Which browser code bases support EME today?

Source: [https://caniuse.com/#search=eme](https://caniuse.com/#search=eme)

October 1-5, 2018 | The Loews Hollywood Hotel | Los Angeles, CA
HTML5 players....many choices!
HTML5 Media Source Extensions (MSE) and Encrypted Media Extensions (EME) work together to enable cross-platform commercial media web apps.

MSE works with segmented media formats like MPEG Common Media Application Format (CMAF).

CMAF supports DRM-interop using MPEG Common Encryption (CENC); both work with EME.

Media presentations can be delivered with MPEG Dynamic Adaptive Streaming over HTTP (DASH) or Apple's IETF-published HTTP Live Streaming (HLS); both work with CMAF.

WAVE exists because the well-coordinated, global adoption of these standards can transform both the broadcast and Internet industries.
CMAF presentations can be constructed from a variety of codecs – the binding to the CMAF container format is called a "Media Profiles".

CMAF defines 1) CMAF bindings for a variety of MPEG codecs, 2) extensibility for bindings outside MPEG.

WAVE has an objective process to qualify Media Profiles for the WAVE Content Specification
- Market relevance, MSE compatibility, and schedule for availability of test tools / test content.
- WAVE’s adoption of new Media Profiles is an ongoing process.
## WAVE Content Specification 2018 - Video Profiles

<table>
<thead>
<tr>
<th>Media Profile Name</th>
<th>Codec</th>
<th>Profile</th>
<th>Level</th>
<th>Color primaries &amp; matrix coefficients</th>
<th>Transfer Characteristics</th>
<th>‘codecs’ MIME subparameters</th>
<th>CMAF Brand</th>
<th>Normative Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD</td>
<td>AVC</td>
<td>High</td>
<td>4.0</td>
<td>1 (BT.709) 1 (BT.709 OETF)</td>
<td>avc1.640028</td>
<td>‘cfhd’</td>
<td>[CMAF]</td>
<td>Table A.1</td>
</tr>
<tr>
<td>HHD10</td>
<td>HEVC</td>
<td>Main10 MainTier</td>
<td>4.1</td>
<td>1 (BT.709) 1 (BT.709)</td>
<td>hev1.2.4.L123.B0</td>
<td>‘chh1’</td>
<td>[CMAF]</td>
<td>Table B.1</td>
</tr>
<tr>
<td>UHD10</td>
<td>HEVC</td>
<td>Main10 MainTier 10-bit</td>
<td>5.1</td>
<td>1 (BT.709) 1 (BT.709 OETF) 14 (BT.2020 OETF)</td>
<td>hev1.2.4.L153.B0</td>
<td>‘cud1’</td>
<td>[CMAF]</td>
<td>Table B.1</td>
</tr>
<tr>
<td>HLG10</td>
<td>HEVC</td>
<td>Main10 MainTier 10-bit</td>
<td>5.1</td>
<td>9 (BT-2020) 18 (BT.2100 Table 5 HLG OETF) 14 (BT.2020 OETF)</td>
<td>hev1.2.4.L153.B0</td>
<td>‘clg1’</td>
<td>[CMAF]</td>
<td>Table B.1</td>
</tr>
<tr>
<td>HDR10</td>
<td>HEVC</td>
<td>Main10 MainTier 10-bit</td>
<td>5.1</td>
<td>9 (BT.2020) 16 (BT.2100 Table 4 PQ EOTF)</td>
<td>hev1.2.4.L153.B0</td>
<td>‘chd1’</td>
<td>[CMAF]</td>
<td>Table B.1</td>
</tr>
</tbody>
</table>

The 2018 Edition of the WAVE Content Specification includes these 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 are publishing bindings specifications for CMAF.
- ETSI is publishing CMAF bindings specs for Dolby and DTS audio codecs.
- Other organizations have suggested they will publish CMAF bindings in 2018.
- The WAVE Content Specification also includes both IMSC1 Text and Image CMAF bindings.

<table>
<thead>
<tr>
<th>Media Profile Name</th>
<th>Codec Family</th>
<th>Allowed Codecs or Profiles</th>
<th>INFORMATIVE Level</th>
<th>INFORMATIVE ‘codecs’ MIME subparameter</th>
<th>NORMATIVE CMAF Brand</th>
<th>NORMATIVE Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAC Core</td>
<td>AAC</td>
<td>AAC-LC, HE-AAC, HE-AAC v2</td>
<td>2</td>
<td>mp4a.40.2, mp4a.40.5, mp4a.40.29</td>
<td>‘caac’</td>
<td>[CMAF] Table A.2</td>
</tr>
<tr>
<td>Adaptive AAC Core</td>
<td>AAC</td>
<td>AAC-LC, HE-AAC, HE-AAC v2</td>
<td>2</td>
<td>mp4a.40.2, mp4a.40.5, mp4a.40.29</td>
<td>‘caaa’</td>
<td>[CMAF] Table A.2</td>
</tr>
<tr>
<td>AAC Multichannel</td>
<td>AAC</td>
<td>AAC-LC, HE-AAC</td>
<td>6</td>
<td>mp4a.40.2, mp4a.40.5, mp4a.40.29</td>
<td>‘camc’</td>
<td>[CMAF A1] Table i.2</td>
</tr>
<tr>
<td>DTS-HD</td>
<td>DTS-HD</td>
<td>DTS, DTS-HD</td>
<td>n.a.</td>
<td>dtsc, dtse, dtsf</td>
<td>‘dts1’</td>
<td>[DTS-HD]</td>
</tr>
<tr>
<td>AC-3 and Enhanced AC-3</td>
<td>AC-3 EAC-3</td>
<td>AC-3, EAC-3</td>
<td>n.a.</td>
<td>ec-3</td>
<td>‘ceac’</td>
<td>[EAC3]</td>
</tr>
<tr>
<td>AC-4, Single Stream</td>
<td>AC-4</td>
<td>AC-4</td>
<td>3</td>
<td>ac-4.02.01.03</td>
<td>‘ca4s’</td>
<td>[AC4]</td>
</tr>
<tr>
<td>MPEG-H, Single Stream</td>
<td>MPEG-H</td>
<td>Low Complexity (LC)</td>
<td>3</td>
<td>mhm1.0x0B, mhm1.0x0C, mhm1.0x0D</td>
<td>‘cmhs’</td>
<td>[CMAF A1] Table j.2</td>
</tr>
</tbody>
</table>
### WAVE Programs and Live Linear Content

- **WAVE Program**: Defined as a sequence of one or more CMAF Presentations.
  - Why? Because live linear content with ad insertions may require multiple CMAF Presentations (unlike VOD).
  - A WAVE Program can (optionally) conform to a WAVE Splice Constraint Profile.
- The **Baseline Splice Constraint Profile** is:
  - Encoding constraints to enable continuous rendering of sequential Switching Sets in WAVE Programs
  - Intended for most existing adaptive streaming Players in the market today.
- WAVE will publish new, more advanced Splice Constraint Profiles as new devices enter the market.

---

**Continuous Rendering for a continuous user experience**
The WAVE Content Specification

Download WAVE specifications in PDF format at:

https://cta.tech/WAVE

This is a free download.
HTML5 API Specification

WAVE Device Playback Capabilities Spec

WAVE Content Spec

WAVE Web Media API spec

- HTML5
- MSE
- EME
- CSS
- Fetch
- XHR
- JavaScript
- WebGL
HTML5 APIs: Reference Platform

One Content Format...

...but multiple devices

Reference Platform

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/](http://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. **Identify gaps in current web APIs**
   - work with W3C Working Groups to update web standards.
Web Media API Snapshot 2017

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 released 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!

---

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.
The WAVE Web Media API Snapshot 2017

Download WAVE specifications in PDF format at:

https://cta.tech/WAVE

This is a free download.
OTT Device Performance Challenges

- Ad splicing problems
- Regional profiles (50/60Hz)
- Request protocol deficiencies
- Unknown codec capabilities
- Unknown rendering capabilities
- Partial profile support
- Codec incompatibility
- Long-term playback instability
- Late Binding Synchronization

- Audio discontinuities
- Glitches when switching bitrate
- Memory problems
- Limited processing power
- Long start-up delay
- Performance monitoring
- DRM support
- Variable HDR support
- Scaling display issues
Device Playback Focus

• Device definition:
  • Codecs & Rendering, possibly on different devices (HDMI, Miracast, etc.)

• Capabilities discovery

• Playback of a Presentation (of Media Profiles)
  • Player Requirements such as splicing segments, switching, random access

• Playback of a sequence of Presentations
  • Splicing—for example for ad insertion or program boundaries

• Other playback capabilities, e.g. support for multiple decoders
Abstracted Device Playback Model

Stimulus/Input

Device Capabilities

Observations

Audio Source Buffer
Video Source Buffer
Subtitle Source Buffer

Device Playback Model

Requirements: If you input WAVE content, this shall be the observation
Connection to HTML5 & MSE

HTML5 and MSE

• Provide APIs for applications to playback WAVE content
• Extend APIs to ensure more consistent and richer user experience

Device Playback Platform:
• Ensuring that WAVE content can be “played” consistently when using “MSE-like” APIs for different use cases and applications.
• Use HTML5 as reference and test platform, not excluding other platforms

Not CMAF
Device Playback

One of the key missing pieces for consistent Internet TV Services

Media Source Extension
• Extends HTMLMediaElement
• Enables JavaScript to generate media streams for playback.
• Allowing JavaScript to generate streams facilitates a variety of use cases like adaptive streaming and time shifting live streams.

ByteStream Format for ISO BMFF
• [https://www.w3.org/TR/mse-byte-stream-format-isobmff/](https://www.w3.org/TR/mse-byte-stream-format-isobmff/)
• This specification defines a Media Source Extensions™ [MEDIA-SOURCE] byte stream format specification based on the ISO Base Media File Format.
Capabilities Discovery by the Player App

• Apps need to know device capabilities—but it is not (yet) fully available
• Some possibilities under discussion:
  • `isSupportedType()` or `canPlayType()` APIs
    • Use MIME type to check device support of Media Profile
  • Device Platform can provide an API to check Media Profiles
    • Media Profile is provided in the manifest or in the CMAF Header (ftyp box).
  • MIME Subparameters
    • App uses a detailed MIME type string when checking capabilities
  • Media Capabilities API
    • Published by the W3C Web Platform Incubator Community Group
    • See https://wicg.github.io/media-capabilities/

• This topic is still under discussion
Device Playback – Next Steps

• Specification release – Q4 2018
• Test suite development begins – Q4 2018
  • Relies on specification
  • RFP process in Q4, award and development starting in Q1 2019
• Annual updates
Questions addressed with the WAVE Test Suite

• Given a content stream,
  1. Does it comply to WAVE Content Spec requirements?

• Given a device platform with a User Agent,
  2. Does the underlying platform meet Device Playback Capabilities Spec requirements?
  3. Does the API comply to WAVE HTML5 API requirements?
WAVE Approach to Test

• Compliance program (not certification or “logo” program)
• Partner with other groups where possible (e.g. DASH-IF, W3C)
  • Extend existing test efforts
  • Some new WAVE use cases lead to new tests
• WAVE arranges for the creation of new test material as needed
  • Cooperate with partner groups
  • Avoid hard ‘forks’ of existing open source tests
  • Continue licensing agreements on existing projects
  • Currently using “free, open source” model
WAVE HTML5 API Test Suite

- Based on W3C Web Platform Tests under agreement with W3C
- Verifies API under certain assumptions
- Published and available now
WMAS2017 Test Suite – Assumptions

• Based on Web Media API Snapshot 2017 (WMAS2017) specification
• Modified to run on general-purpose and embedded systems
  • E.g., laptops/tablets/phones and smart TVs/media sticks/STBs
• Targets APIs that pass on the four main browser codebases (Chromium, Edge, Gecko, WebKit; using CanIUse.com)
• Verified on:
  • Downloadable browsers (cf. codebases)
  • Three embedded systems (smart TV, media stick, gaming console)
Select APIs to test

Select only the APIs that pass specific browsers

And run the tests
WAVE Test Material – HTML5 API Reference Platform

• Web Media API Snapshot 2017 Test Suite
  • Test drive live (unblock port 8050)
    • https://webapitests2017.ctawave.org/
  • Open Source version (for porting to e.g. smart TVs)
    • https://github.com/cta-wave/WMAS2017
  • Issues list (*public—if you encounter a bug or need a feature*)
    • https://github.com/cta-wave/WMAS2017/issues
WAVE Content Validator

- Based on DASH-IF Content Validator under agreement with DASH-IF
- Verifies CMAF packaging of content
- Does not inspect elementary streams *inside* the CMAF packaged content
- Project under way; should publish Q1 2018
WAVE Content Conformance

• WAVE Content is CMAF Content

• Starting with MPEG-DASH conformance tool
  • “MPEG-DASH format” is almost “CMAF format”

• Validation against:
  • ISO-BMFF rules
  • General CMAF rules about segment boxes/CMAF Tracks and Addressable Resources
  • MPD information specific rules for segment boxes (MPD is assumed as manifest for CMAF Presentation)
Architecture - Conformance Software

**Test Client**
- HTML/JS
- DASH Validator
- MPD or MPD location
- Progress information
- Pass/Fail Report

**Conformance Server**
- MPD loading
  - MPD
  - MPD Schema
  - Schematron
- Segment fetching
- Cache
  1. Segments
  2. Pass/Error Reports
  3. Progress Reports
- Segment timing information
  - DASH cross check
  - Test Finished
- CMAF Validation
  - CMAF Additional Flags
  ++Flags
  - Segment validation (DASH + ISOBMFF + CMAF)
- Segment box structure
  - PHP

**Content Server**
- MPD get
  - MPD
  - Initialization segment
  - Media segment(s)

---

October 1-5, 2018 | The Loews Hollywood Hotel | Los Angeles, CA
WAVE Device Playback Capabilities Test

- Not based (yet) on existing test suites
- Downstream of specification release

Content

Device Playback Capabilities

Device Playback Test Suite

HTML5 Reference Platform

WMAS2017 Test Suite
Wrap-Up

WAVE Device Playback Capabilities Spec

WAVE Content Spec

WAVE Web Media API spec

RFC 6381
HLS
AC-3/4
DTS
MPEG Audio
CENC
AVC
HEVC
BMFF
DASH
CMAF
IMSC1
HTML5
MSE
EME
CSS
Fetch
XHR
JavaScript
WebGL
# WAVE Roadmap 2018

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr'18</td>
<td>Content Specification Apr 2018</td>
</tr>
<tr>
<td>May'18</td>
<td>Web Media API Snapshot (WMAS 2017) Dec 2017</td>
</tr>
<tr>
<td>Jun'18</td>
<td>WMAS2017 Test Suite (in coop. w/ W3C)</td>
</tr>
<tr>
<td>Jul'19</td>
<td></td>
</tr>
<tr>
<td>Aug'18</td>
<td></td>
</tr>
<tr>
<td>Sep'18</td>
<td></td>
</tr>
<tr>
<td>Oct'18</td>
<td>Amd 1 (adds media profiles, Some tweaks)</td>
</tr>
<tr>
<td>Nov'18</td>
<td>Content Validator Tool (in cooperation with DASH-IF)</td>
</tr>
<tr>
<td>Dec'18</td>
<td>Device Playback Capabilities Specification 2018</td>
</tr>
<tr>
<td>Jan'19</td>
<td>Test Tools &amp; Test Cases</td>
</tr>
<tr>
<td></td>
<td>Web Media Application Developer Guidelines</td>
</tr>
<tr>
<td></td>
<td>WMAS 2018</td>
</tr>
</tbody>
</table>
Key Take-Aways

• WAVE promotes interop for commercial OTT streaming
  • on laptops, phones, and tablets;
  • and on embedded systems like smart TVs, media sticks, gaming consoles, and STBs.
• Key specs are MPEG-CMAF and MPEG CENC (content preparation) over HLS and MPEG-DASH to a (preferred) environment based on HTML5 APIs incl. MSE/EME.
• The WAVE Content and HTML5 API specifications available now
• The HTML5 API test suite is available now; the Content Validator is due Q1 2019
• The DPCTF specification and test suite are coming soon
• WAVE is global in scope and welcomes increased global participation.
How to Get Involved

• WAVE Specifications – free PDF download at CTA.tech/WAVE

• This slide deck: CTA.tech/WAVE under Resources (by Thursday 10/4/2018)

• Join the WAVE Project:
  standards@CTA.tech Or: Mike Bergman mbergman@CTA.tech