



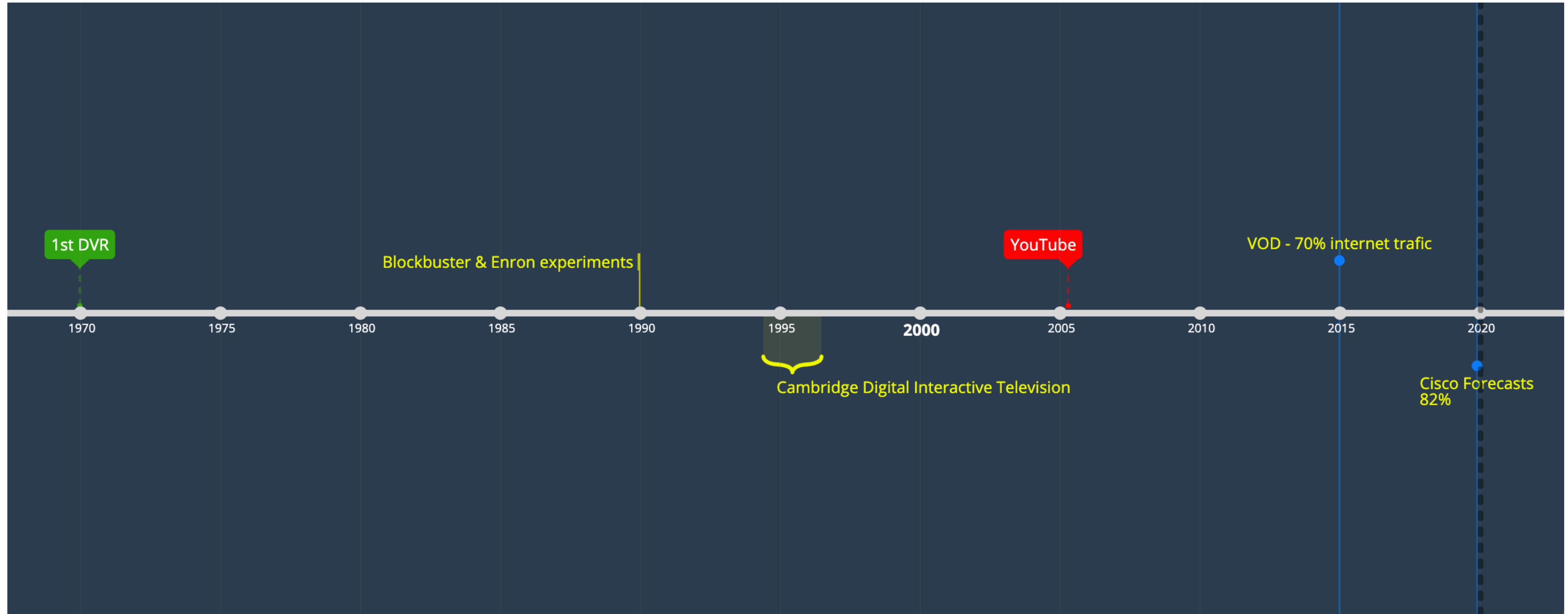
Hello, VOD!

MARKO ĆILIMKOVIĆ

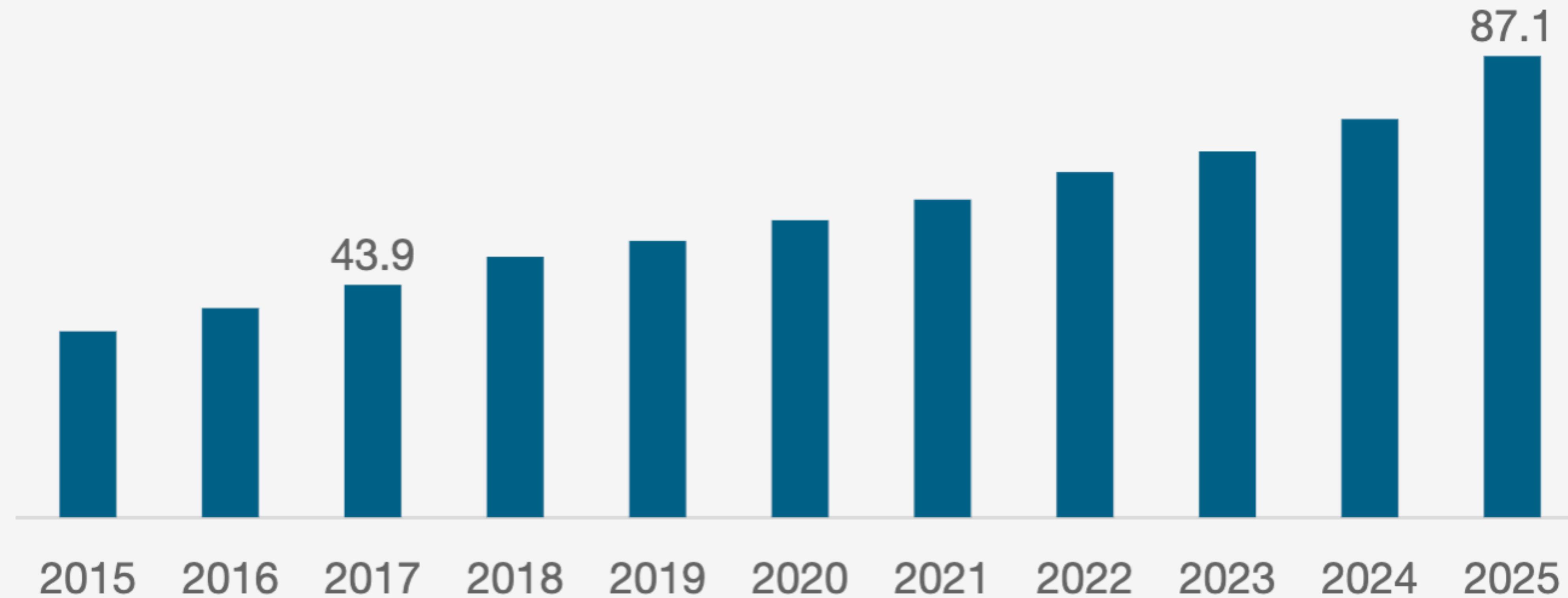
01

DEFINITION

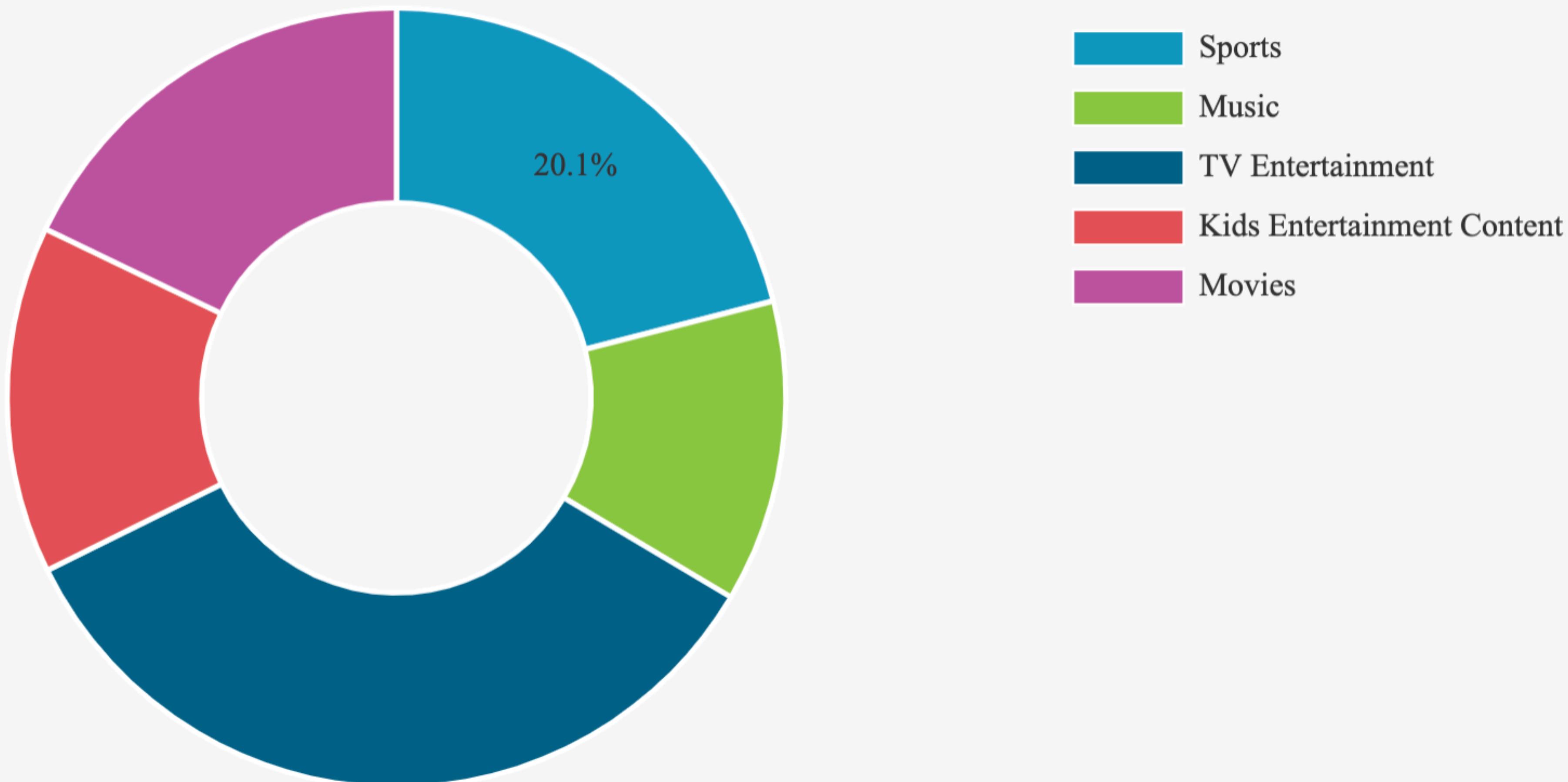
System that allows viewers to watch **any content at their convenience** instead of a schedule as decided by traditional TV providers



Global Video On Demand Market Size, 2015-2025 (US\$ Billion)



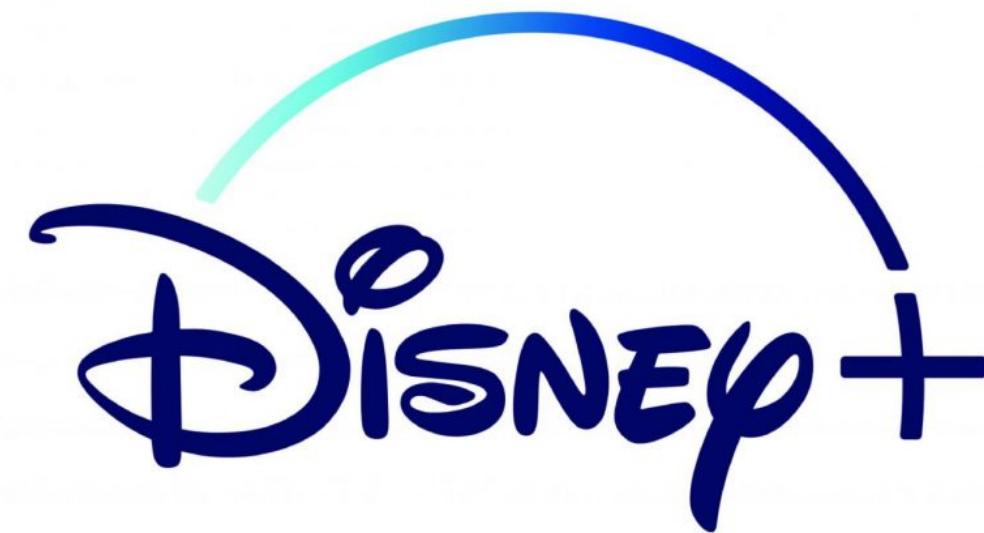
Global Video on Demand Market Share, By Application, 2017



PLATFORMS



SERVICES



hulu

OCBS

NETFLIX

HBO NOW

slingTM
TELEVISION

prime video
The Amazon smile logo, which is a blue curved arrow pointing upwards and to the right, positioned below the word "prime video".



JUST USE YOUTUBE?



- global reach
- analytics



- content management
- video length



- content protection
- video monetization
- player customisation
- branding
- video size

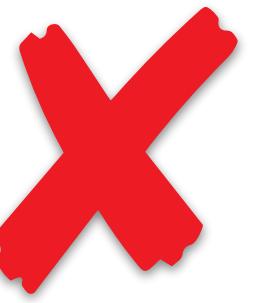


02

FORMATS



video.mp4





.m3u8



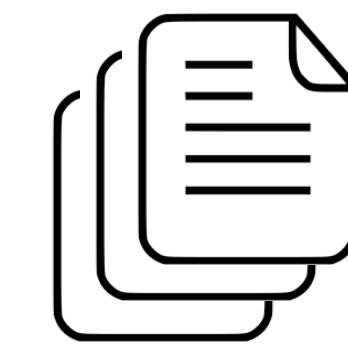
.ts



.ts



.ts



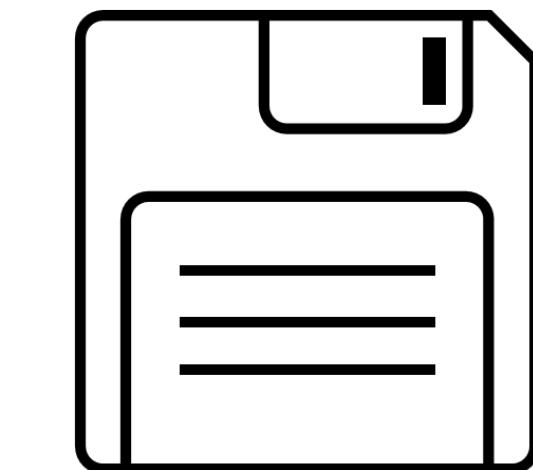
.ts



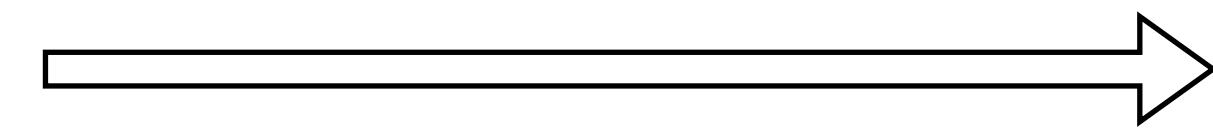
FORMATS

Containers

CONTAINER



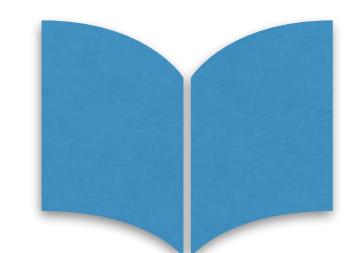
video.mp4



video stream



audio stream



metadata
bitrate, device,
resolution, subtitles,
Time of creation



FORMATS

Codecs

CODER DECODER

- creates an encoded video or audio stream making it smaller and easy to manage

VP8

WMA

FLAC

WMV

MP4

TAK

FPS1

DOLBY

VP6

MAC

H.264

AAC

VP9

MP3

H262

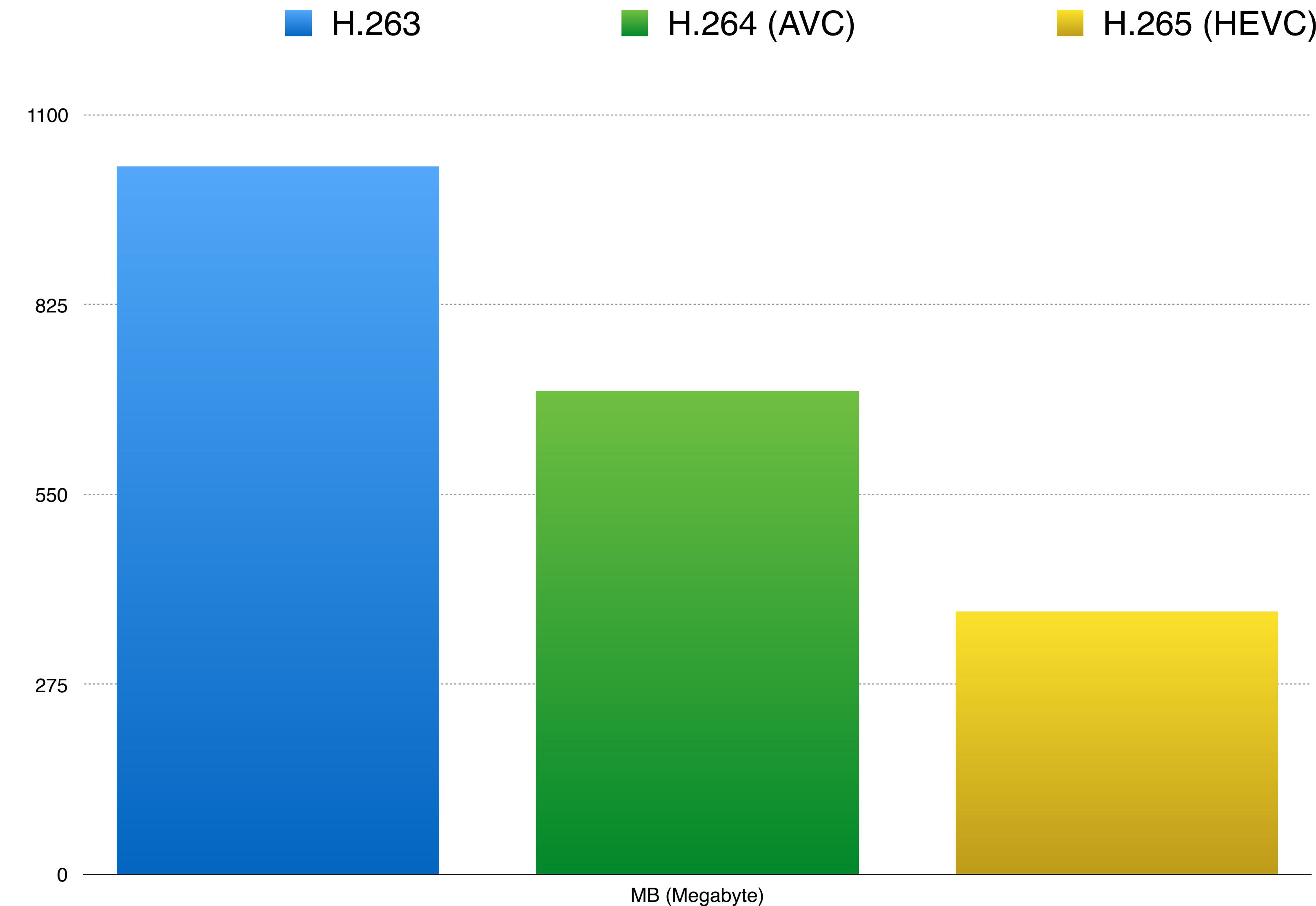
TOSS

H.263

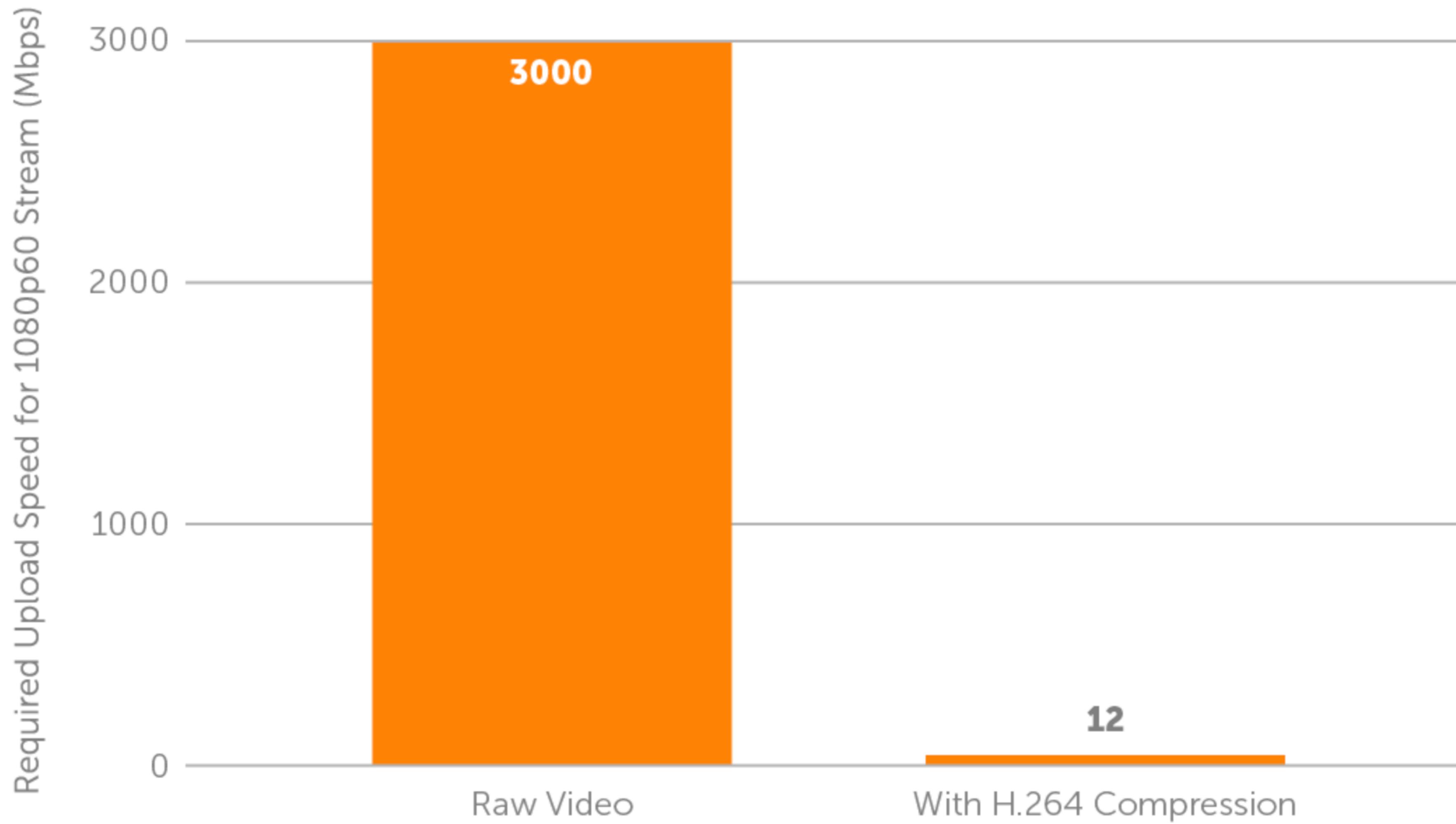
VERBS

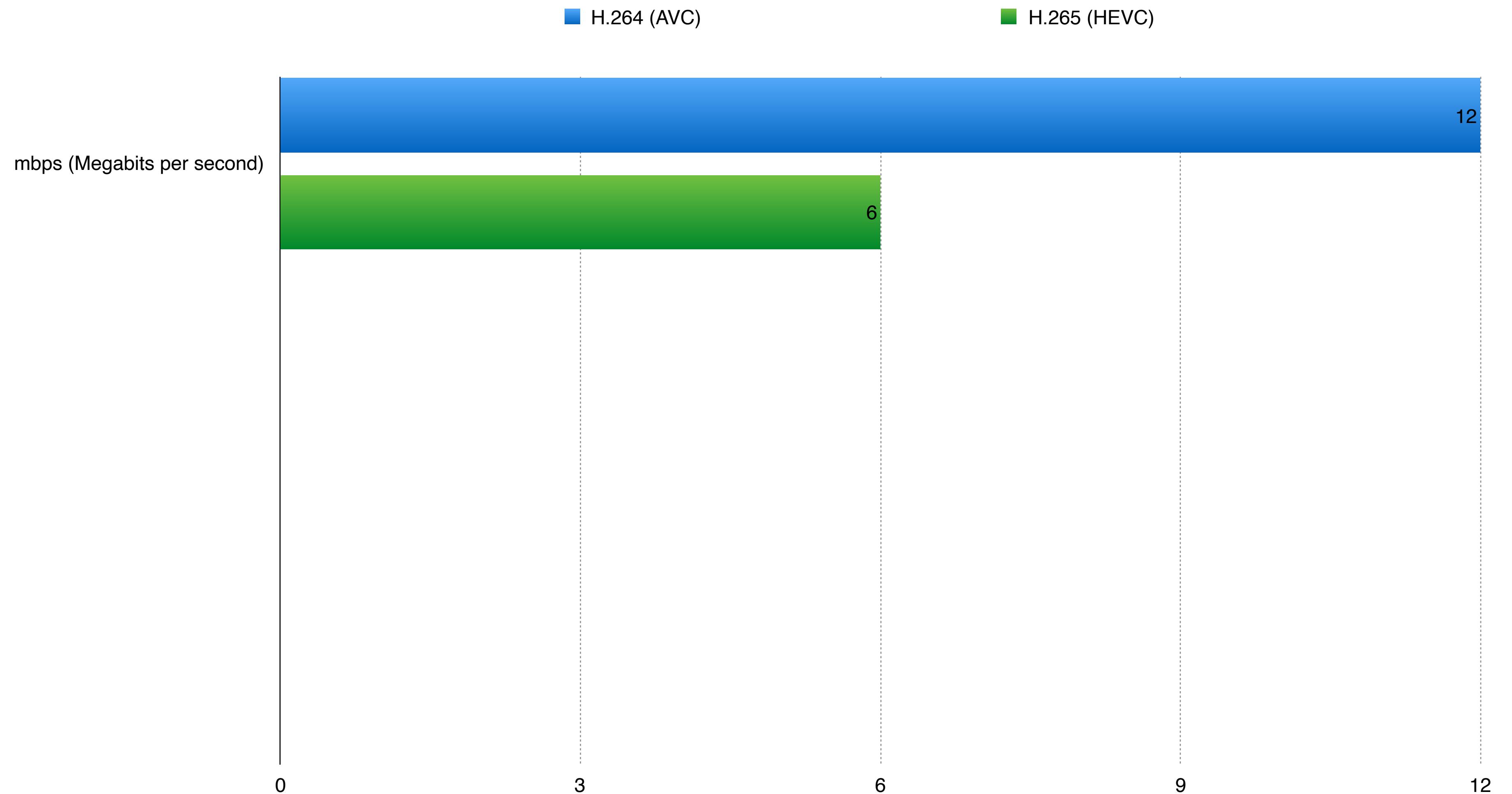
ALAS

H.265

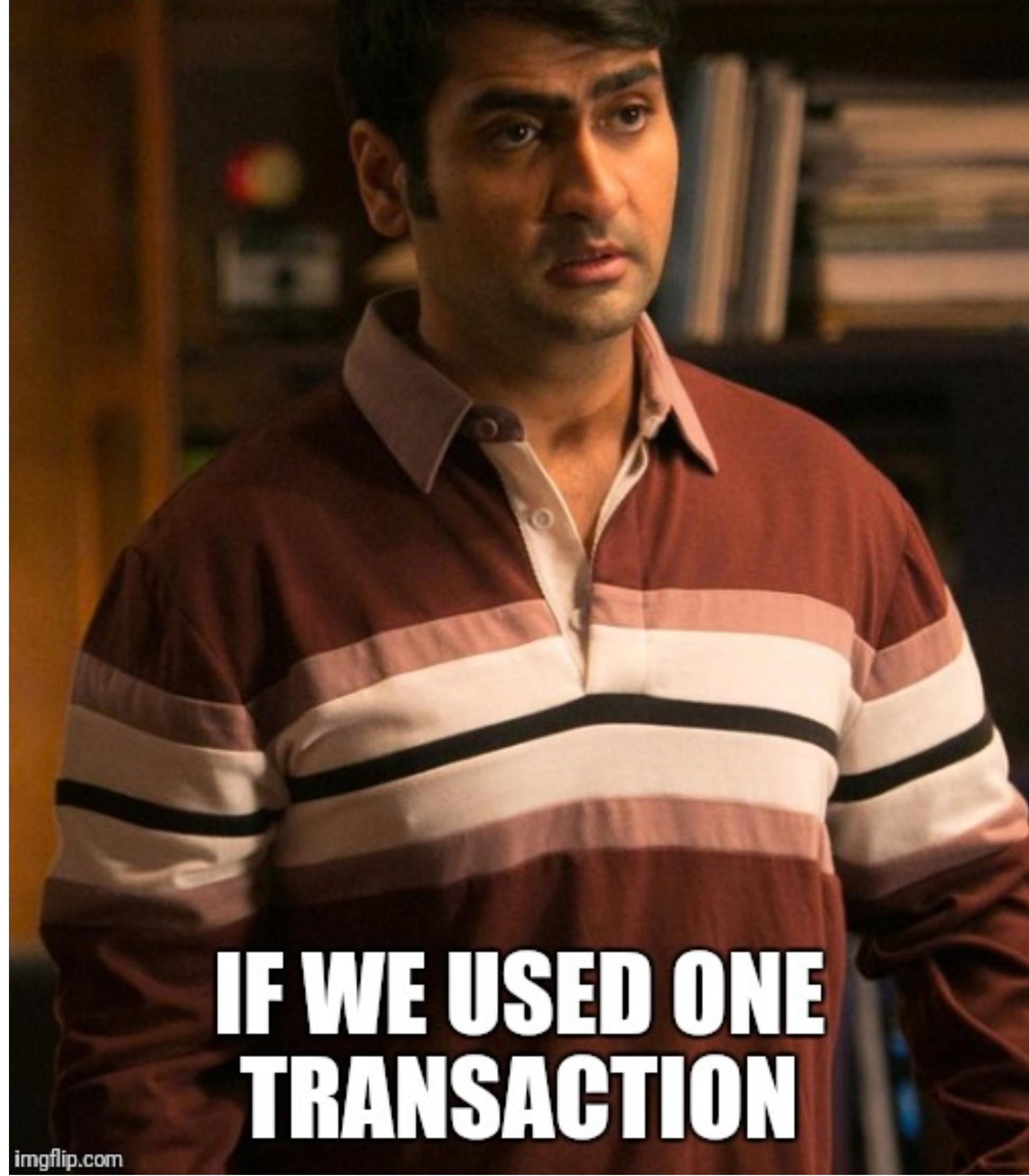


Required Upload Speed for 1080p60 Stream (Mbps)





**ACTUALLY WE COULD ACHIEVE
NEARLY 100% COMPRESSION**



**IF WE USED ONE
TRANSACTION**

OTHER VIDEO CODECS

- AV1 (Alliance for Open Media)
- H.266
- VP9 (Google)

AUDIO CODECS

- Mp3
 - popular wide support ✓
 - saves space without noticeable quality loss ✓
 - limited functionality for video ✗
- AAC
 - widely supported ✓
 - better sound for same bitrate ✓
 - little support issues ✗
- AC-3
 - 5.1 surround sound ✓
 - narrow device support ✗

A format is a standardised set of rules for
storing containers, codecs, meta data and
sometimes folder structure

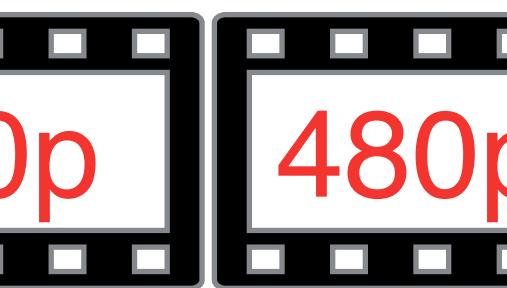
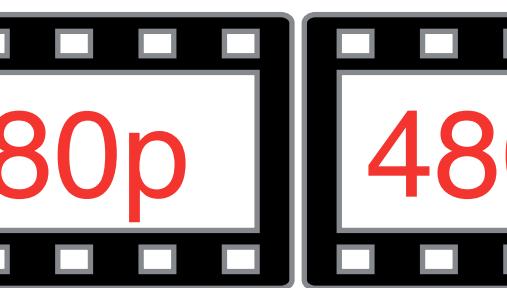
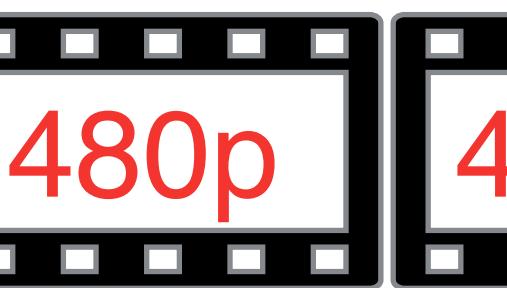
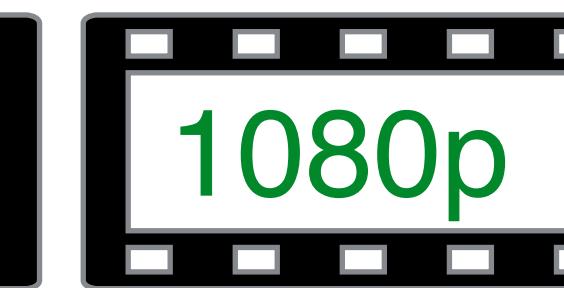
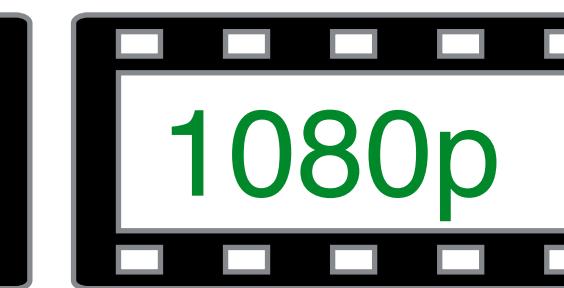
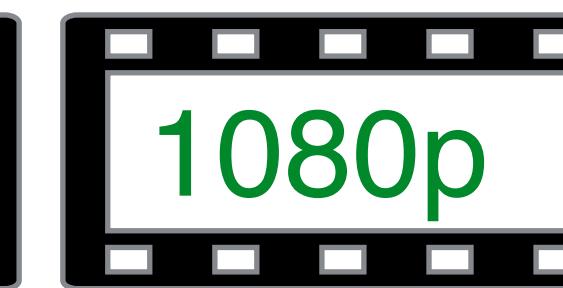
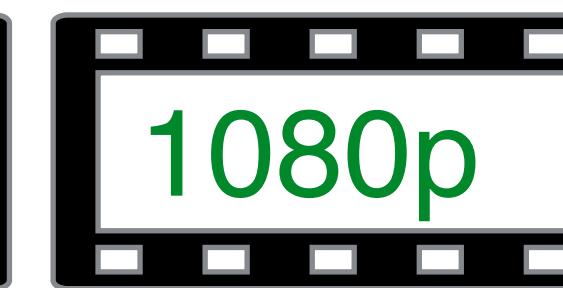
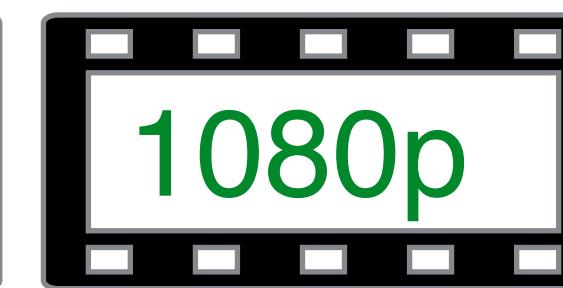
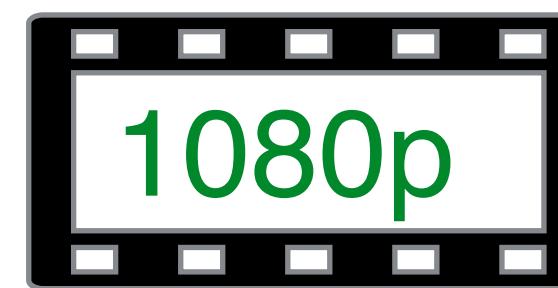
FORMAT DOMAINS

Video Editing

Online Distribution



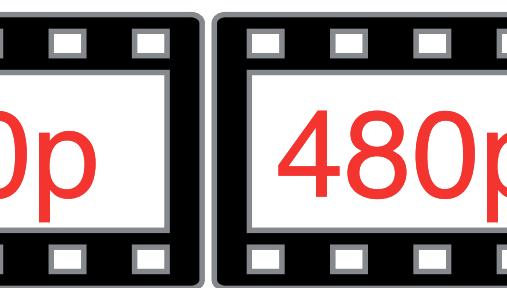
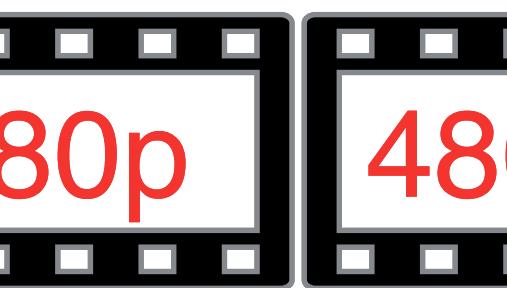
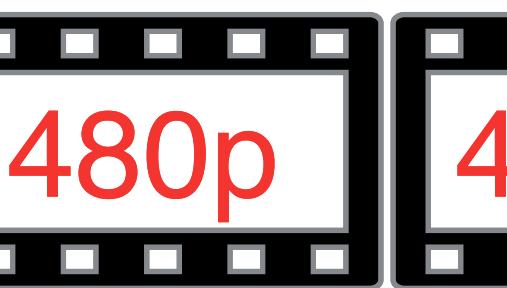
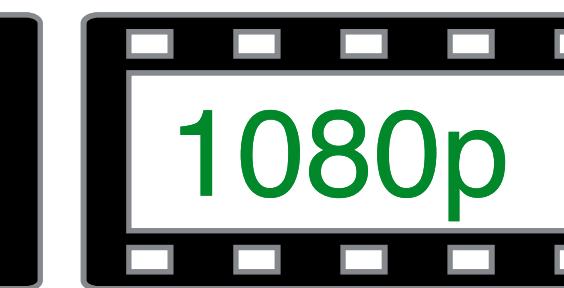
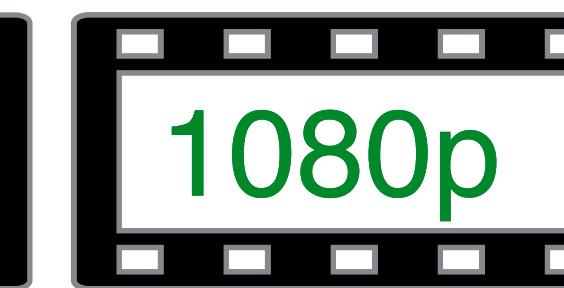
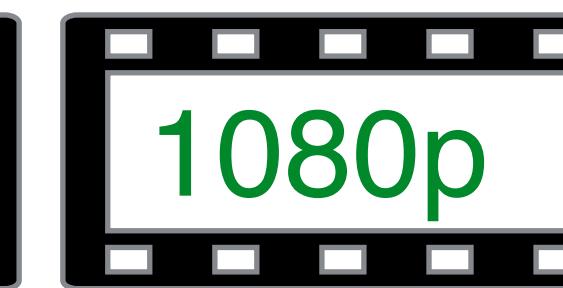
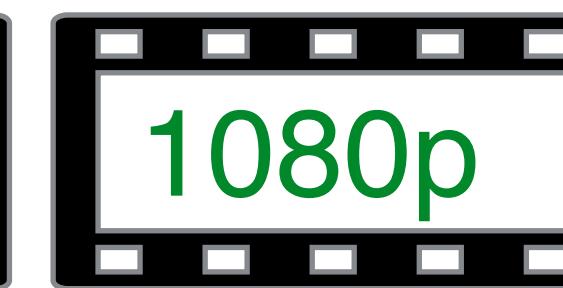
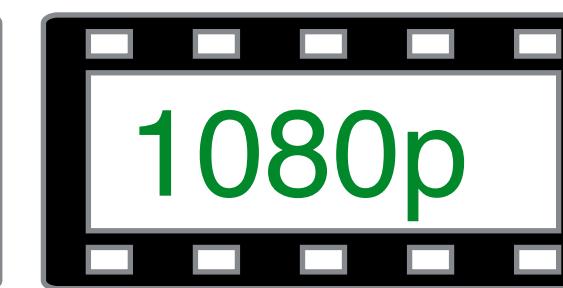
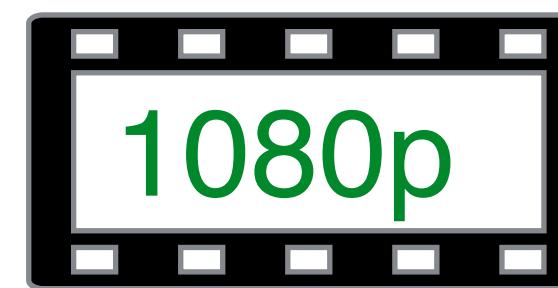
ABR



MEDIUM

SLOW

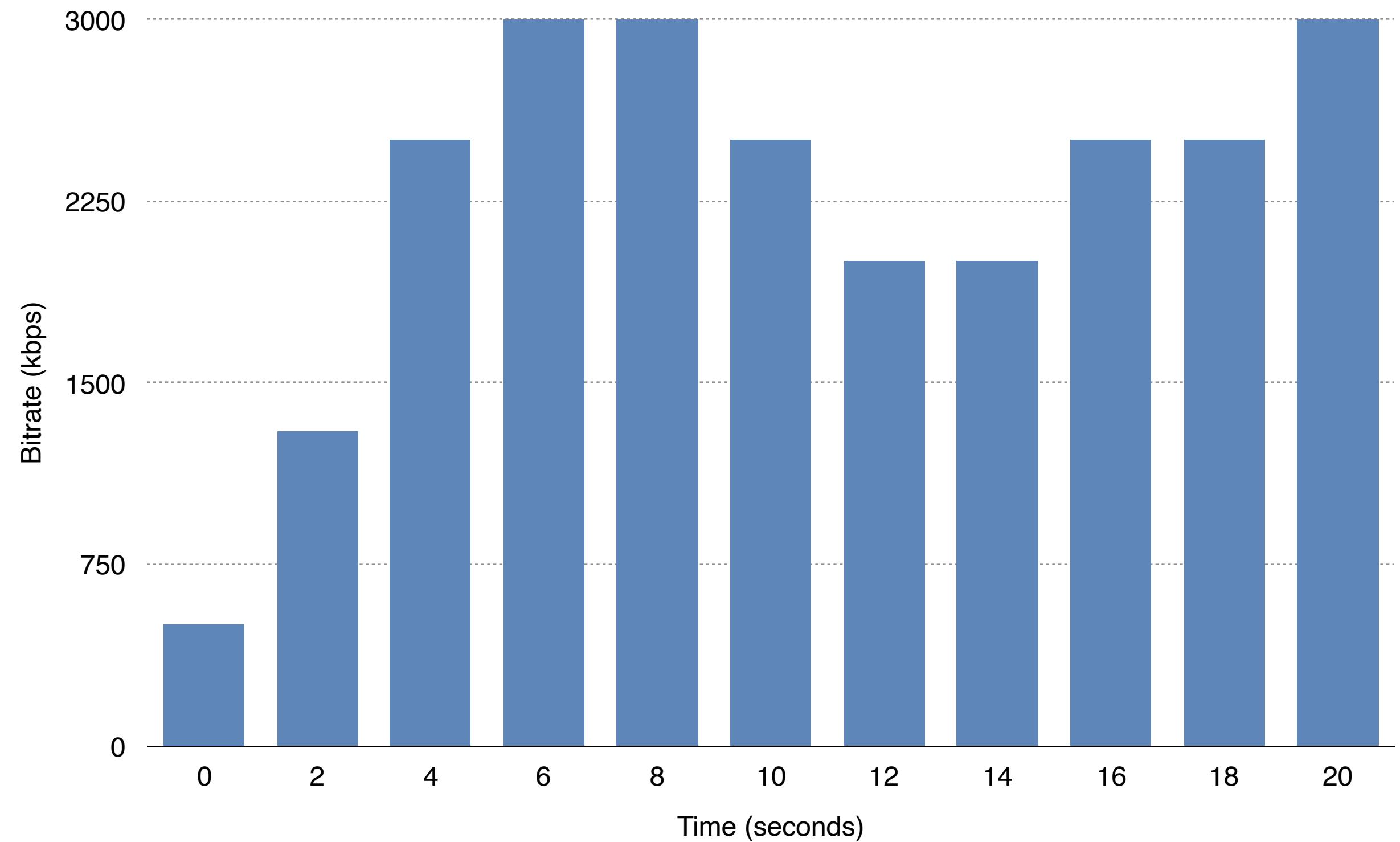
FAST

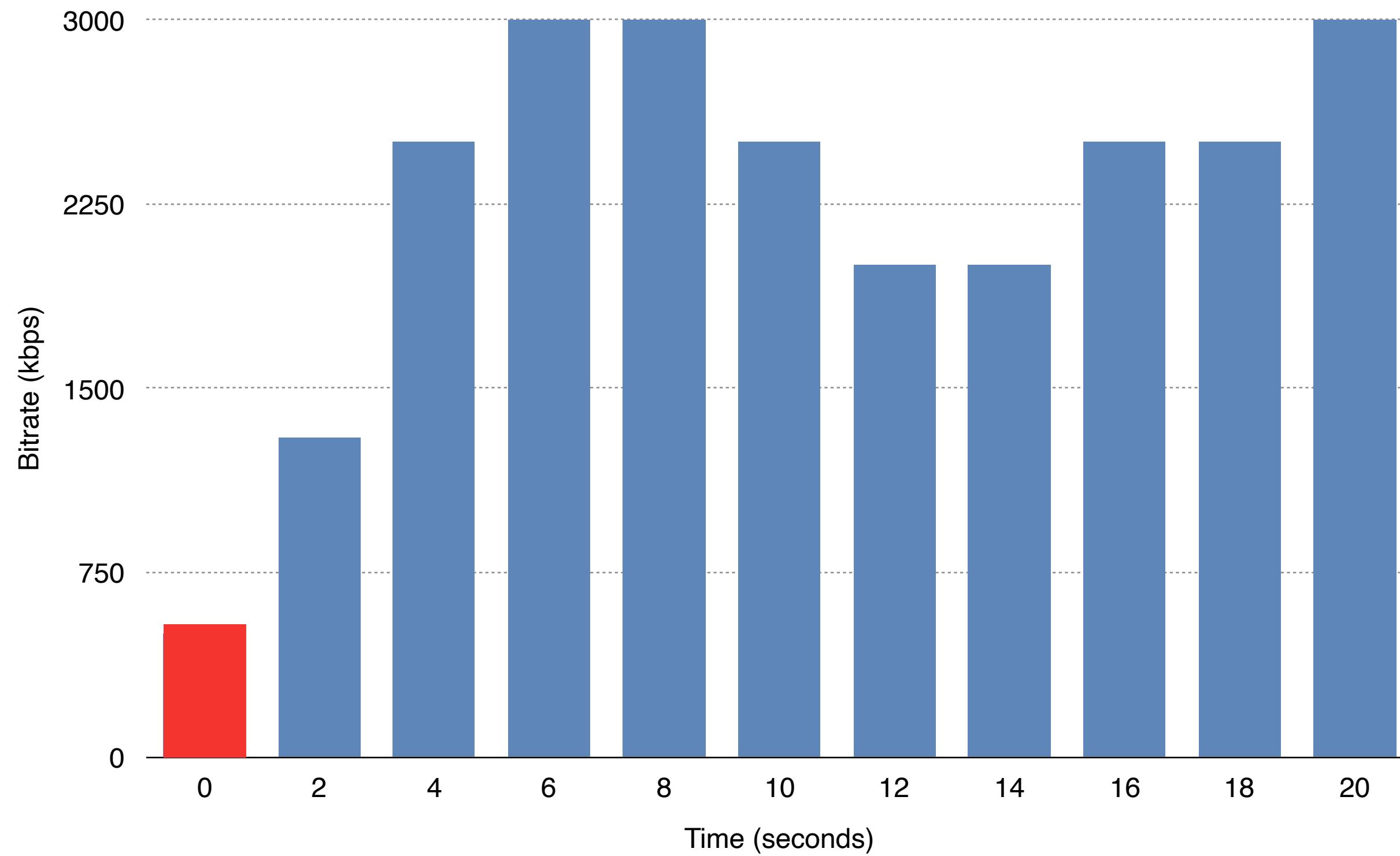


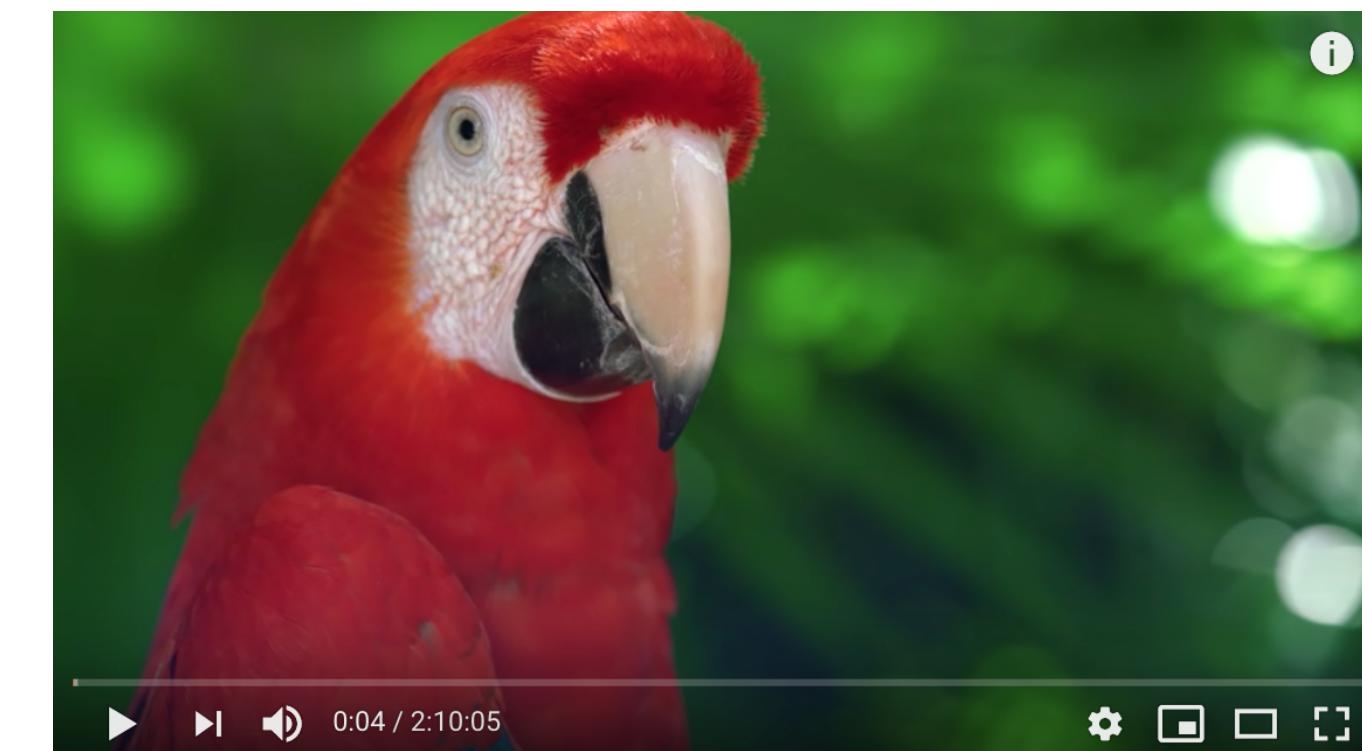
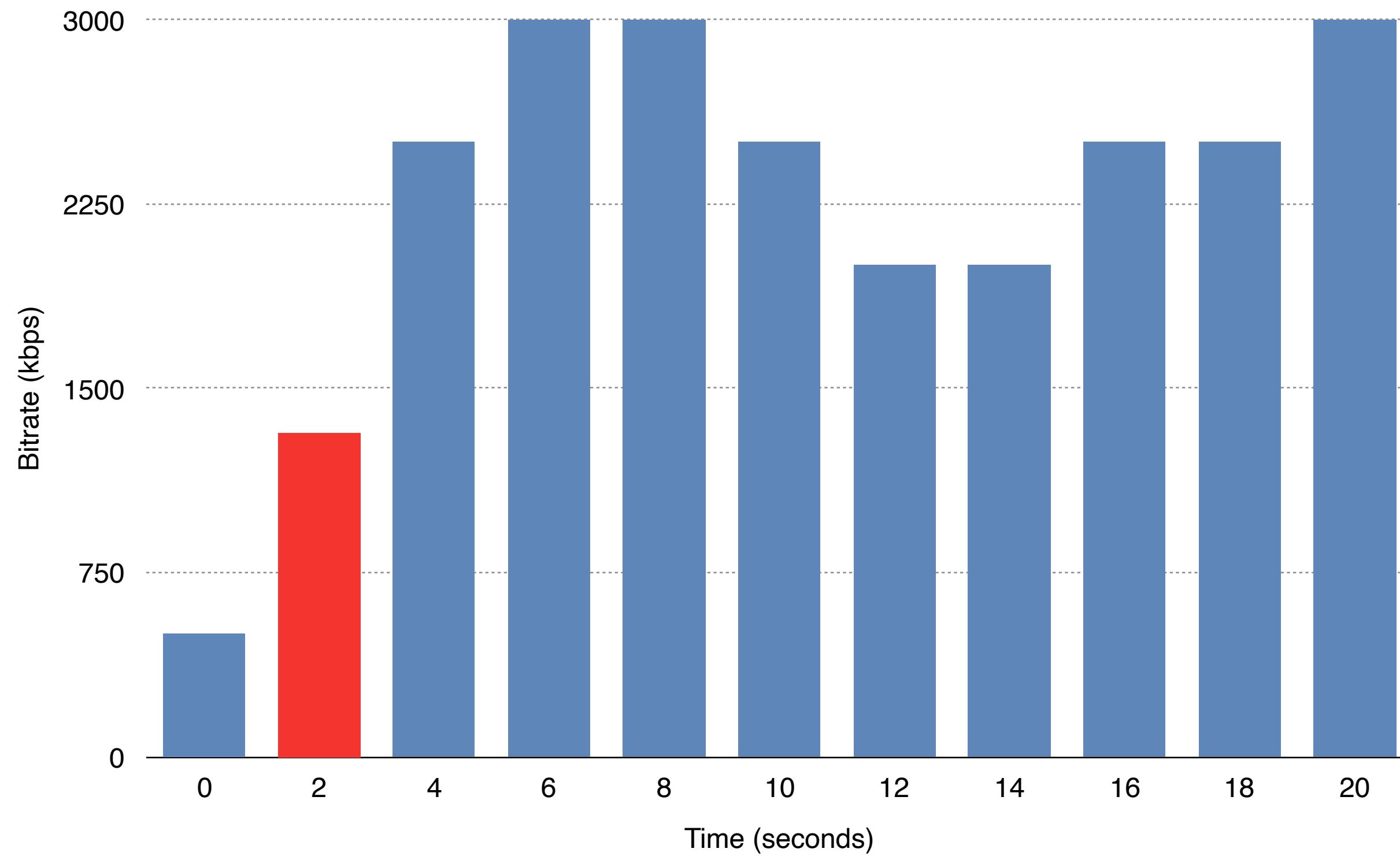
MEDIUM

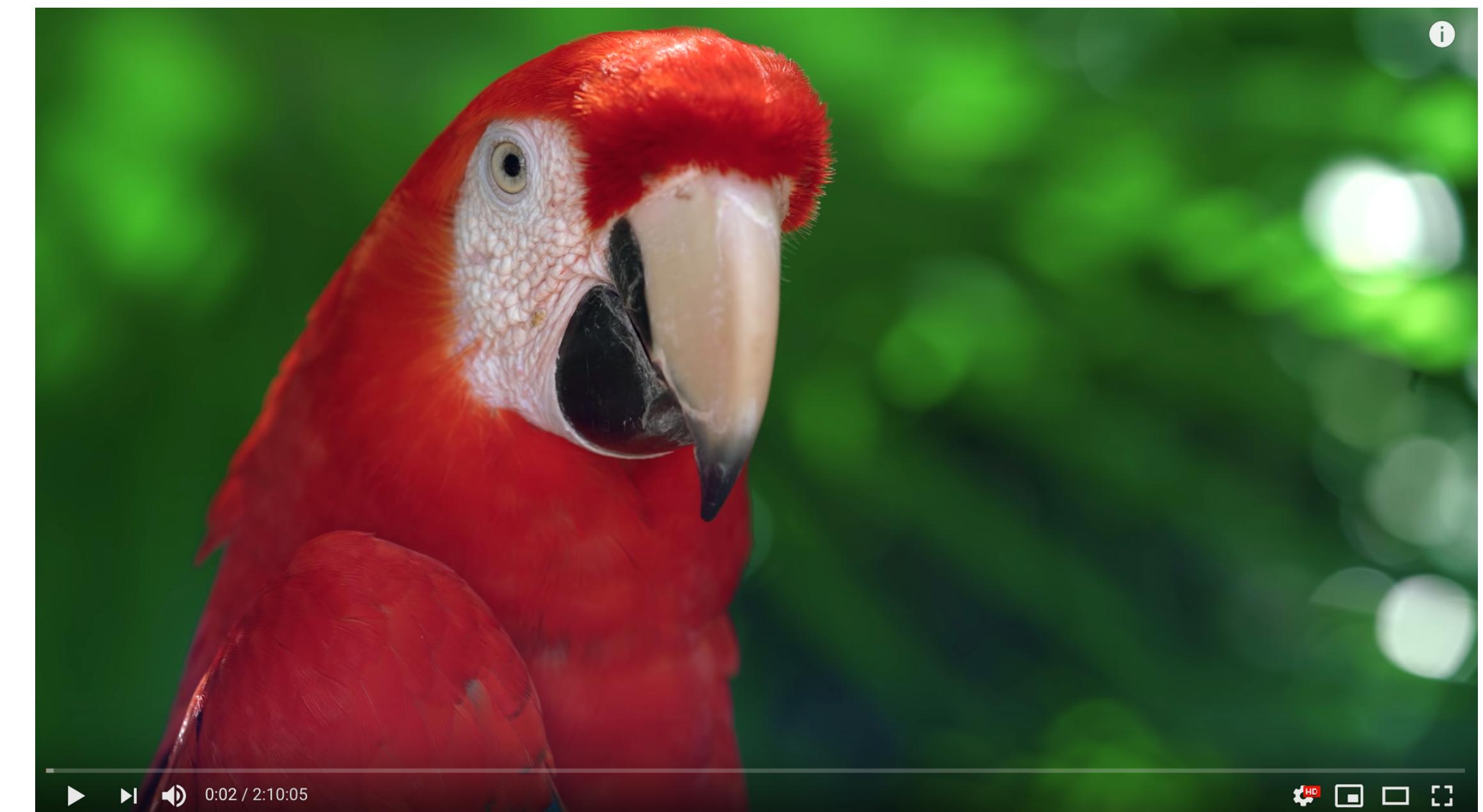
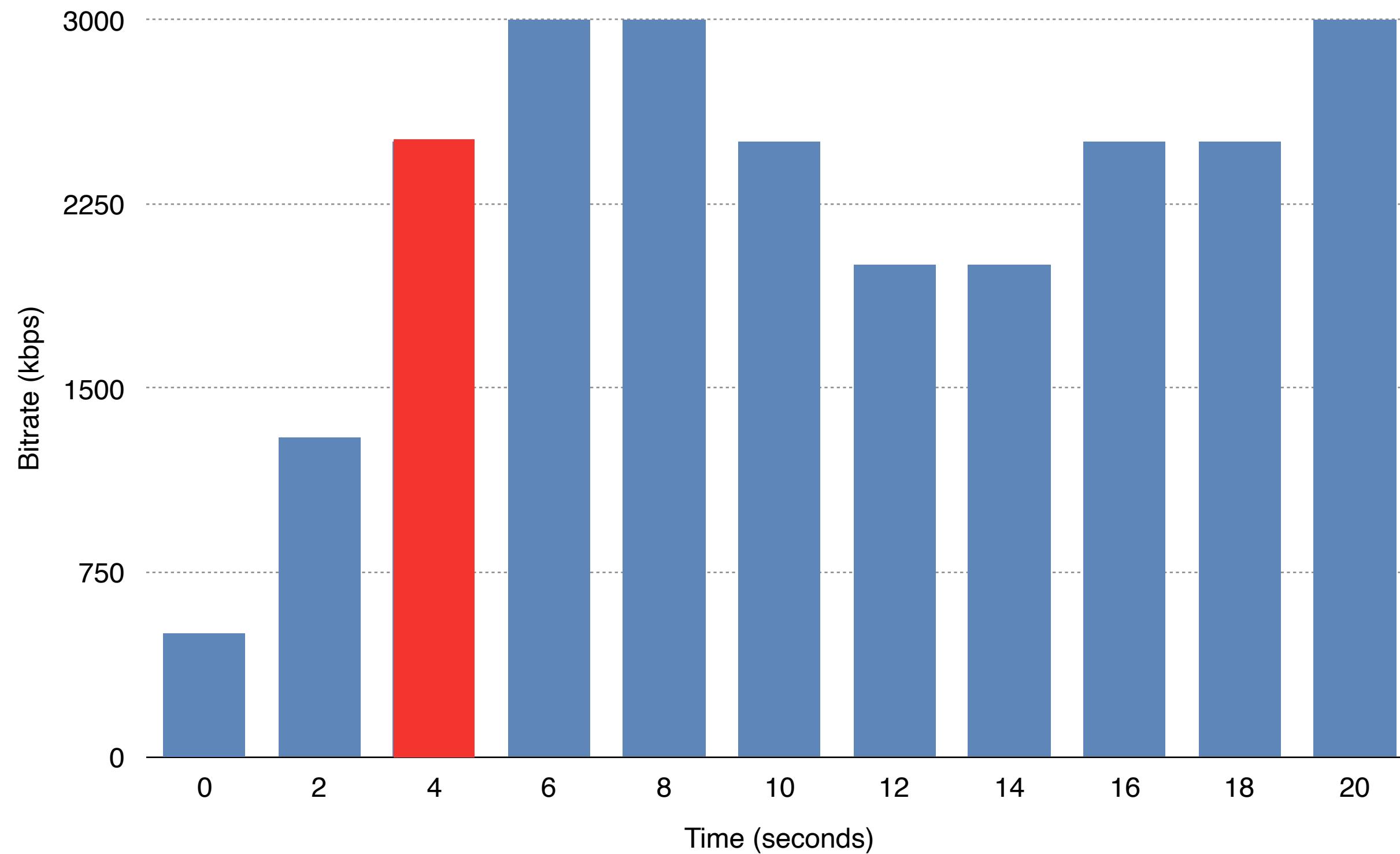
SLOW

FAST

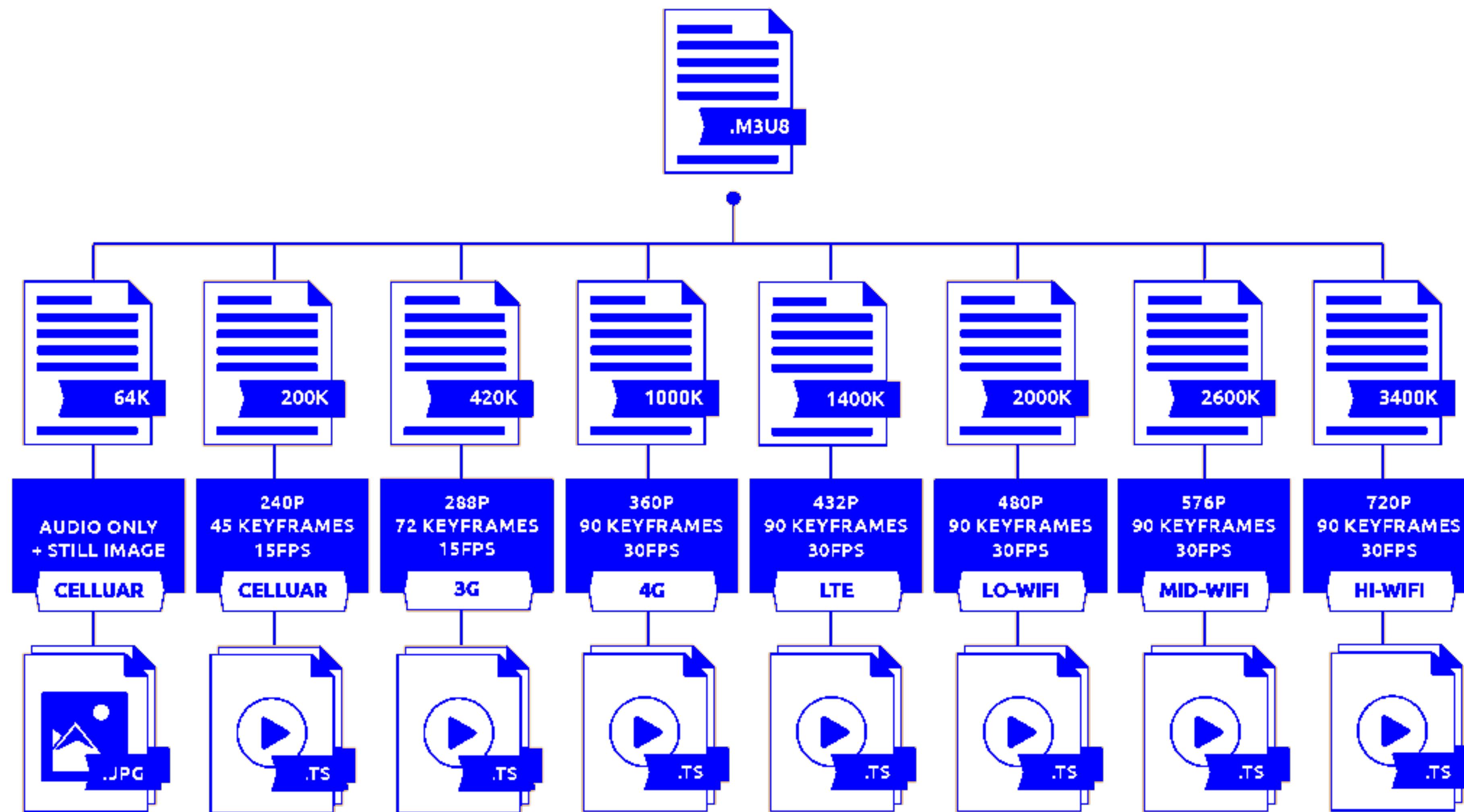


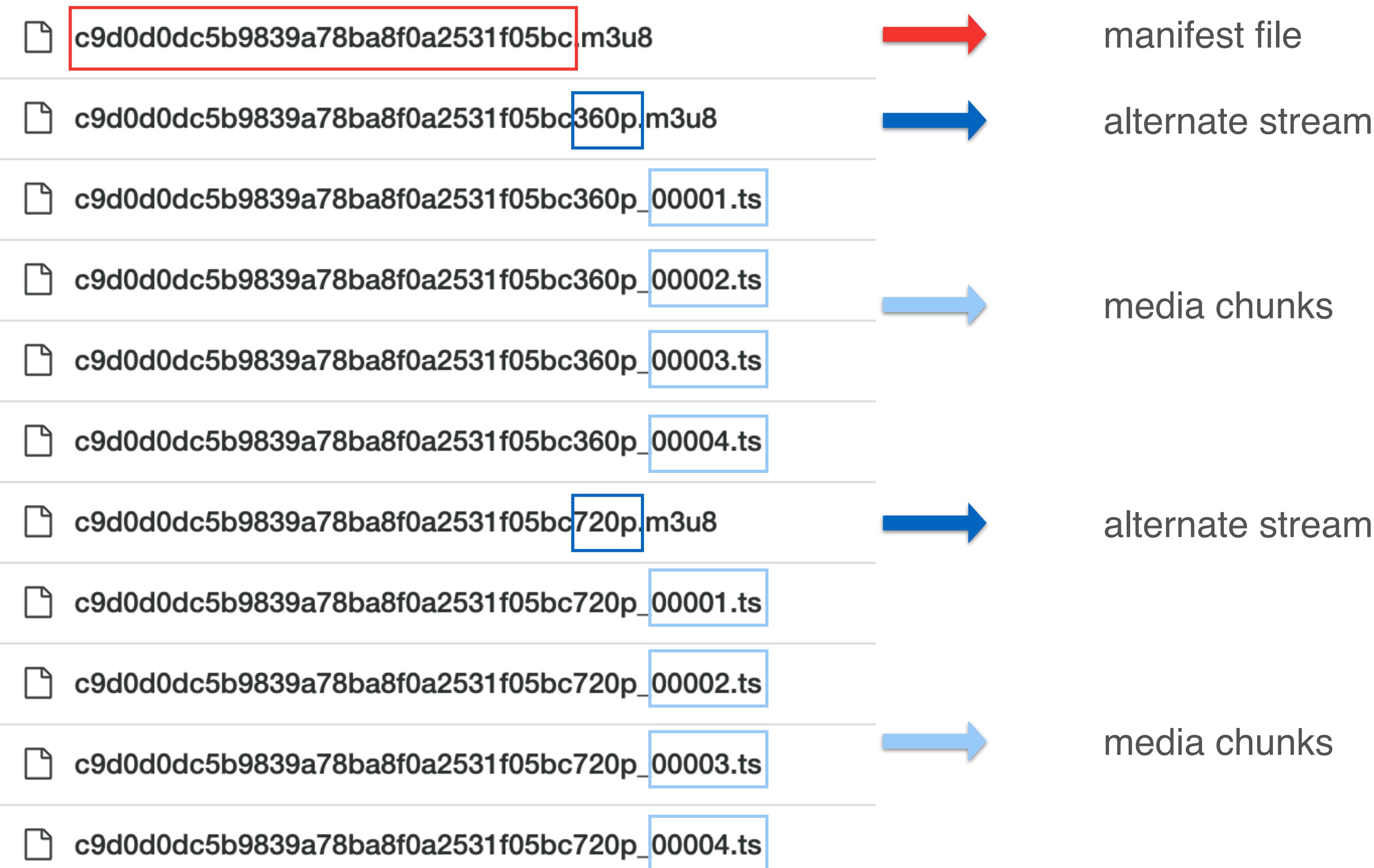






Quality	Resolution	bitrate - low motion	bitrate - high motion	audio bitrate
240p	426x240	400k	600k	64k
360p	640x360	700k	900k	96k
480p	854x480	1250k	1600k	128k
HD 720p	1280x720	2500k	3200k	128k
HD 720p 60fps	1280x720	3500k	4400k	128k
Full HD 1080p	1920x1080	4500k	5300k	192k
Full HD 1080p 60fps	1920x1080	5800k	7400k	192k
4k	3840x2160	14000k	18200	192k
4k 60fps	3840x2160	23000k	29500k	192k





#EXTM3U
#EXT-X-VERSION:3
#EXT-X-INDEPENDENT-SEGMENTS
#EXT-X-STREAM-INF: BANDWIDTH=716136, AVERAGE-
BANDWIDTH=713515, CODECS="avc1.4d401f,mp4a.40.5", RESOLUTION=640x360, FRAME-
RATE=29.970
c9d0d0dc5b9839a78ba8f0a2531f05bc360p.m3u8
#EXT-X-STREAM-INF: BANDWIDTH=3768872, AVERAGE-
BANDWIDTH=3721496, CODECS="avc1.4d401f,mp4a.40.5", RESOLUTION=1280x720, FRAME-
RATE=29.970
c9d0d0dc5b9839a78ba8f0a2531f05bc720p.m3u8

360p

```
#EXTM3U
#EXT-X-VERSION:3
#EXT-X-TARGETDURATION:13
#EXT-X-MEDIA-SEQUENCE:1
#EXT-X-PLAYLIST-TYPE:VOD
#EXTINF:12,
c9d0d0dc5b9839a78ba8f0a2531f05bc360p_00001.ts
#EXTINF:12,
c9d0d0dc5b9839a78ba8f0a2531f05bc360p_00002.ts
#EXTINF:12,
c9d0d0dc5b9839a78ba8f0a2531f05bc360p_00003.ts
#EXTINF:8,
c9d0d0dc5b9839a78ba8f0a2531f05bc360p_00004.ts
#EXT-X-ENDLIST
```

720p

```
#EXTM3U
#EXT-X-VERSION:3
#EXT-X-TARGETDURATION:13
#EXT-X-MEDIA-SEQUENCE:1
#EXT-X-PLAYLIST-TYPE:VOD
#EXTINF:12,
c9d0d0dc5b9839a78ba8f0a2531f05bc720p_00001.ts
#EXTINF:12,
c9d0d0dc5b9839a78ba8f0a2531f05bc720p_00002.ts
#EXTINF:12,
c9d0d0dc5b9839a78ba8f0a2531f05bc720p_00003.ts
#EXTINF:8,
c9d0d0dc5b9839a78ba8f0a2531f05bc720p_00004.ts
#EXT-X-ENDLIST
```

Moving Picture Experts Group Audio Layer

3 Uniform Resource Locator

PROTOCOL S⁴



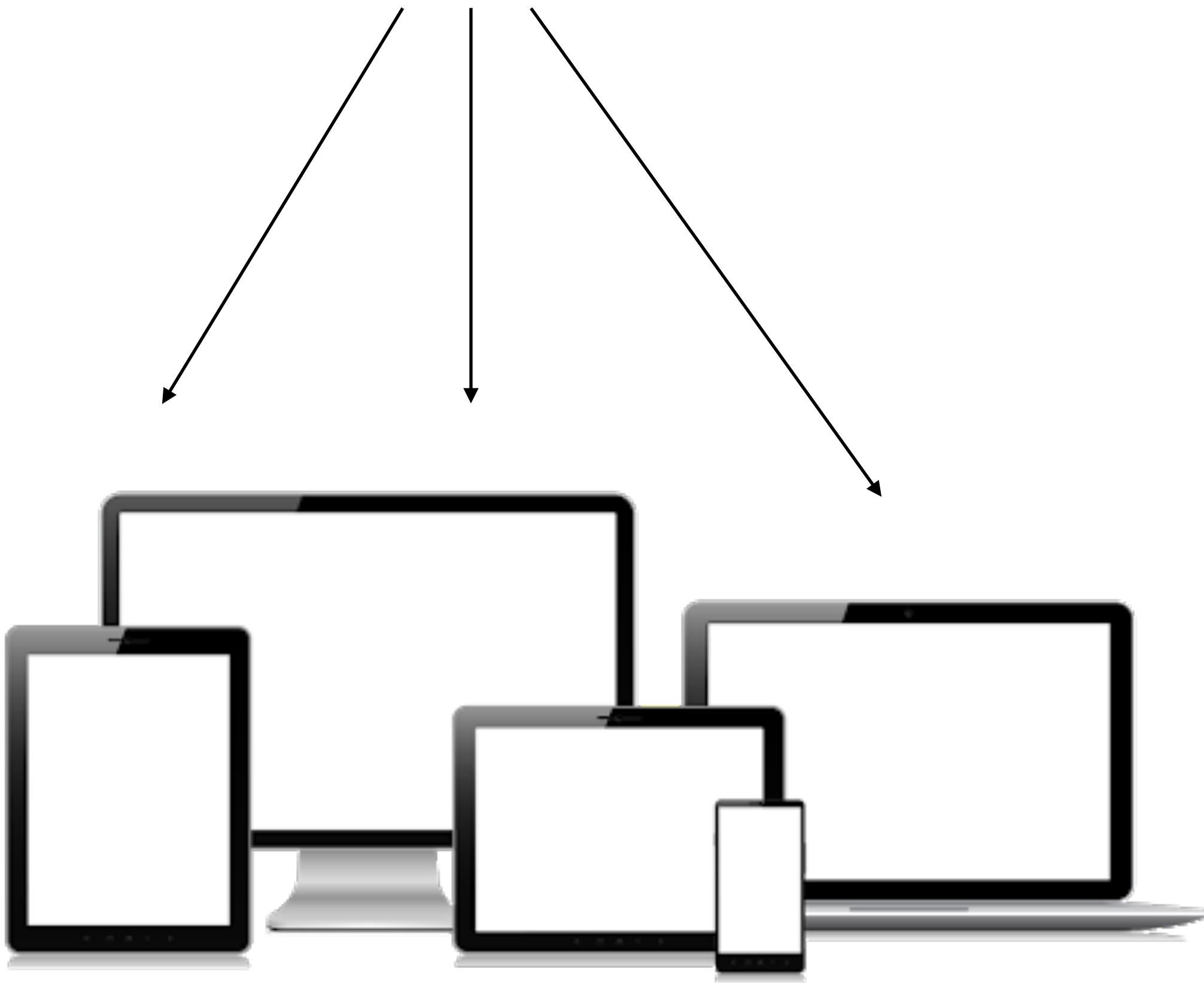
1996-2020

HLS

MPEG-DASH

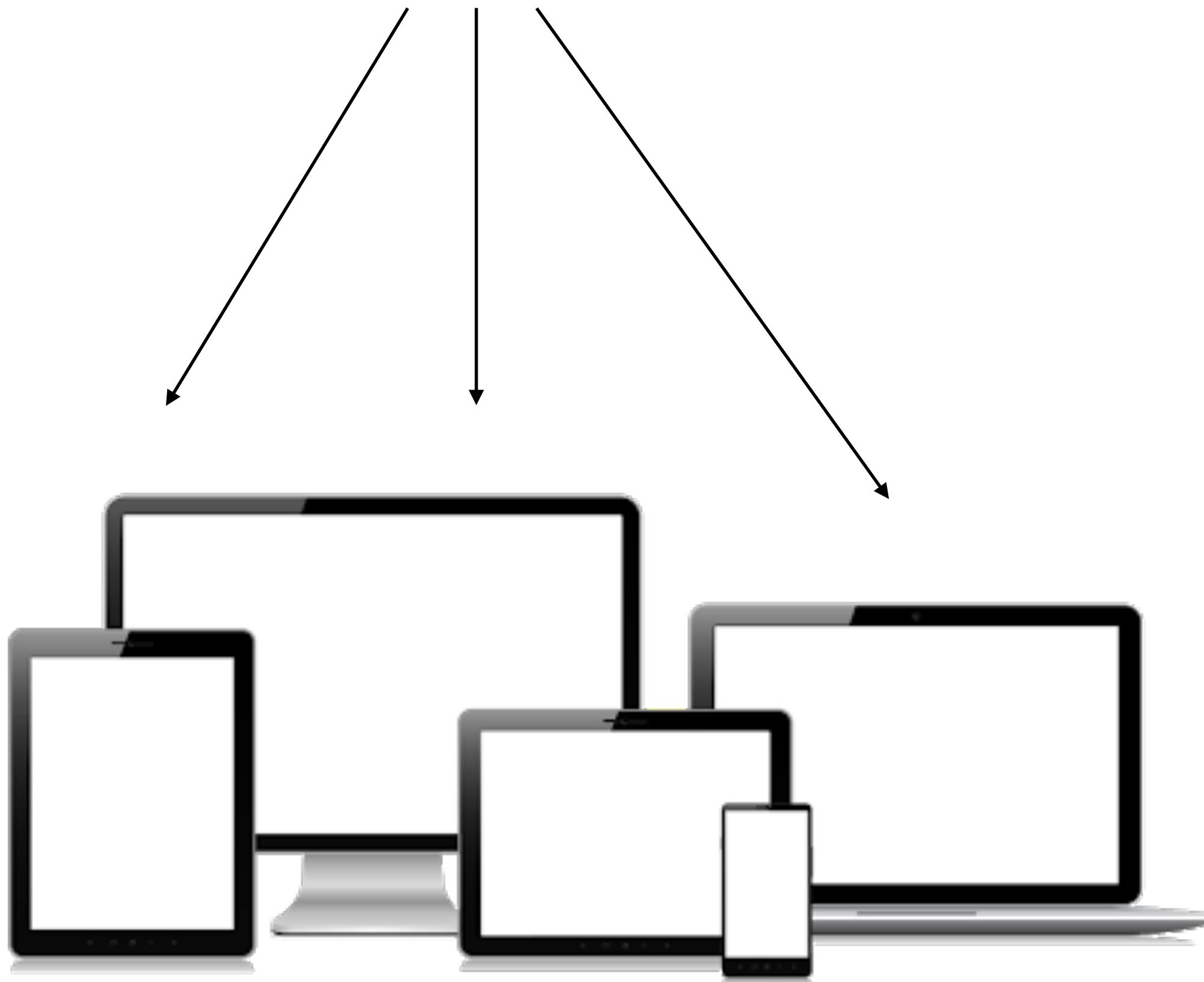


HLS





DASH



	Apple HLS	MPEG DASH
Video Codecs	H.264 + others (H.265)	H.264 + others (agnostic)
Audio Codecs	AAC, MP3	AAC + others (agnostic)
Package/Segment Format	MPEG-2 TS	MP4 Fragments + MPEG-2 TS
File storage on server	Individual file per segment (pre iOS 5.0)	Contiguous or individual files per segment
Audio/Video/Text packaging	Multiplexed in 1 segment(pre iOS 5.0)	Multiplexed or separate segments for audio, video
Playback	Apple iOS, Quick Time X	3GPP-Rel 9 or MPEG clients
Protection	AES-128 encryption	Flexible (e.g., OMA or UV)
Typical Segment Duration	10 sec	2 - 4 sec
DRM Solution	Unified (FairPlay)	Widevine (Google) & PlayReady (Microsoft)



05

TOOLS



FFmpeg

A complete, cross-platform
solution to record, convert and
stream audio and video



```
ffprobe video.mp4
```

```
ffmpeg -i video.mp4 \
```

```
ffmpeg -i video.mp4 \
-vf scale=w=1280:h=720:force_original_aspect_ratio=decrease \
```

```
ffmpeg -i video.mp4 \
-vf scale=w=1280:h=720:force_original_aspect_ratio=decrease \
-c:a aac -ar 48000 -b:a 128k \
```

```
ffmpeg -i video.mp4 \
-vf scale=w=1280:h=720:force_original_aspect_ratio=decrease \
-c:a aac -ar 48000 -b:a 128k \
-c:v h264 \
```

```
ffmpeg -i video.mp4 \
-vf scale=w=1280:h=720:force_original_aspect_ratio=decrease \
-c:a aac -ar 48000 -b:a 128k \
-c:v h264 \
-profile:v main \
```

```
ffmpeg -i video.mp4 \
-vf scale=w=1280:h=720:force_original_aspect_ratio=decrease \
-c:a aac -ar 48000 -b:a 128k \
-c:v h264 \
-profile:v main \
-crf 20 \
```

```
ffmpeg -i video.mp4 \
-vf scale=w=1280:h=720:force_original_aspect_ratio=decrease \
-c:a aac -ar 48000 -b:a 128k \
-c:v h264 \
-profile:v main \
-crf 20 \
-g 48 -keyint_min 48 \
```

```
ffmpeg -i video.mp4 \
-vf scale=w=1280:h=720:force_original_aspect_ratio=decrease \
-c:a aac -ar 48000 -b:a 128k \
-c:v h264 \
-profile:v main \
-crf 20 \
-g 48 -keyint_min 48 \
-sc_threshold 0 \
```

```
ffmpeg -i video.mp4 \
-vf scale=w=1280:h=720:force_original_aspect_ratio=decrease \
-c:a aac -ar 48000 -b:a 128k \
-c:v h264 \
-profile:v main \
-crf 20 \
-g 48 -keyint_min 48 \
-sc_threshold 0 \
-b:v 2500k -maxrate 3200k -bufsize 3750k \
```

```
ffmpeg -i video.mp4 \
-vf scale=w=1280:h=720:force_original_aspect_ratio=decrease \
-c:a aac -ar 48000 -b:a 128k \
-c:v h264 \
-profile:v main \
-crf 20 \
-g 48 -keyint_min 48 \
-sc_threshold 0 \
-b:v 2500k -maxrate 2675k -bufsize 3750k \
-hls_time 6 \
```

```
ffmpeg -i video.mp4 \
-vf scale=w=1280:h=720:force_original_aspect_ratio=decrease \
-c:a aac -ar 48000 -b:a 128k \
-c:v h264 \
-profile:v main \
-crf 20 \
-g 48 -keyint_min 48 \
-sc_threshold 0 \
-b:v 2500k -maxrate 2675k -bufsize 3750k \
-hls_time 6 \
-hls_playlist_type vod \
```

```
ffmpeg -i video.mp4 \
-vf scale=w=1280:h=720:force_original_aspect_ratio=decrease \
-c:a aac -ar 48000 -b:a 128k \
-c:v h264 \
-profile:v main \
-crf 20 \
-g 48 -keyint_min 48 \
-sc_threshold 0 \
-b:v 2500k -maxrate 2675k -bufsize 3750k \
-hls_time 6 \
-hls_playlist_type vod \
-hls_segment_filename video/720p_%03d.ts video/720p.m3u8
```

```
ffmpeg -i video.mp4 \
-vf scale=w=1280:h=720:force_original_aspect_ratio=decrease \
-c:a aac -ar 48000 -b:a 128k \
-c:v h264 \
-profile:v main \
-crf 20 \
-g 48 -keyint_min 48 \
-sc_threshold 0 \
-b:v 2500k -maxrate 2675k -bufsize 3750k \
-hls_time 6 \
-hls_playlist_type vod \
-hls_segment_filename video/720p_%03d.ts video/720p.m3u8 \
-vf scale=w=1920:h=1080:force_original_aspect_ratio=decrease
-c:a aac -ar 96000 -b:a 192k \
-c:v h264 \
-profile:v main \
.
.
.
```

#EXTM3U
#EXT-X-VERSION:3
#EXT-X-STREAM-INF: BANDWIDTH=800000, RESOLUTION=640x360
360p.m3u8
#EXT-X-STREAM-INF: BANDWIDTH=1400000, RESOLUTION=842x480
480p.m3u8
#EXT-X-STREAM-INF: BANDWIDTH=2800000, RESOLUTION=1280x720
720p.m3u8
#EXT-X-STREAM-INF: BANDWIDTH=5000000, RESOLUTION=1920x1080
1080p.m3u8

ALTERNATIVE?



FFmpeg

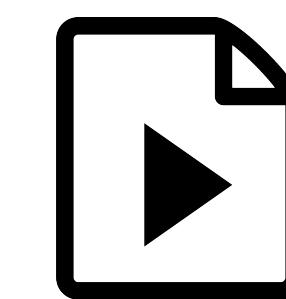
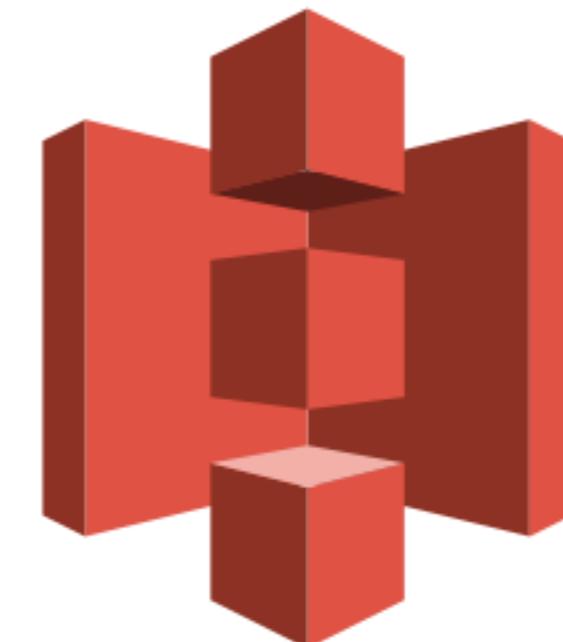
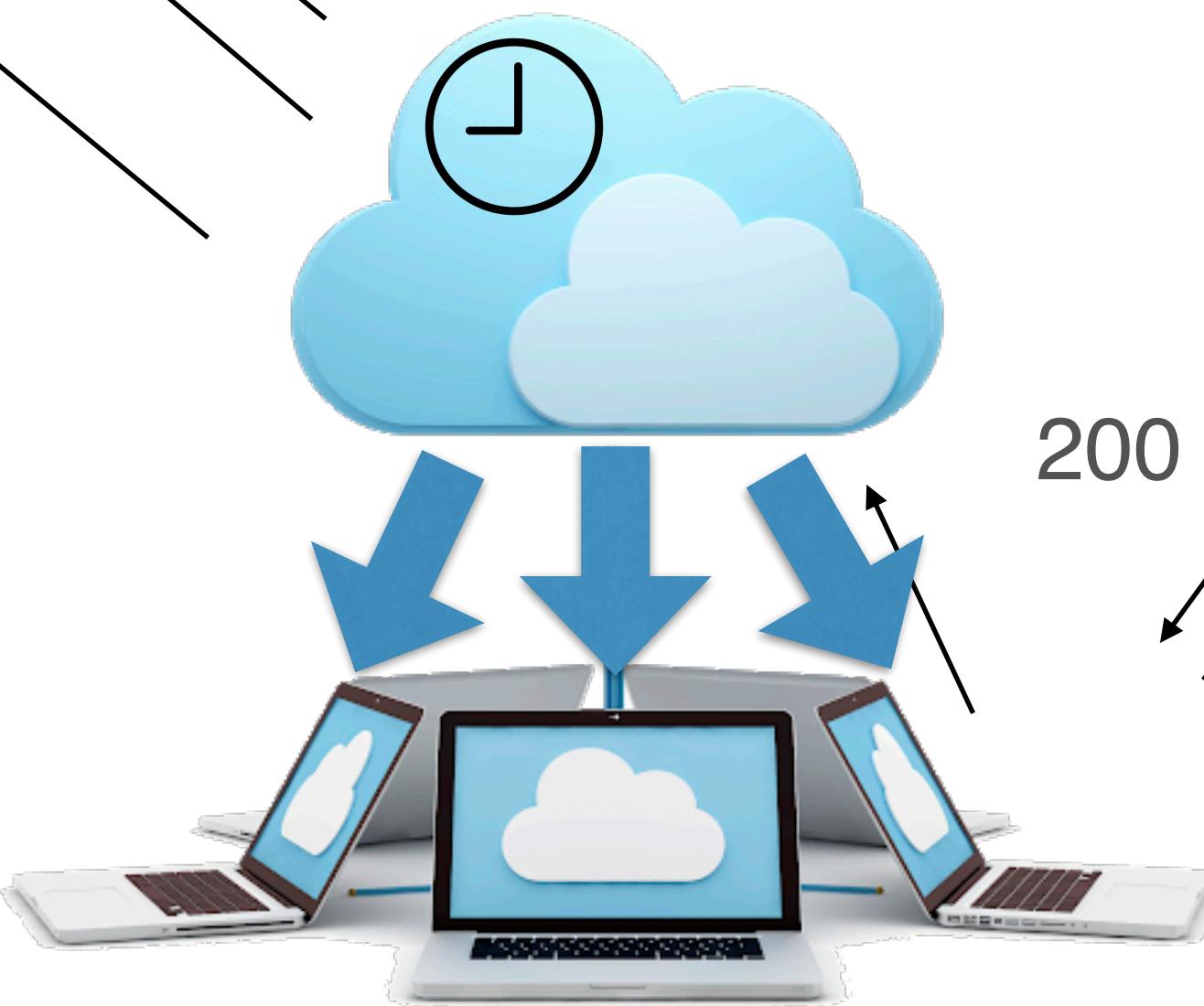


AWS
Media Convert

- ❑ **c9d0d0dc5b9839a78ba8f0a2531f05bc.m3u8**
- ❑ c9d0d0dc5b9839a78ba8f0a2531f05bc360p.m3u8
- ❑ c9d0d0dc5b9839a78ba8f0a2531f05bc360p_00001.ts
- ❑ c9d0d0dc5b9839a78ba8f0a2531f05bc360p_00002.ts
- ❑ c9d0d0dc5b9839a78ba8f0a2531f05bc360p_00003.ts
- ❑ c9d0d0dc5b9839a78ba8f0a2531f05bc360p_00004.ts
- ❑ c9d0d0dc5b9839a78ba8f0a2531f05bc720p.m3u8
- ❑ c9d0d0dc5b9839a78ba8f0a2531f05bc720p_00001.ts
- ❑ c9d0d0dc5b9839a78ba8f0a2531f05bc720p_00002.ts
- ❑ c9d0d0dc5b9839a78ba8f0a2531f05bc720p_00003.ts
- ❑ c9d0d0dc5b9839a78ba8f0a2531f05bc720p_00004.ts



S3 video url
+
S3 output folder path
+
conversion params





JUST-IN-TIME
PACKAGING

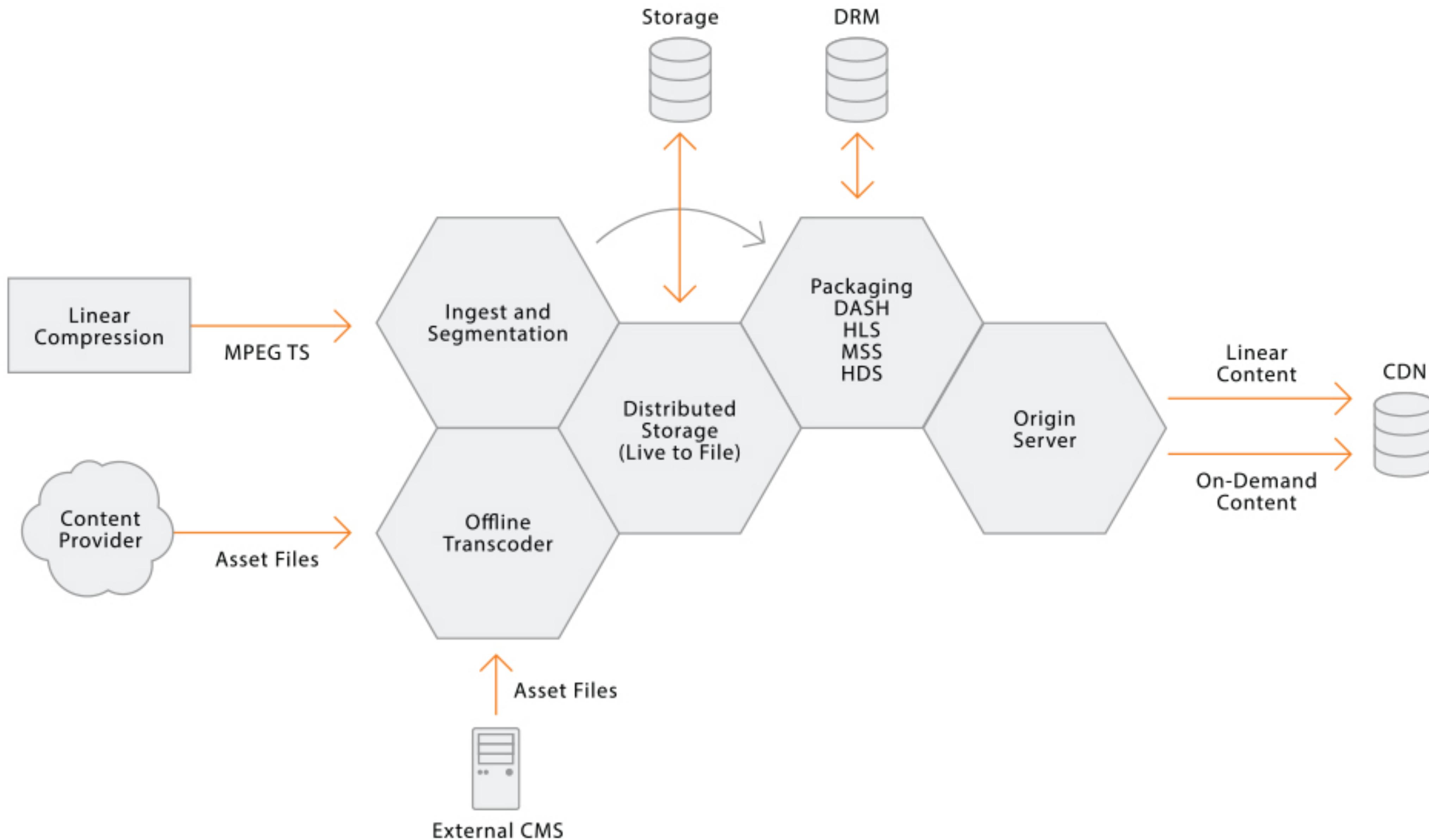
JUST-IN-TIME PACKAGING

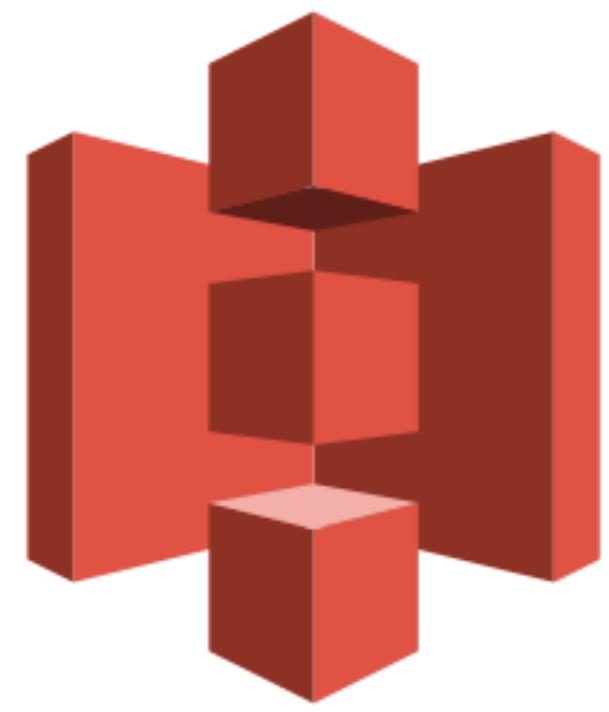
DRM
Encryption

Packaging

Stream Selection

Manifest Changes





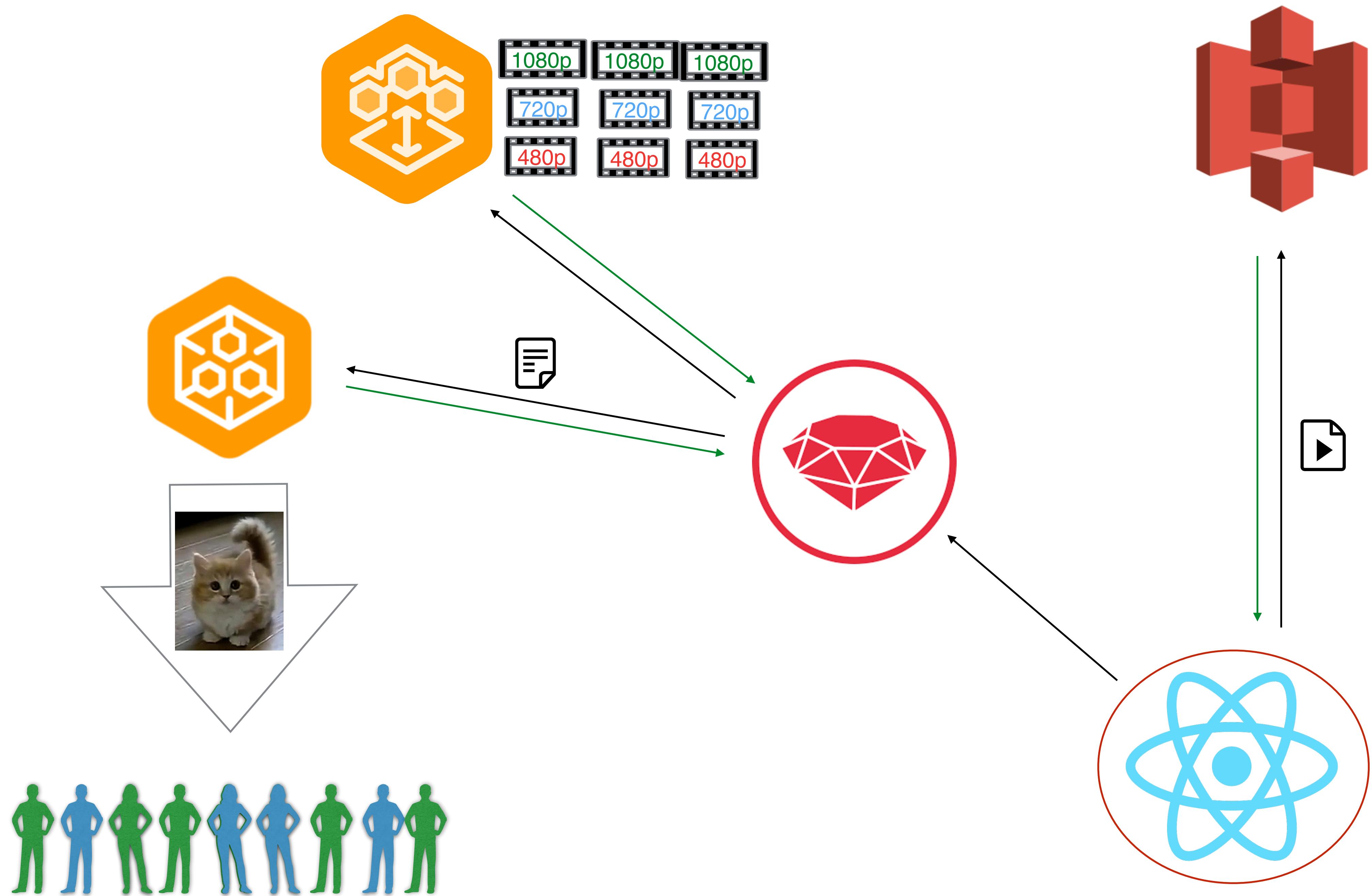
S3



Media Convert



Media Package



REFERENCES

- <https://www.ibc.org/delivery/codec-wars-the-battle-between-hevc-and-av1/2710.article>
- <https://www.wowza.com/blog/video-codecs-encoding>
- [https://www.streamingmedia.com/Articles/Editorial/What-Is-.../What-Is-HLS-\(HTTP-Live-Streaming\)-78221.aspx](https://www.streamingmedia.com/Articles/Editorial/What-Is-.../What-Is-HLS-(HTTP-Live-Streaming)-78221.aspx)
- <https://www.apple.com/hotnews/thoughts-on-flash/>
- <https://anevia.com/glossary-ott-getting-jargon-right>
- <https://www.youtube.com/watch?v=z1m9NadpGAg>
- <https://aws.amazon.com/mediapackage/faqs/>
- <https://docs.aws.amazon.com/mediapackage/>
- <https://docs.aws.amazon.com/mediapackage/latest/ug/what-is-terms.html>



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