Dynamic Adaptive Streaming over HTTP

Overview, State of the Art, and Challenges

Mobile Multimedia Computing @ IEEE ICME 2017, Hong Kong, Jul 14, 2017

Priv.-Doz. Dr. Christian Timmerer

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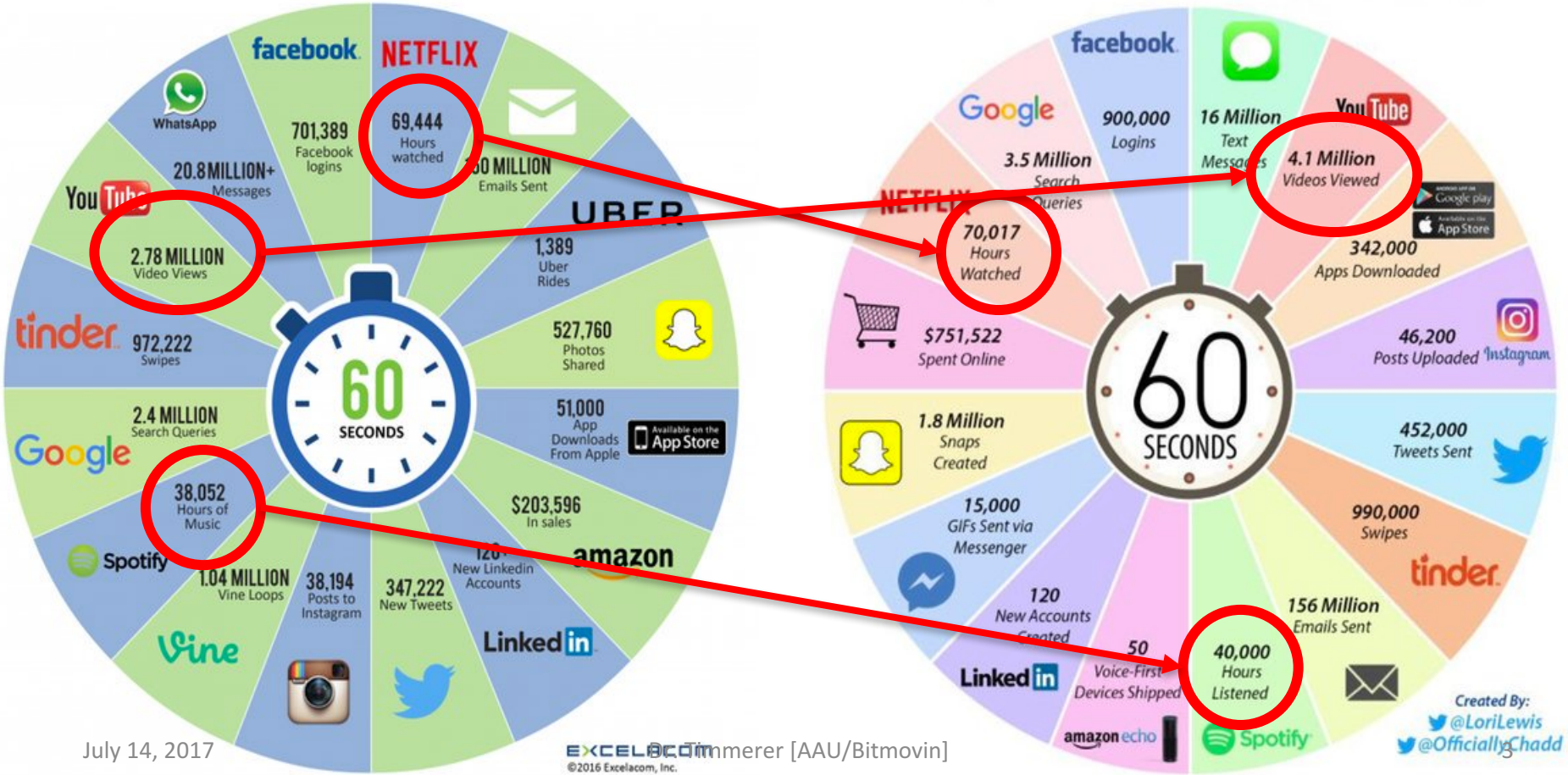
Change Log:
- EBU/ASBU Week of Technology, Tunis, Oct 19, 2016
- TU Wien, Vienna, Feb 9, 2017
- TNC17, Linz, May 30, 2017
- MMC, IEEE ICME'17, Hong Kong, Jul 14, 2017

ACM MMSys 2018 CfP is Out!

- City: Amsterdam
- Dates: June 12-15, 2018
- Co-located with
  - NOSSDAV
  - MoVid
  - MMVE
- http://www.mmsys2018.org/


2016 What happens in an INTERNET MINUTE?
facebook
NETFLIX
WhatsApp
701,389 Facebook logins
69,444 Hours watched
20.8 MILLION+ Messages
Emails Sent
YouTube
2.78 MILLION Video Views
UBER
1,389 Uber Rides
tinder
972,222 Swipes
527,760 Photos Shared
60 SECONDS
2.4 MILLION Search Queries
Google
51,000 App Downloads From Apple
Available on the App Store
38,052 Hours of Music
$203,596 In sales
Spotify
1.04 MILLION Vine Loops
38,194 Posts to Instagram
347,222 New Tweets
New Linkedin Accounts
amazon
Vine
LinkedIn
2017 This Is What Happens In An Internet Minute
facebook
900,000 Logins
Google
3.5 Million Search Queries
16 Million Text Messages
YouTube
4.1 Million Videos Viewed
NETFLIX
70,017 Hours Watched
Google play
App Store
342,000 Apps Downloaded
$751,522 Spent Online
46,200 Posts Uploaded
Instagram
60 SECONDS
1.8 Million Snaps Created
452,000 Tweets Sent
990,000 Swipes
15,000 GIFs Sent via Messenger
tinder
120 New Accounts Created
156 Million Emails Sent
50 Voice-First Devices Shipped
40,000 Hours Listened
LinkedIn
amazon echo
Spotify
Created By:
@LoriLewis
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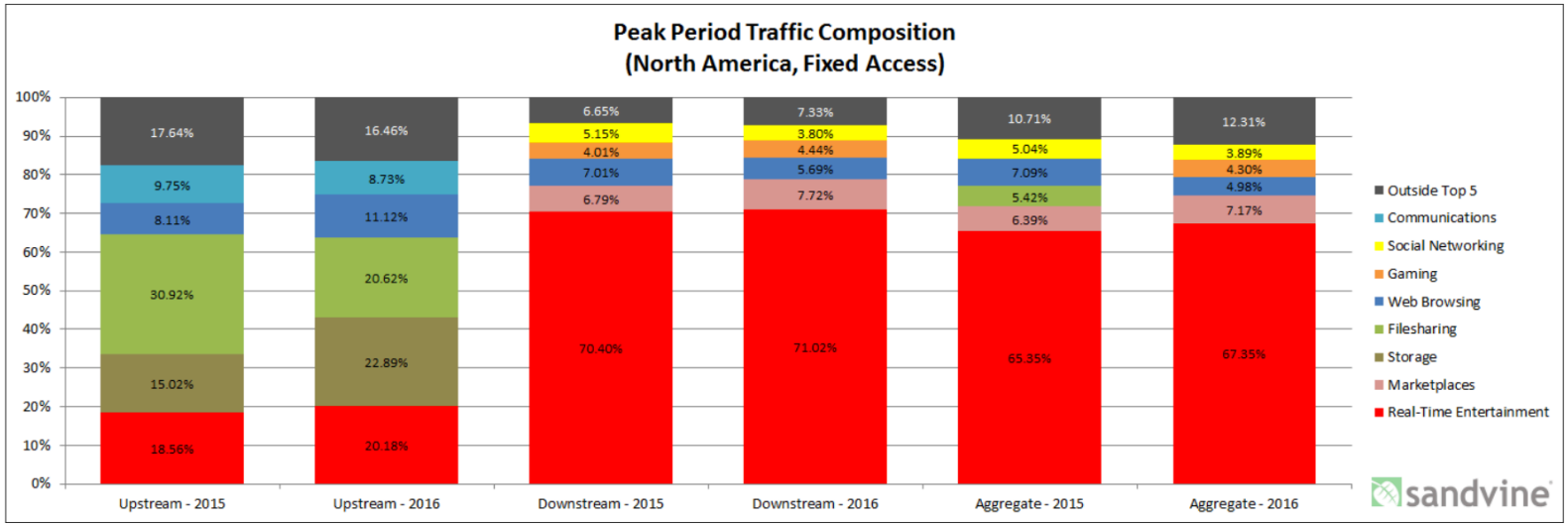
Importance of Multimedia Delivery

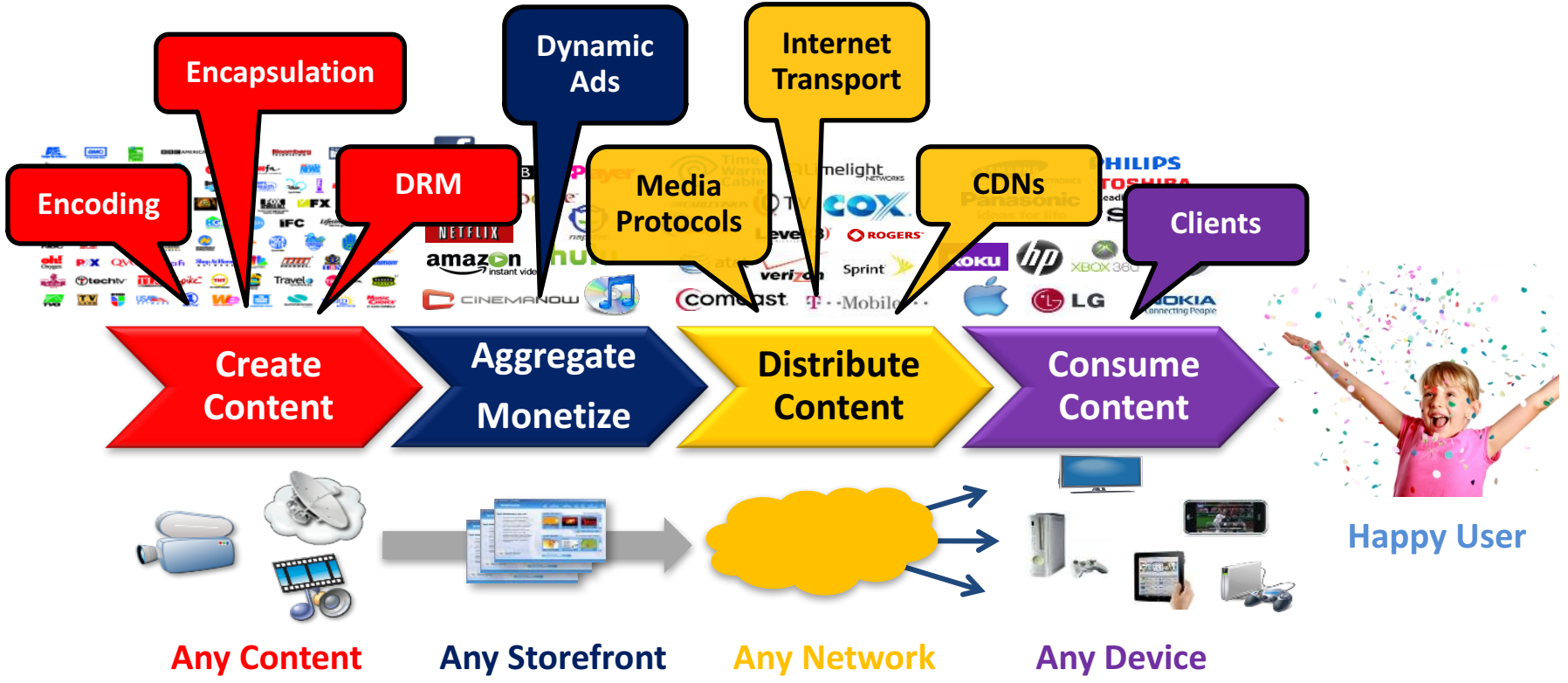


- Multimedia is predominant on the Internet

Global Internet Phenomena Report: 2016

- Real-time entertainment: Streaming video and audio; >70% of Internet traffic at peak periods
- Popular services: YouTube (17.53%), Netflix (35.15%), Amazon Video (4.26%), Hulu (2.68%); all delivered over-the-top (OTT); huge potential for mobile access!

Open Digital Media Value Chain



1 Source

The input files can start from a variety of sources such as AWS S3, Google Cloud Storage of FT/SFTP

amazon web services
AWS S3

Google
Google Cloud Storage

FTP & SFTP
FTP/SFTP

2 Encoding

Source files encoded into adaptive streaming formats e.g. MPEG-DASH and HLS

3 Storage

Files are stored on the Bitmovin storage which could be used as an origin for your CDN

4 CDN

Global delivery of your video files to provide the best possible quality

5 HTML5 Playback

HMTL5 playback of HLS and MPEG-DASH in any browser and any device

VR - 360°

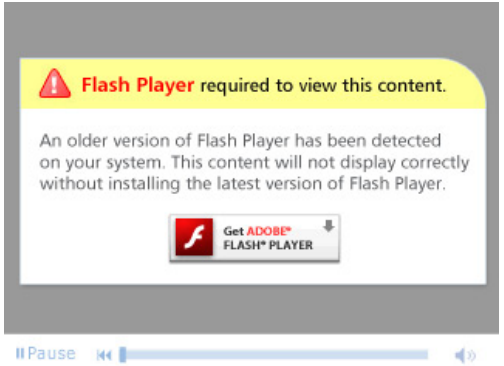
6 Analytics

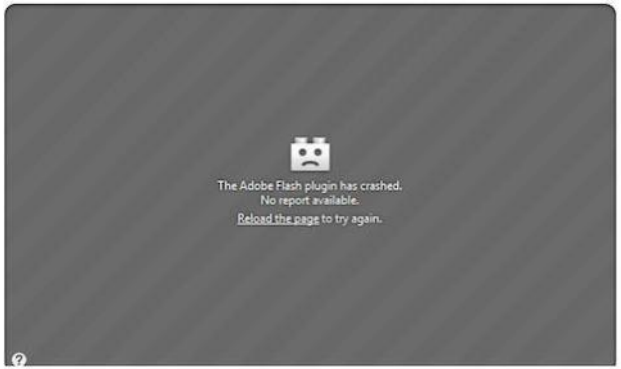
Monitoring and reporting helps to quickly identify problems and improve user experience

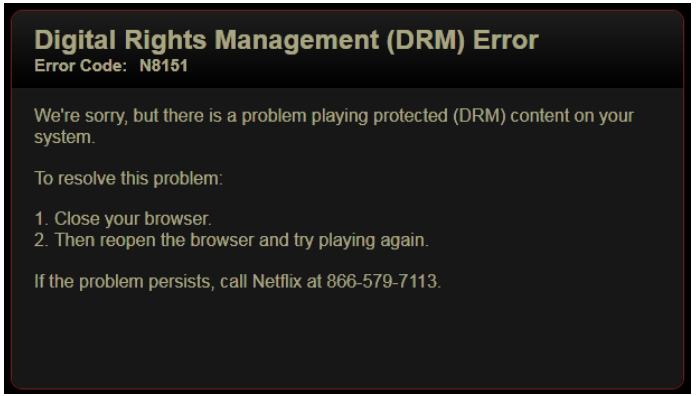
BITMOVIN

Common Annoyances in Streaming

- Wrong format
- Wrong protocol
- Plugin requirements
- DRM issues
- Long start-up delay
- Poor quality
- Frequent stalls
- Quality oscillations
- No seeking features







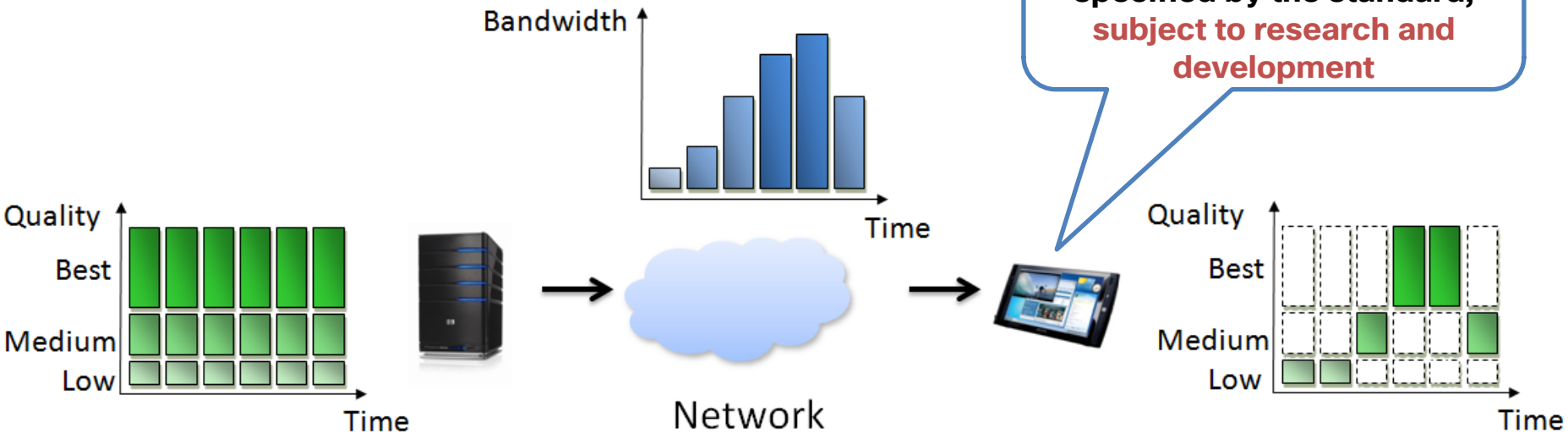
What is DASH?

DASH
UNIVERSALWASCHMITTEL

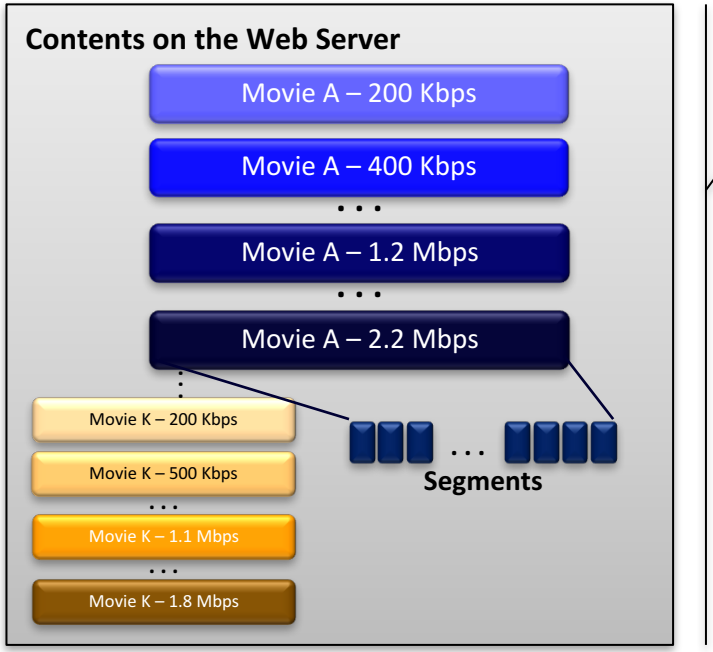
Reading: http://en.wikipedia.org/wiki/Dash_(disambiguation)

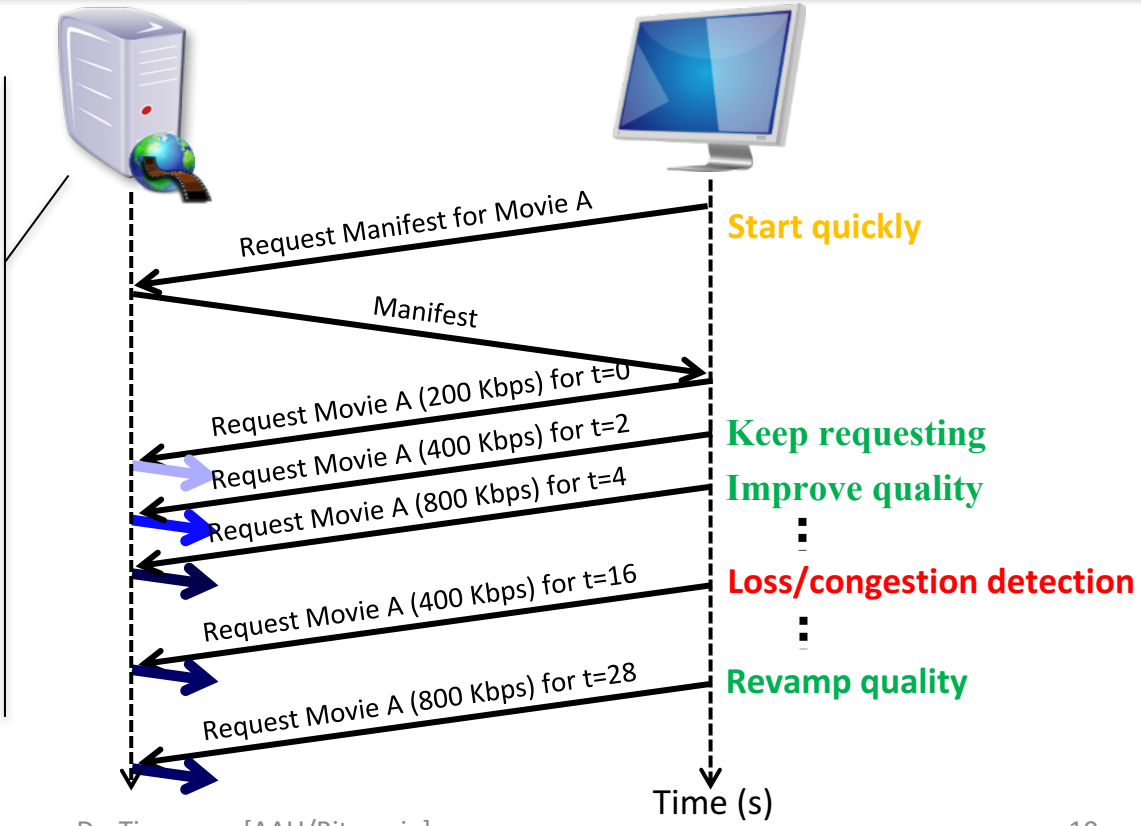
Over-The-Top – Adaptive Media Streaming

- In a nutshell…

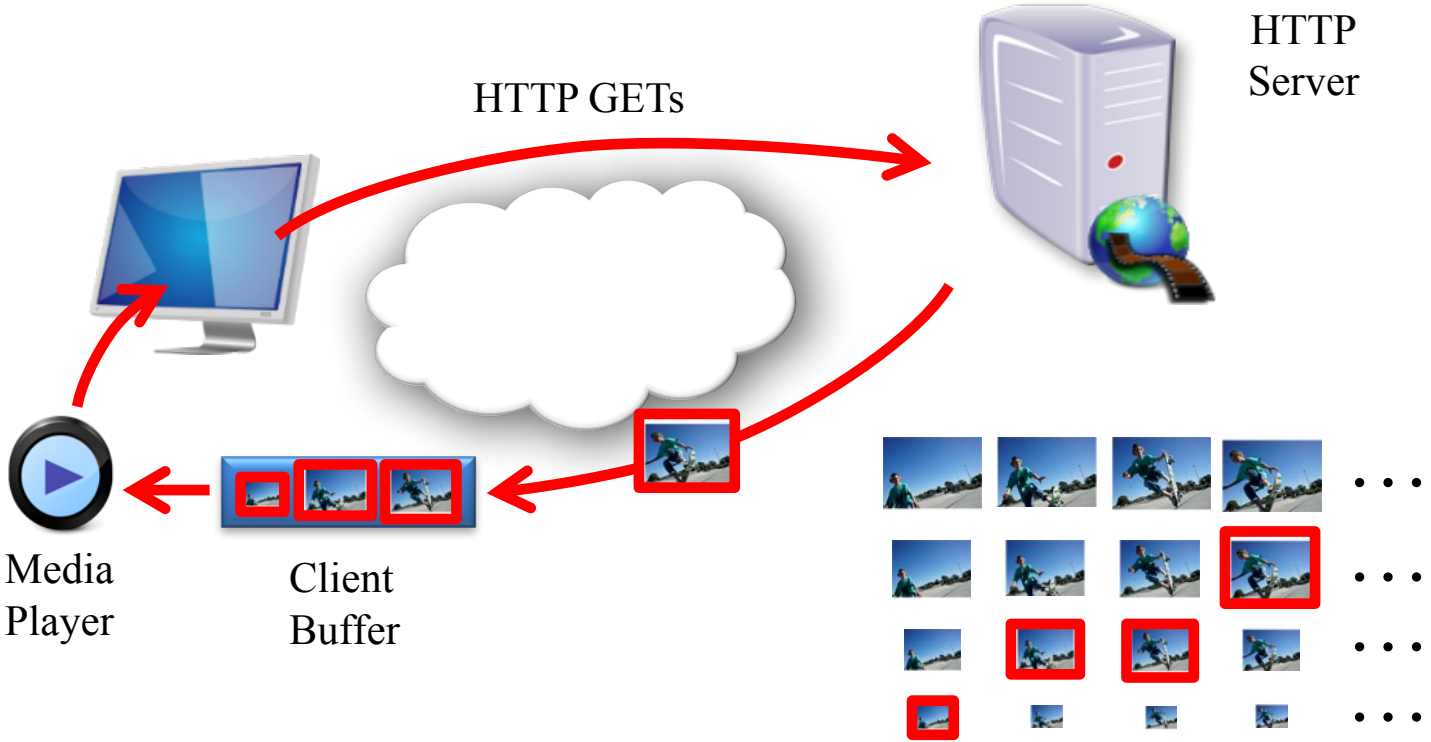


Multi-Bitrate Encoding and Representation Switching



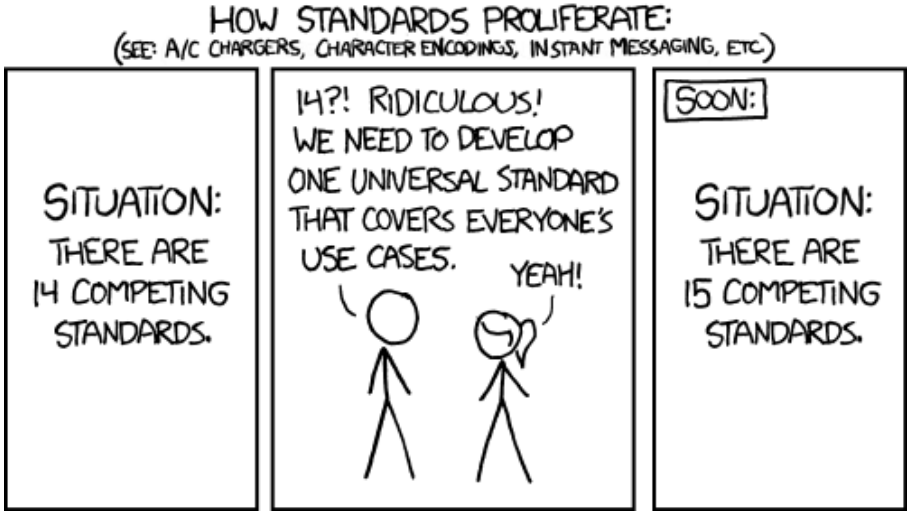


Adaptive Streaming over HTTP



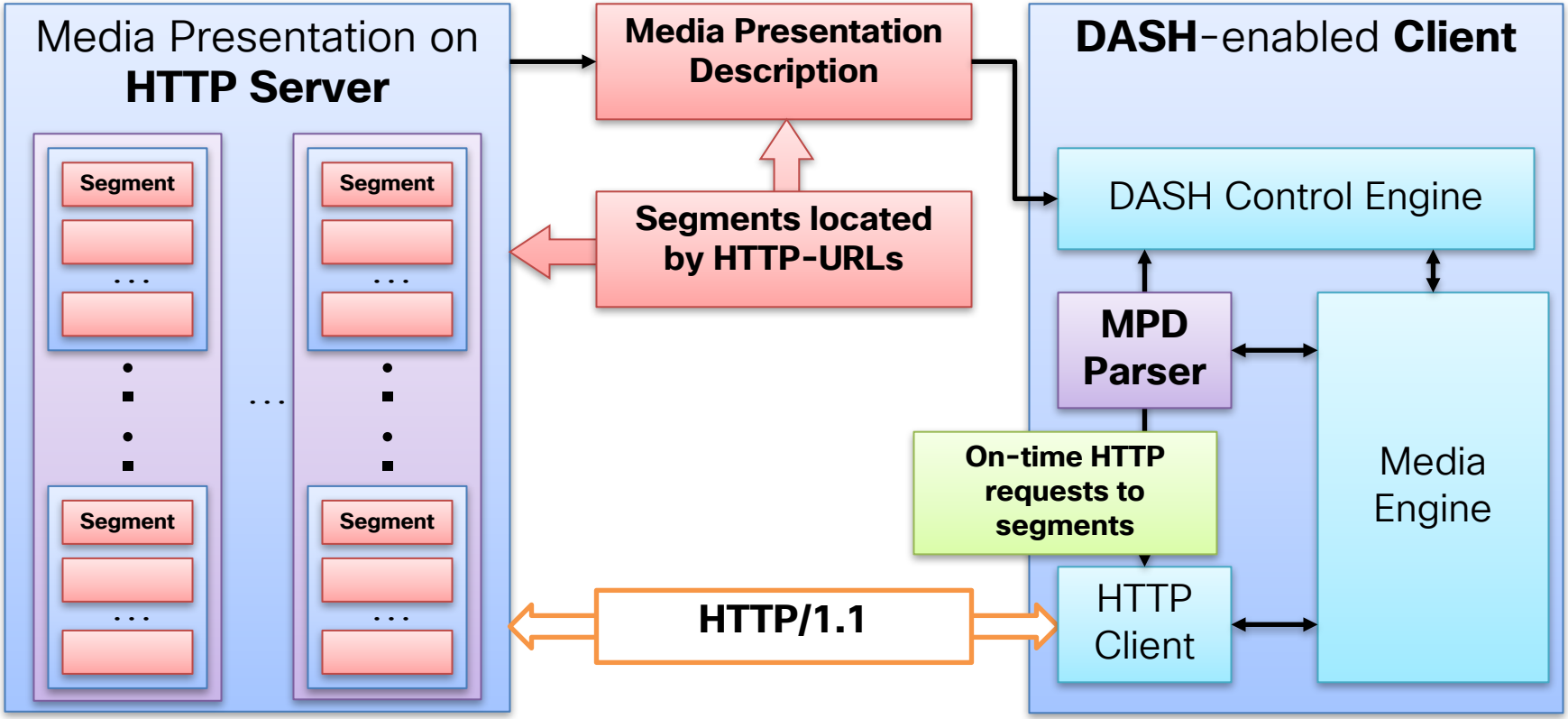
Formats and Standards

- Adobe
  - HTTP Dynamic Streaming (HDS)
  - Switched to DASH
- Apple
  - HTTP Live Streaming (HLS)
  - Required for iOS
- Microsoft
  - Smooth Streaming
  - Switched to DASH, almost..
- MPEG Dynamic Adaptive Streaming over HTTP (DASH)
  - Supported by Netflix, YouTube, Bitmovin, etc.
- MPEG Common Media Application Format (MPEG-A Part 19)
  - The new kid on the block – support for “fragmented mp4 in HLS”
  - DASH/HLS convergence at segment level – some open issues with encryption format

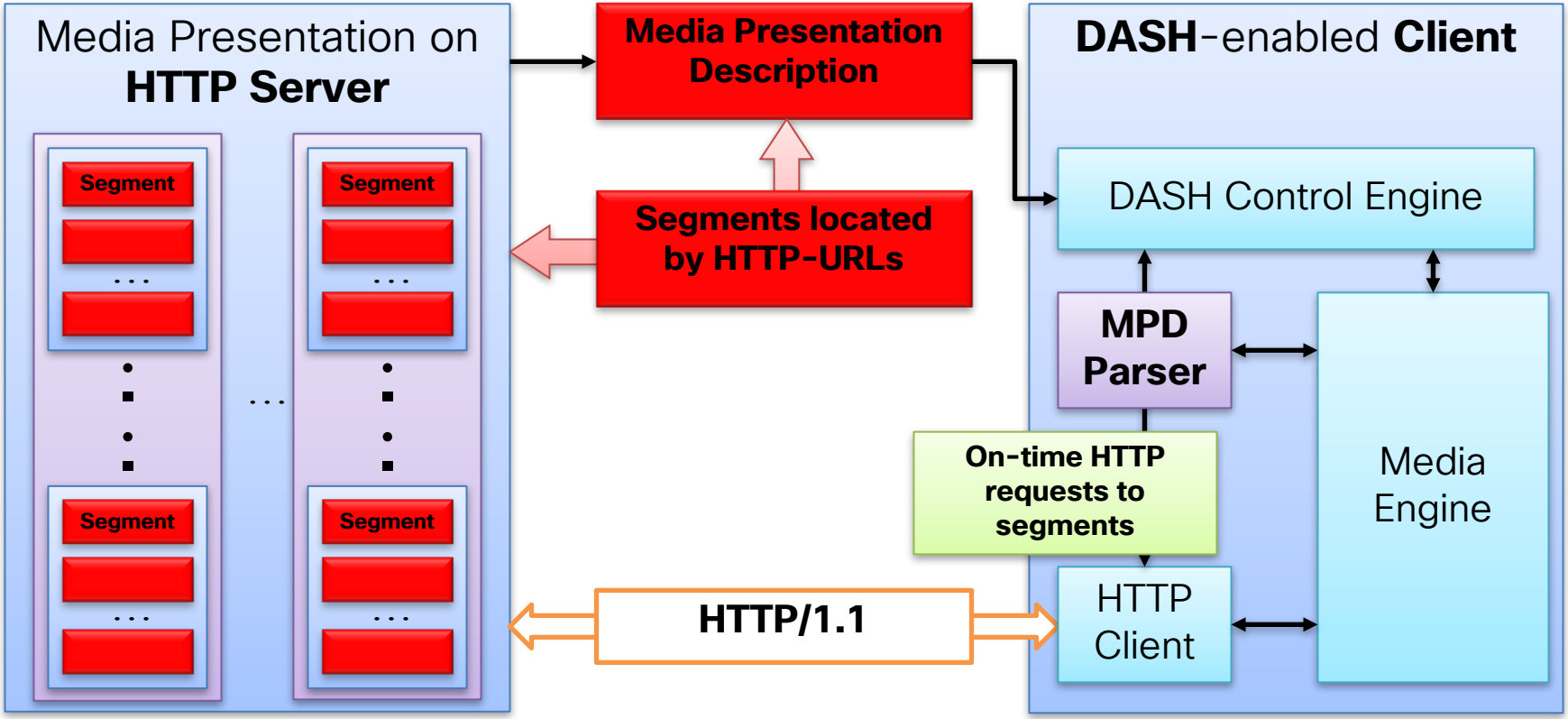


Source: http://xkcd.com/927/

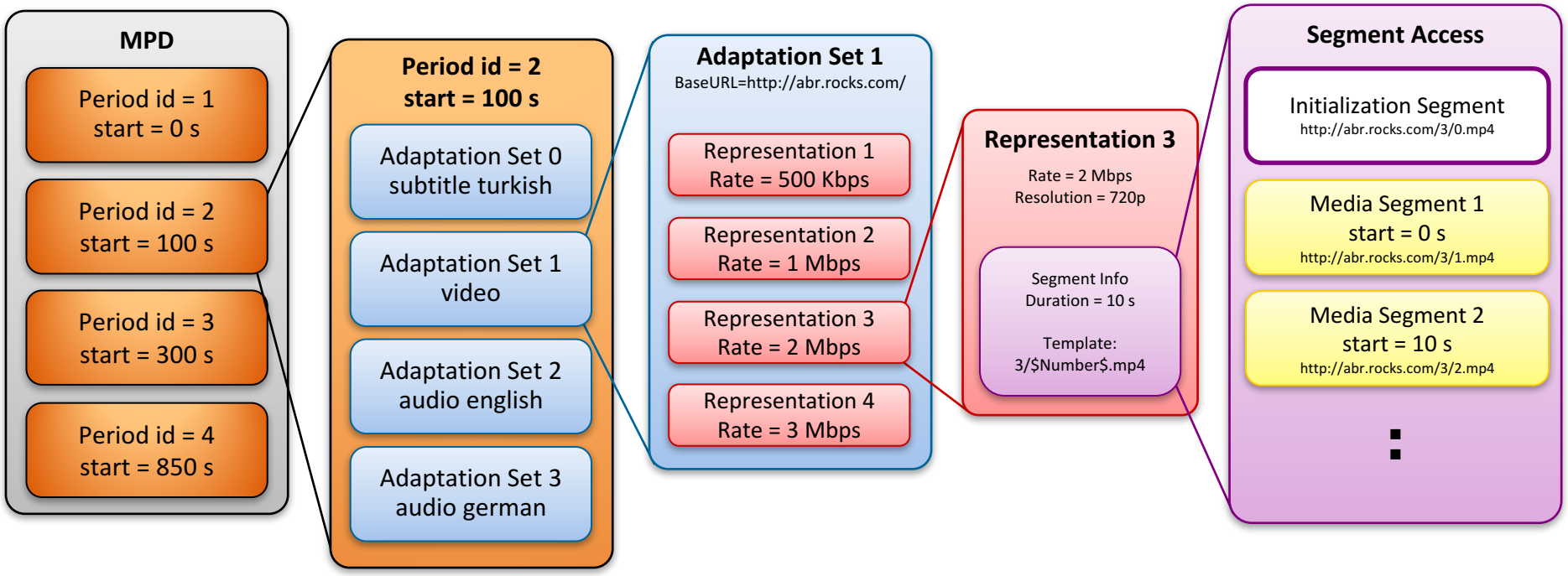
Scope of DASH: what is specified?



Scope of DASH: what is specified?



DASH Data Model



Splicing of arbitrary content like ads

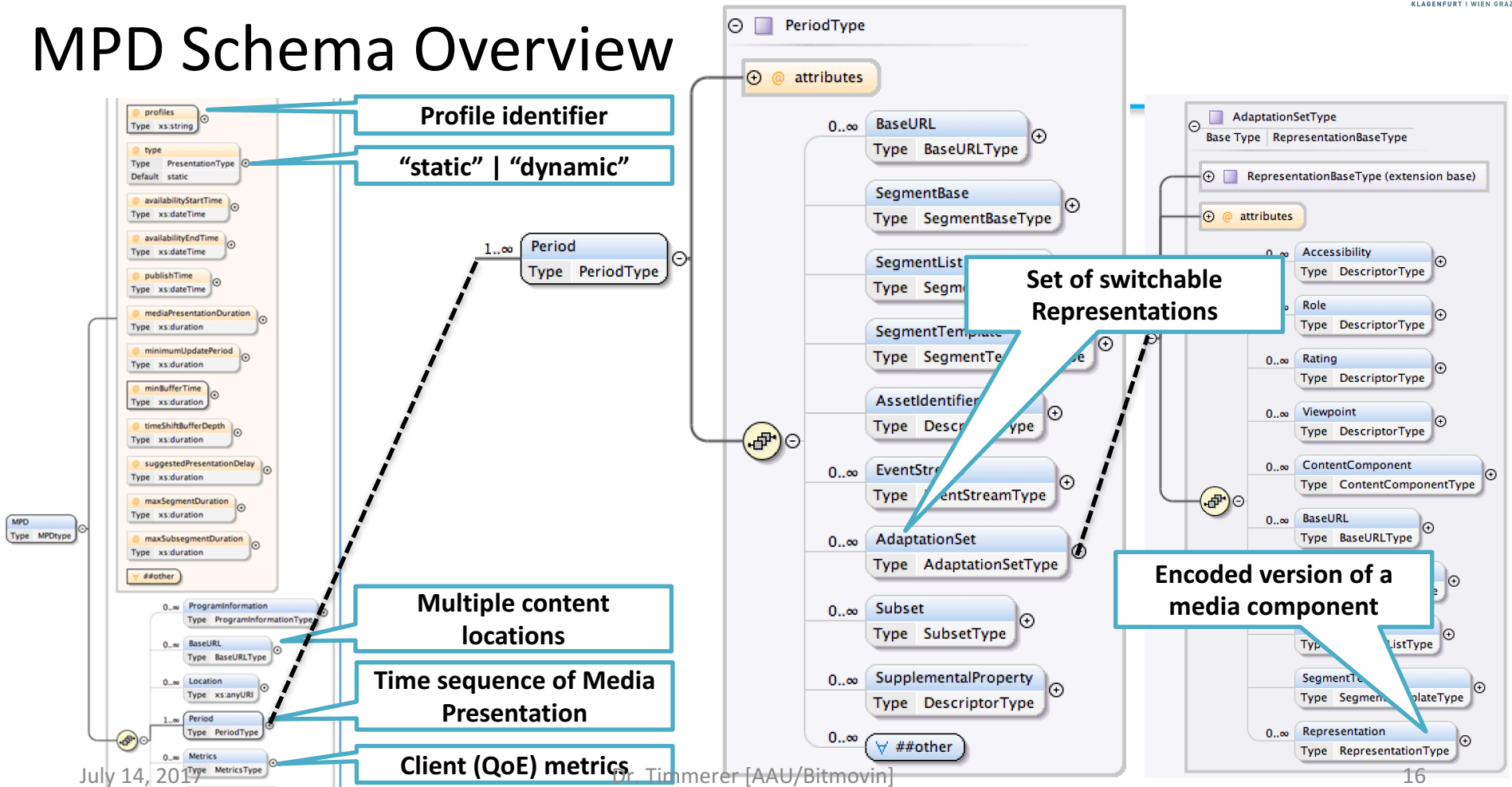
Selection of components/tracks

Selection of representations

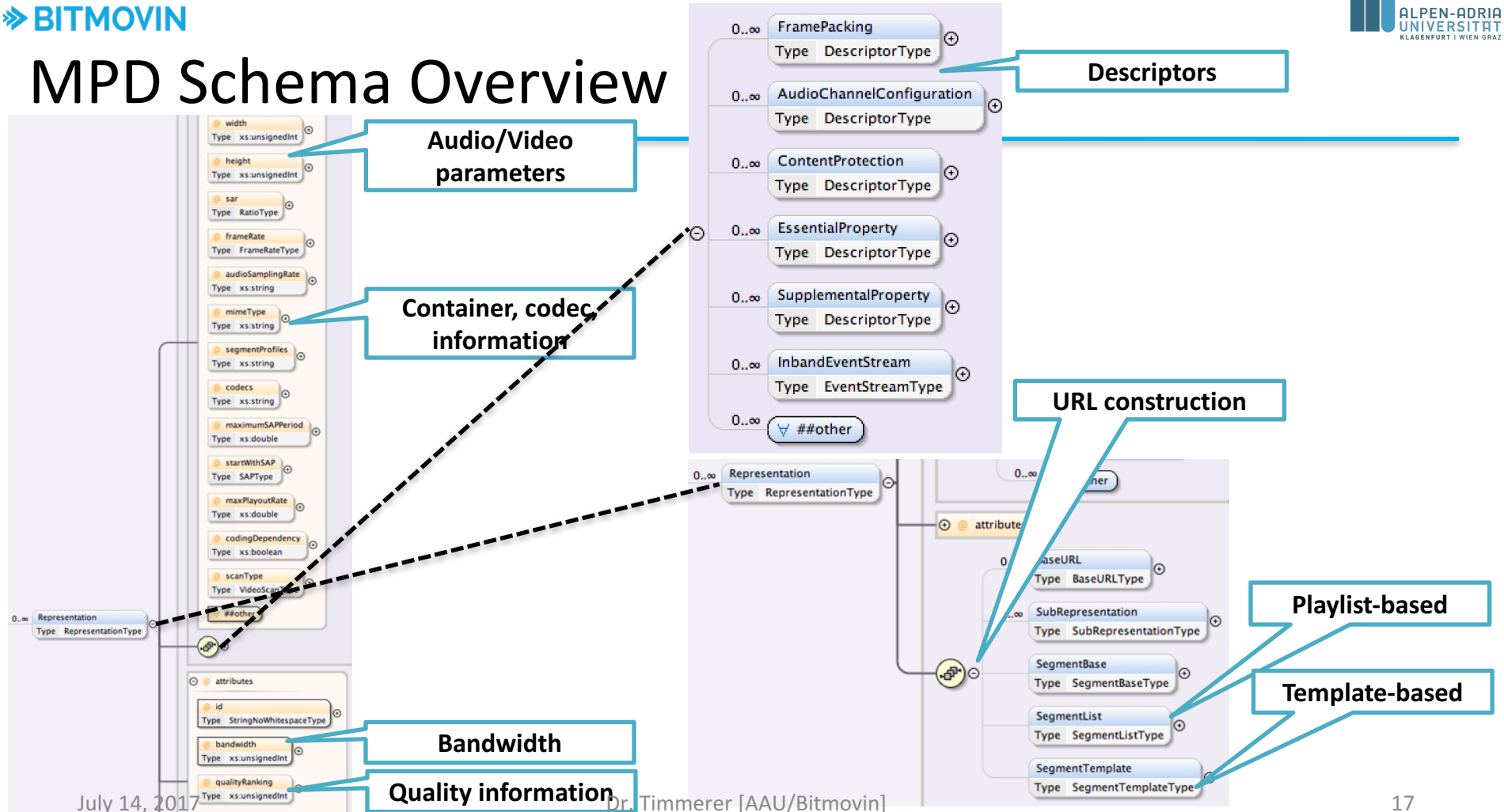
Well-defined media format

Chunks with addresses and timing

MPD Schema Overview



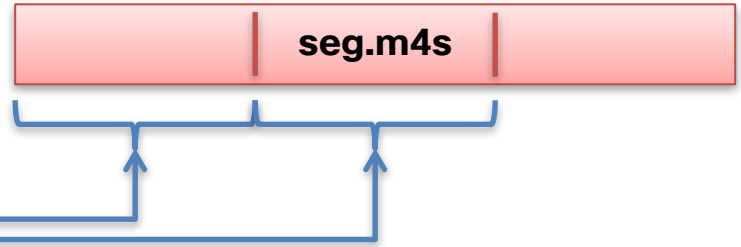
MPD Schema Overview



Segment Index in MPD only

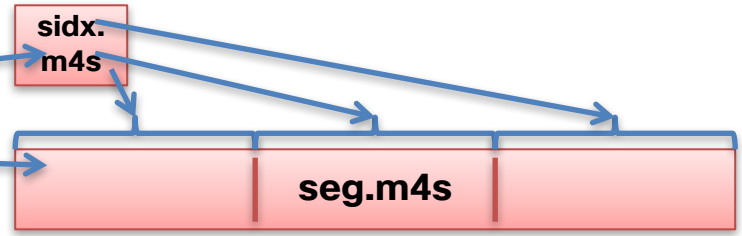
```
<MPD>
  ...
  <URL sourceURL="seg1.m4s"/>
  <URL sourceURL="seg2.m4s"/>
</MPD>
```


```
<MPD>
  ...
  <URL sourceURL="seg.m4s" range="0-499"/>
  <URL sourceURL="seg.m4s" range="500-999"/>
</MPD>
```



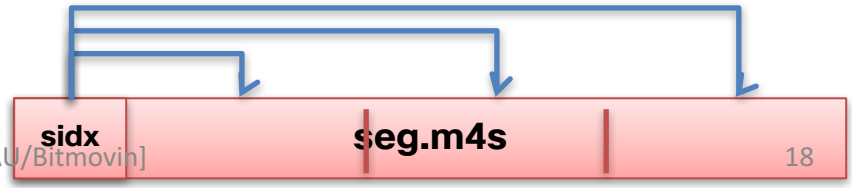
Segment Index in MPD + Segment

```
<MPD>
  ...
  <Index sourceURL="sidx.mp4"/>
  <URL sourceURL="seg.m4s"/>
</MPD>
```



Segment Index in Segment only

```
<MPD>
  ...
  <BaseURL>seg.m4s</BaseURL>
</MPD>
```




type=static typically, for on demand content
Base URL of the segments
Subtitles
Audio adaptation set with different representations (bw)
Video adaptation set with different representations (bw)
Different codecs (profiles)
Segment URL constructed with template and base URL

https://bitmovin.com/demo/

Custom Adaptation Logic

Bitmovin's customizable adaptation logic in action

HTML5 Video Thumbnail Seeking

Thumbnail Seeking is a must have for any video longer than a few minutes

HLS Supports Fragmented MP4

A demo of the Bitmovin Player streaming Fragmented MP4 in HLS

HLS & MPEG-DASH DRM Test

Interactive demo to test your DRM settings for your adaptive video stream

MPEG-DASH & HLS Player Test

Test your HLS, MPEG-DASH or progressive adaptive streams in HTML5 playback

Bitmovin Player goes Chromecast!

Streaming direct to Google's Chromecast from the Bitmovin Player!

Advertising using VAST, VPAID, IMA and VMAP Video Ads

VAST Video Ads for DASH and HLS in Bitmovin's HTML5 Player

HTML5 Adaptive Streaming Player Demo

The worlds most intelligent and intuitive HTML5 Adaptive Streaming Player

VR & 360° HTML5 Player

See the versatility of our Player in action with this VR/360° video demo.

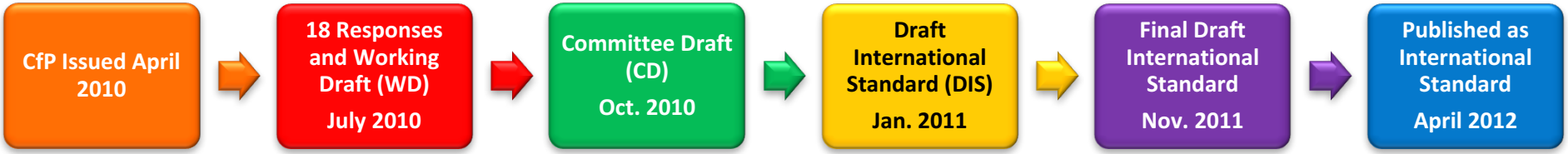
Adaption from SD to 1080 60 FPS

Smooth adaption from SD to 1080 60 FPS extremely high quality results.

Multi Language & Multi Audio

Switch between multiple audio and language options as the video plays.

ISO/IEC 23009-1 Timeline

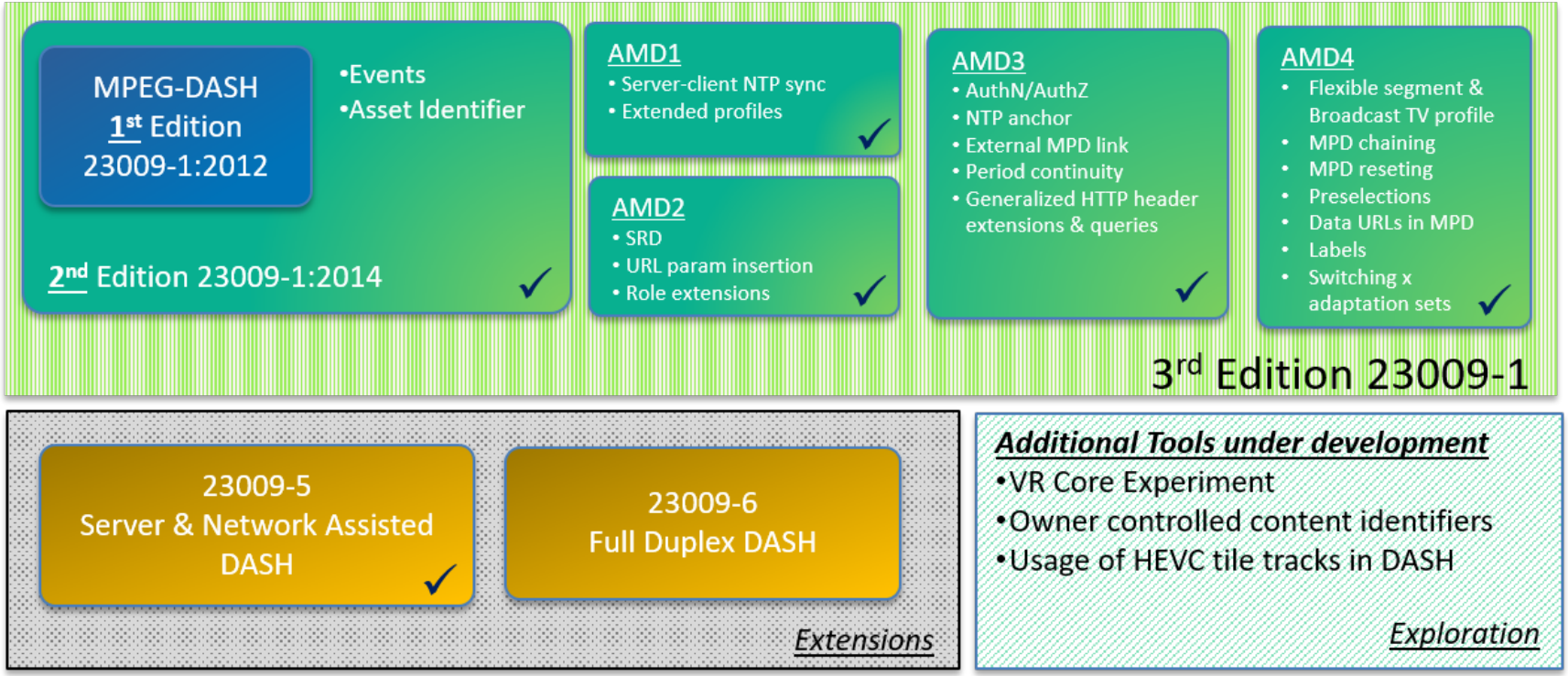


Fastest time ever that a standard was developed in MPEG to address the demand of the market

- **Other Relevant Specifications**
  - 14496-12: ISO Base Media File Format
  - 14496-15: Carriage of NAL unit structured video in the ISO Base Media File Format
  - 23001-7: Common encryption format for ISO base media file format
  - 23001-8: Coding-Independent Code Points
  - 23001-10: Carriage of Timed Metadata Metrics of Media in ISO Base Media File Format

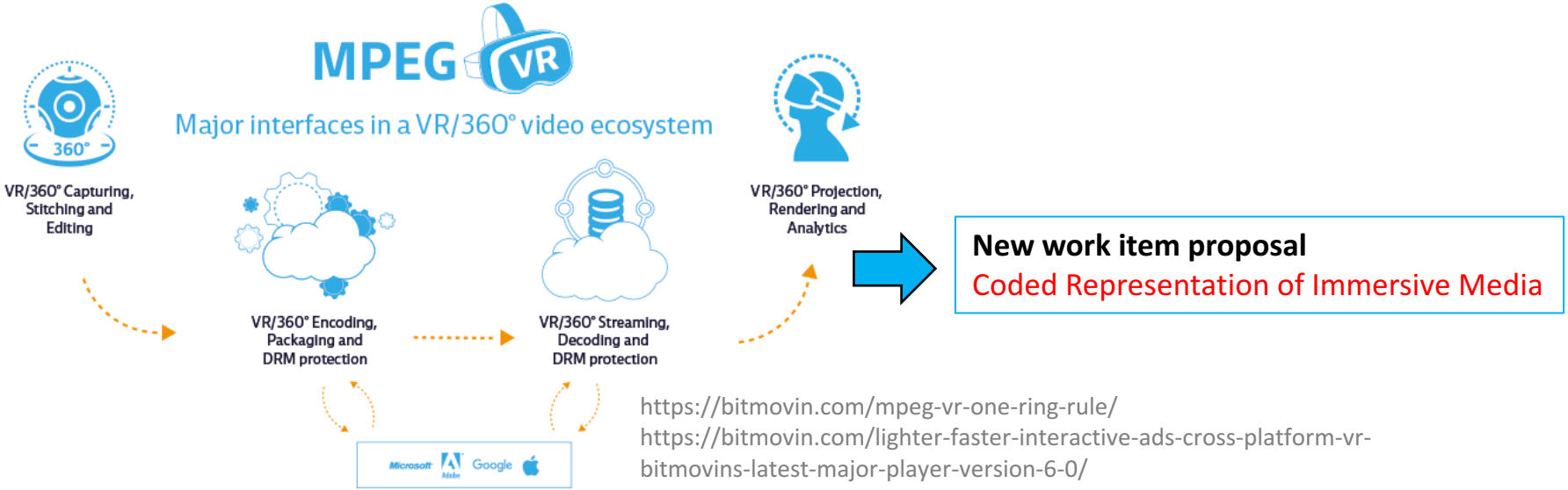
See also here https://multimediacommunication.blogspot.co.at/2010/05/http-streaming-of-mpeg-media.html

MPEG-DASH Features (Jan'17)



Ongoing Work in MPEG-DASH

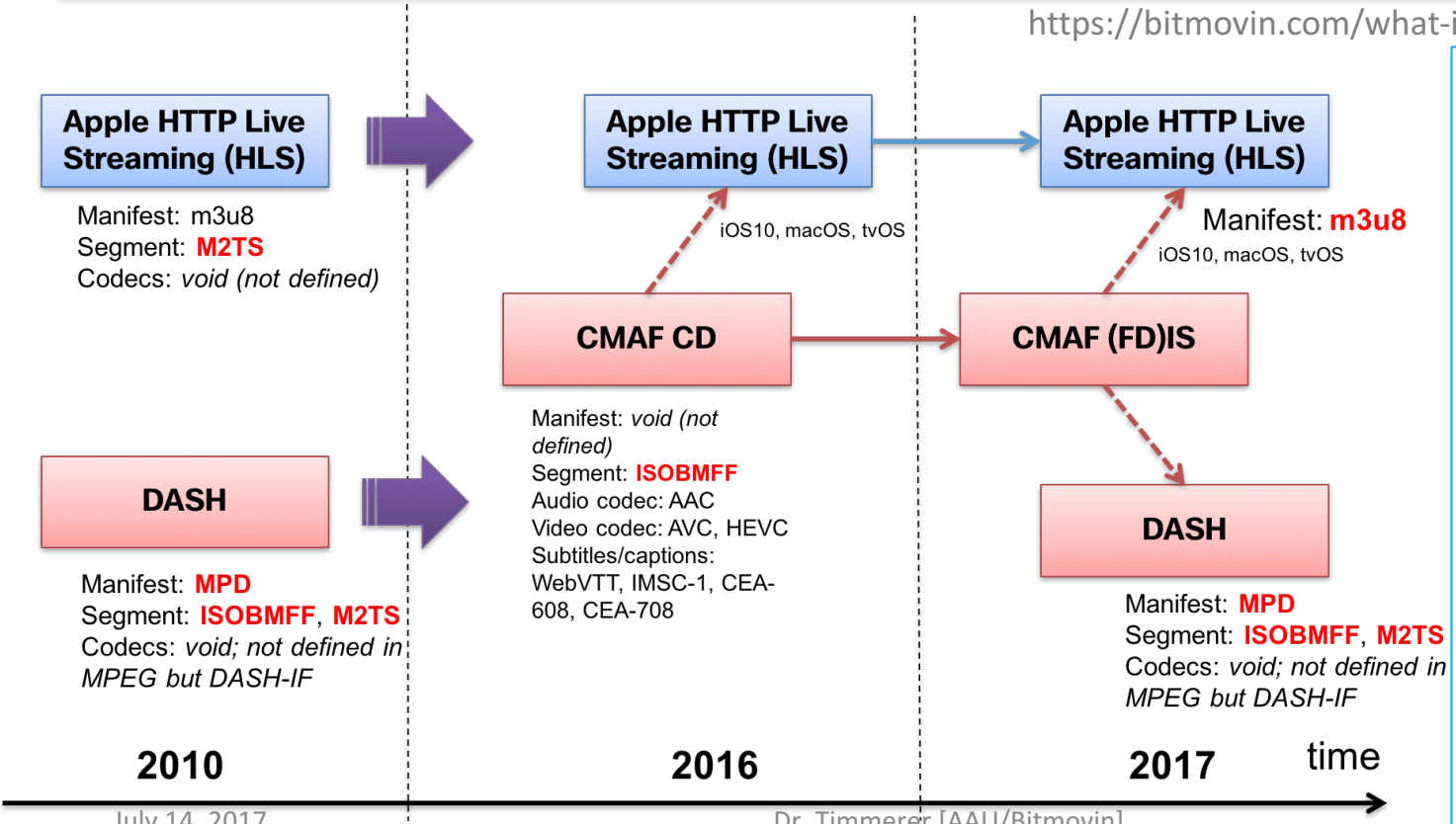
- Currently Running Core Experiments
  - High Quality VR delivery with DASH (DASH-VR)



https://bitmovin.com/mpeg-vr-one-ring-rule/
https://bitmovin.com/lighter-faster-interactive-ads-cross-platform-vr-bitmovins-latest-major-player-version-6-0/

MPEG CMAF: Threat or Opportunity?

https://bitmovin.com/what-is-cmaf-threat-opportunity/



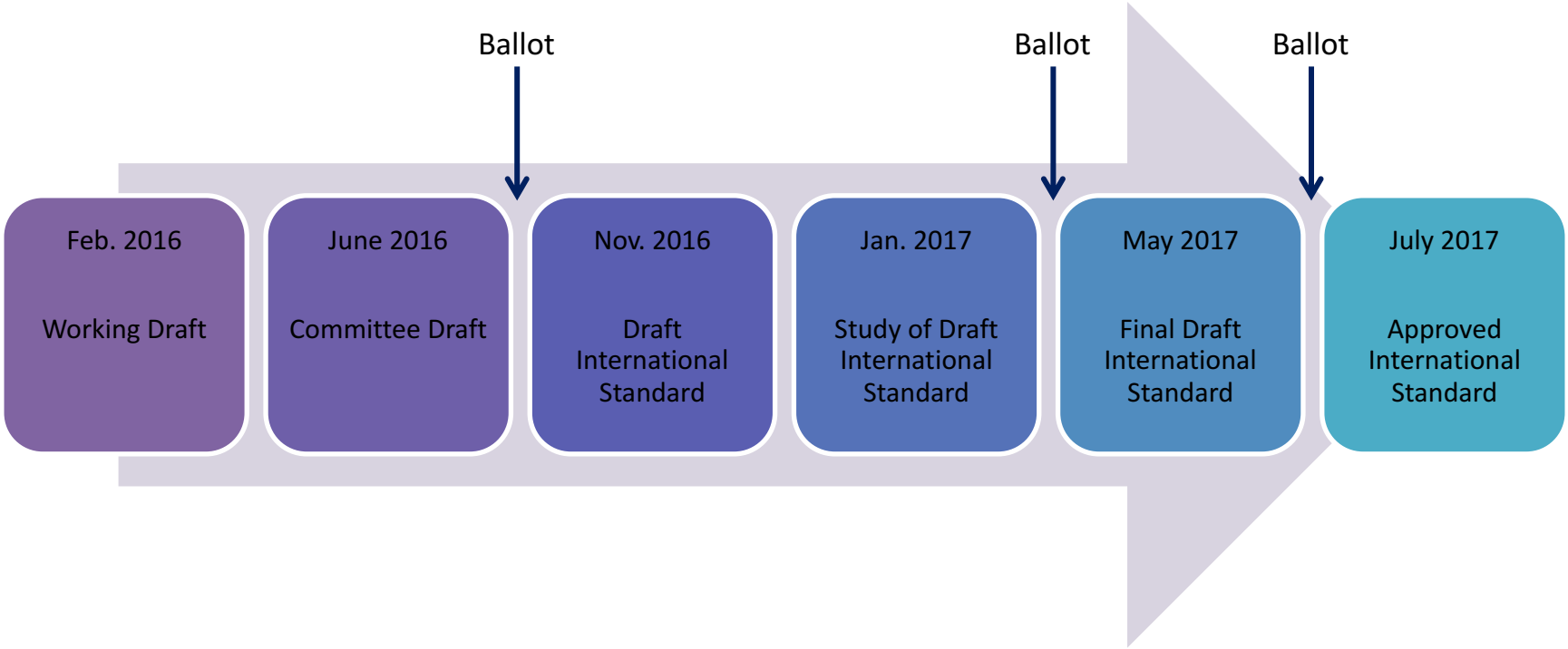
+ CMAF Media Object Model compatible with DASH Data Model

+ Segment formats based on ISOBMFF

- Different manifest formats (MPD vs. m3u8)

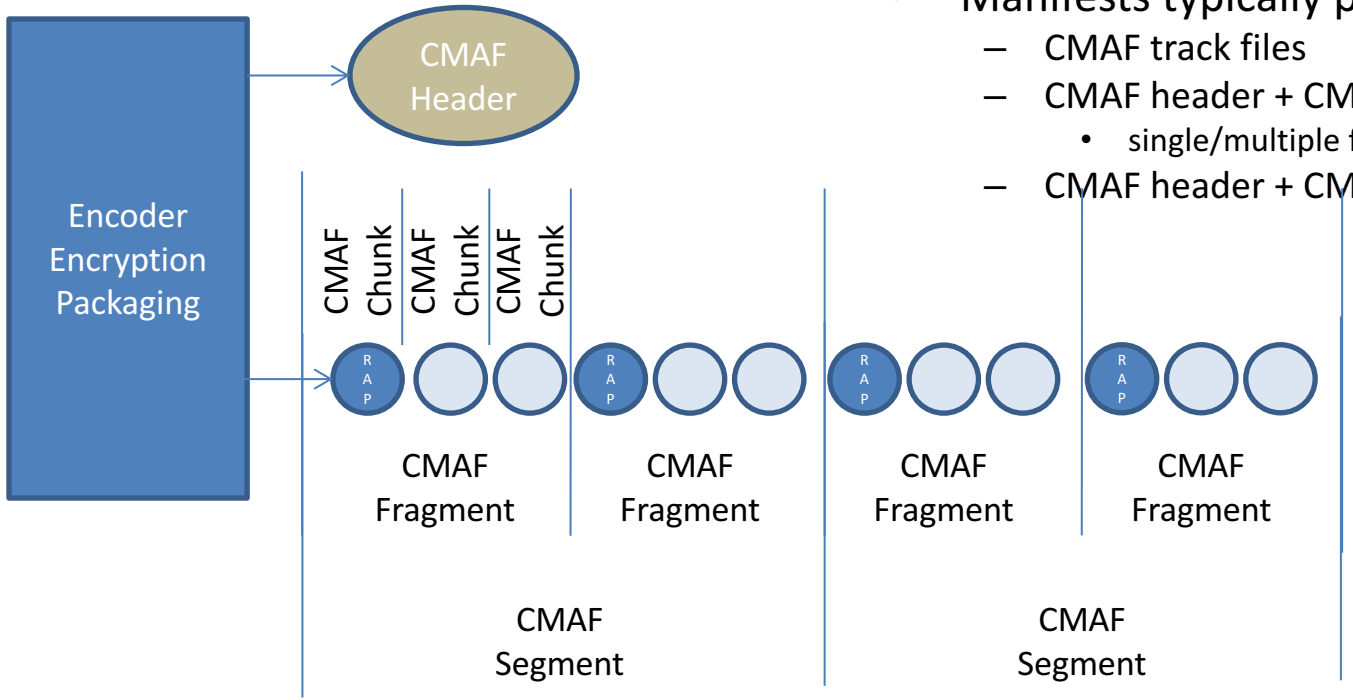
- CENC: AES-128 CBC (HLS) vs. AES-128 CTR (all others) mode

CMAF Development Timeline

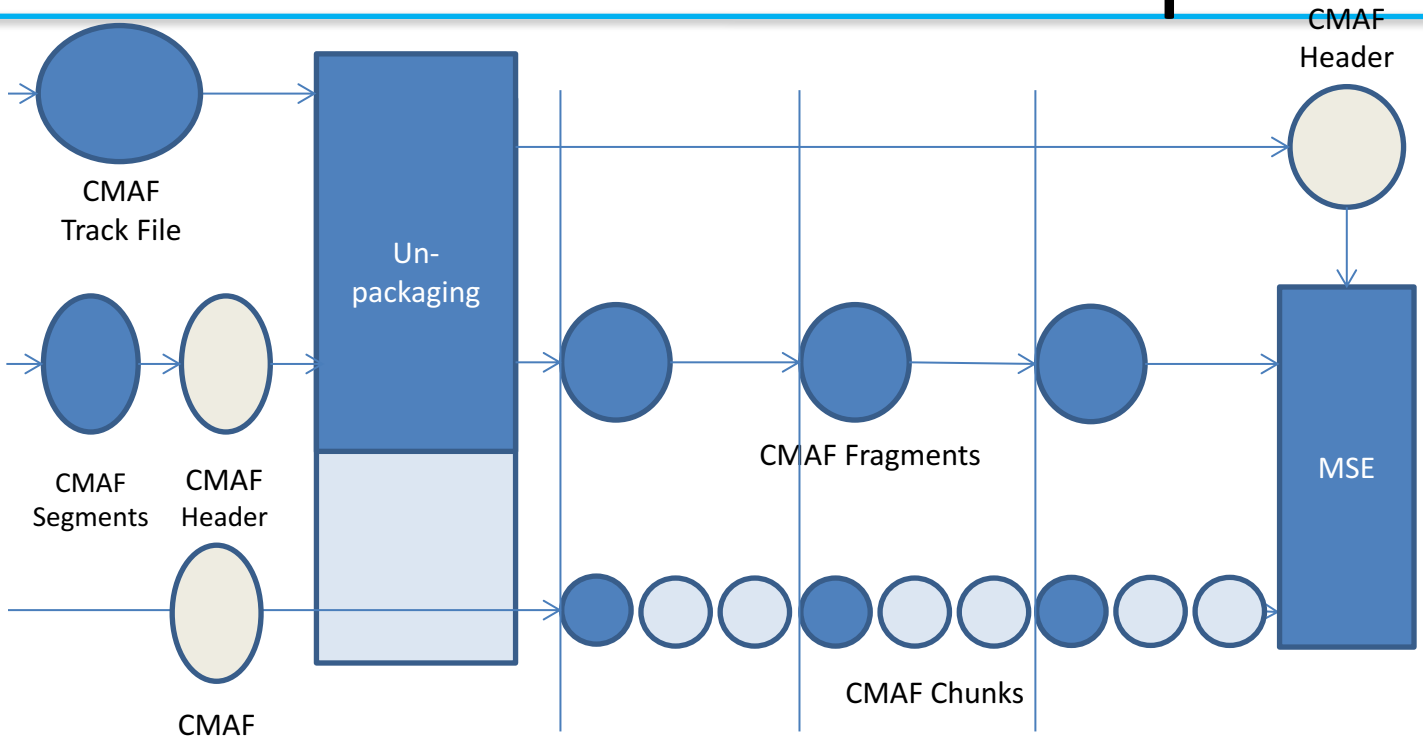


CMAF ISO-BMFF Media Objects

- Manifests typically provide URLs to
  - CMAF track files
  - CMAF header + CMAF segments
    - single/multiple fragment(s)
  - CMAF header + CMAF chunk



CMAF Content Consumption

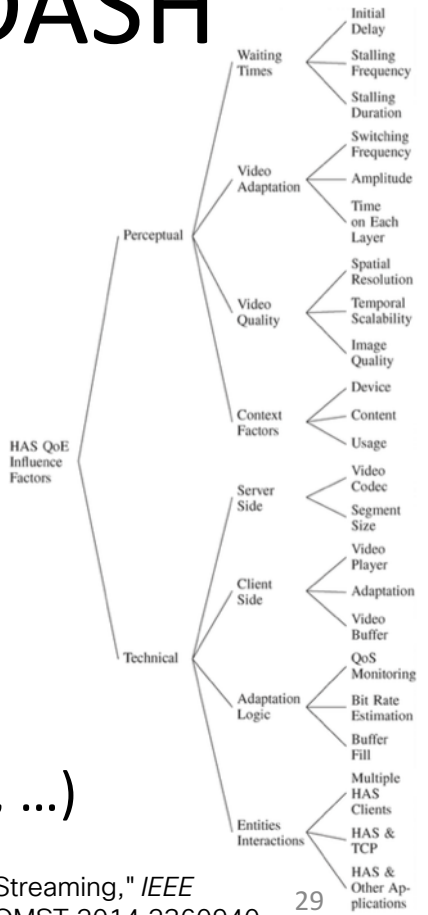


Common Problems in DASH

- Encoding | Packaging | Encryption
  - Guidelines: 3-20 different representations (mobile to UHD)
  - Segment length: 4s shows good tradeoff (2s vs. 9s)
    - https://bitmovin.com/mpeg-dash-hls-segment-length/
  - Offline vs. on-the-fly
- Delivery, distribution, CDN
  - MMSys'16 keynote by Neill Kipp: https://mmsys2016.itec.aau.at/
- Consumption and Quality of Experience (QoE)
  - Adaptation strategies: buffer- vs. throughput-based
  - Multi-client competition: on-off behavior
  - Quality-aware streaming: highest possible bitrate vs. highest quality
  - Inter-Destination Media Synchronization (IDMS): new applications
  - Virtual Reality / 360-degree video: tiled streaming

Quality of Experience for DASH

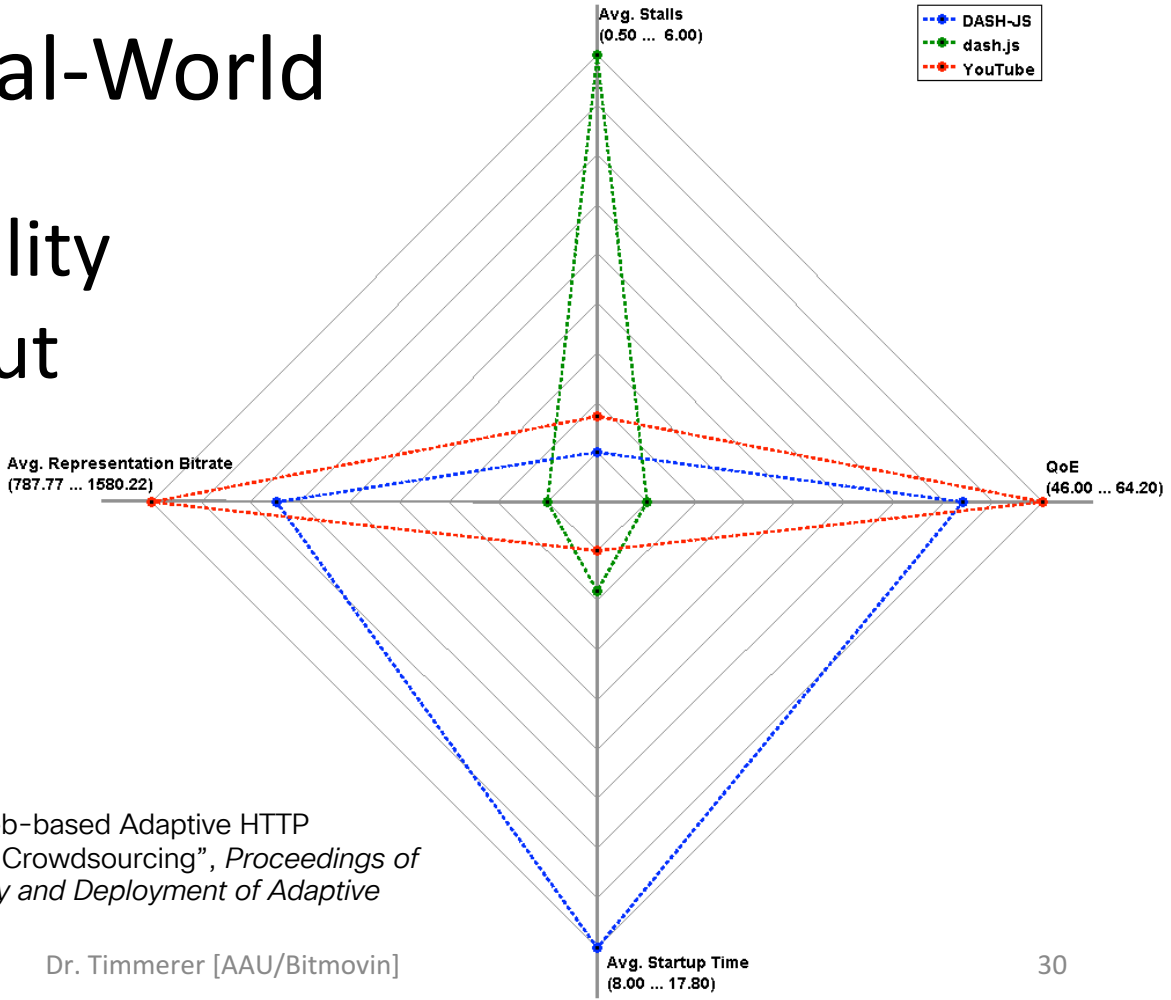
- Objective
  - Initial or startup delay (low)
  - Buffer underrun / stalls (zero)
  - Quality switches (low)
  - Media throughput (high)
  - [Other media-related configuration: encoding, representations, segment length, …]
- Subjective
  - Mean Opinion Score (MOS) – various scales
  - Various methodologies (e.g., DSCQS, DSIS, ACR, PC, …)



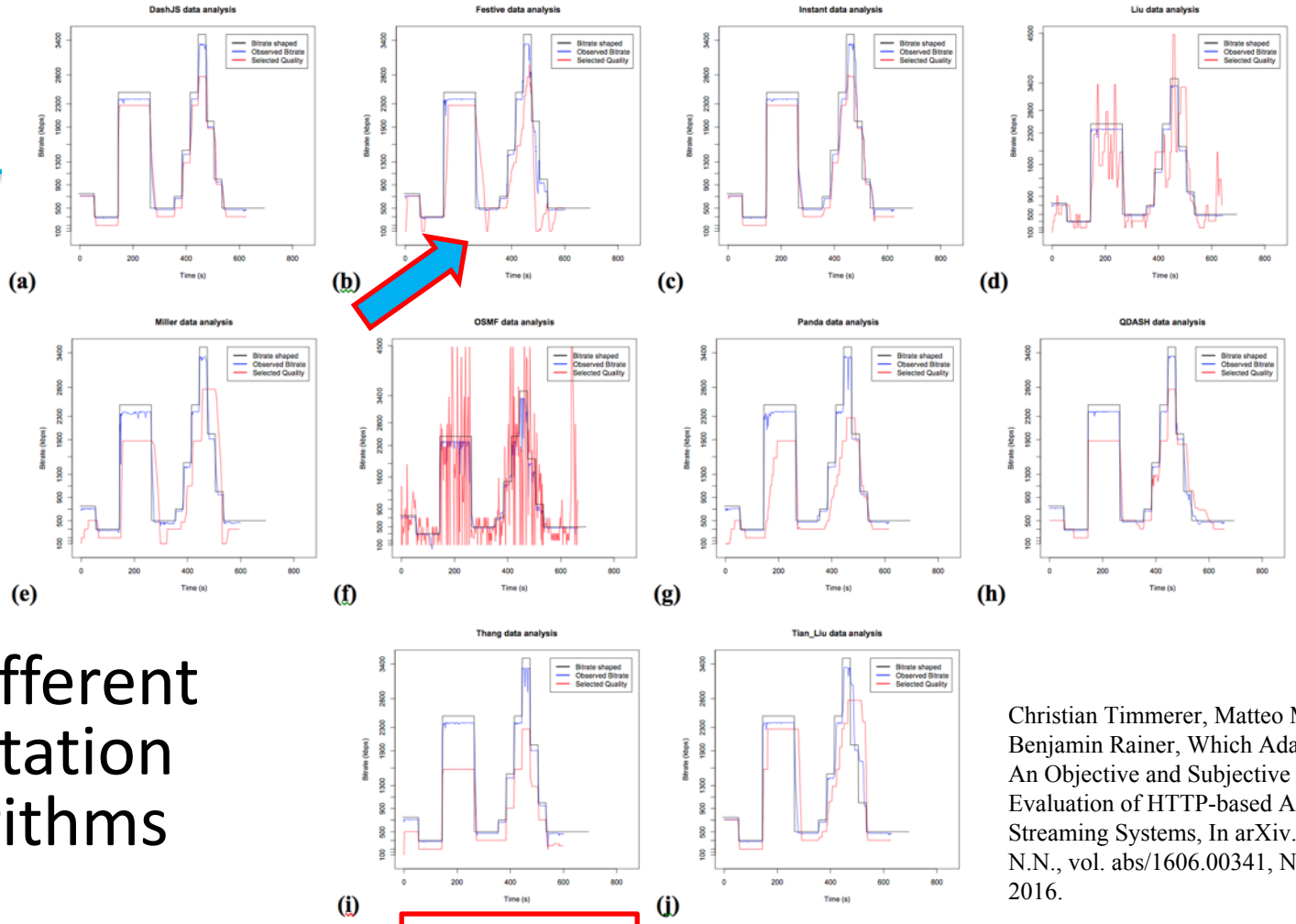
M. Seufert, et al., "A Survey on Quality of Experience of HTTP Adaptive Streaming," *IEEE Communications Surveys & Tutorials*, vol.17, no.1, 2015. doi:10.1109/COMST.2014.2360940

DASH QoE in Real-World

Stalls and low quality are bad for QoE but not startup delay



B. Rainer, C. Timmerer, "Quality of Experience of Web-based Adaptive HTTP Streaming Clients in Real-World Environments using Crowdsourcing", *Proceedings of International Workshop on VideoNext: Design, Quality and Deployment of Adaptive Video Streaming*, Sydney, Australia, Dec. 2014.



10 different adaptation algorithms

Christian Timmerer, Matteo Maiero, Benjamin Rainer, Which Adaptation Logic? An Objective and Subjective Performance Evaluation of HTTP-based Adaptive Media Streaming Systems, In arXiv.org [cs.MM], N.N., vol. abs/1606.00341, N.N., pp. 11, 2016.

Figure 4. Bandwidth Adaptation with 2s segment size for (a) DASH-JS, (b) FESTIVE, (c) Instant, (d) Liu, (e) Miller, (f) OSMF, (g) PANDA, (h) QDASH, (i) Thang, and (j) Tian-Liu.

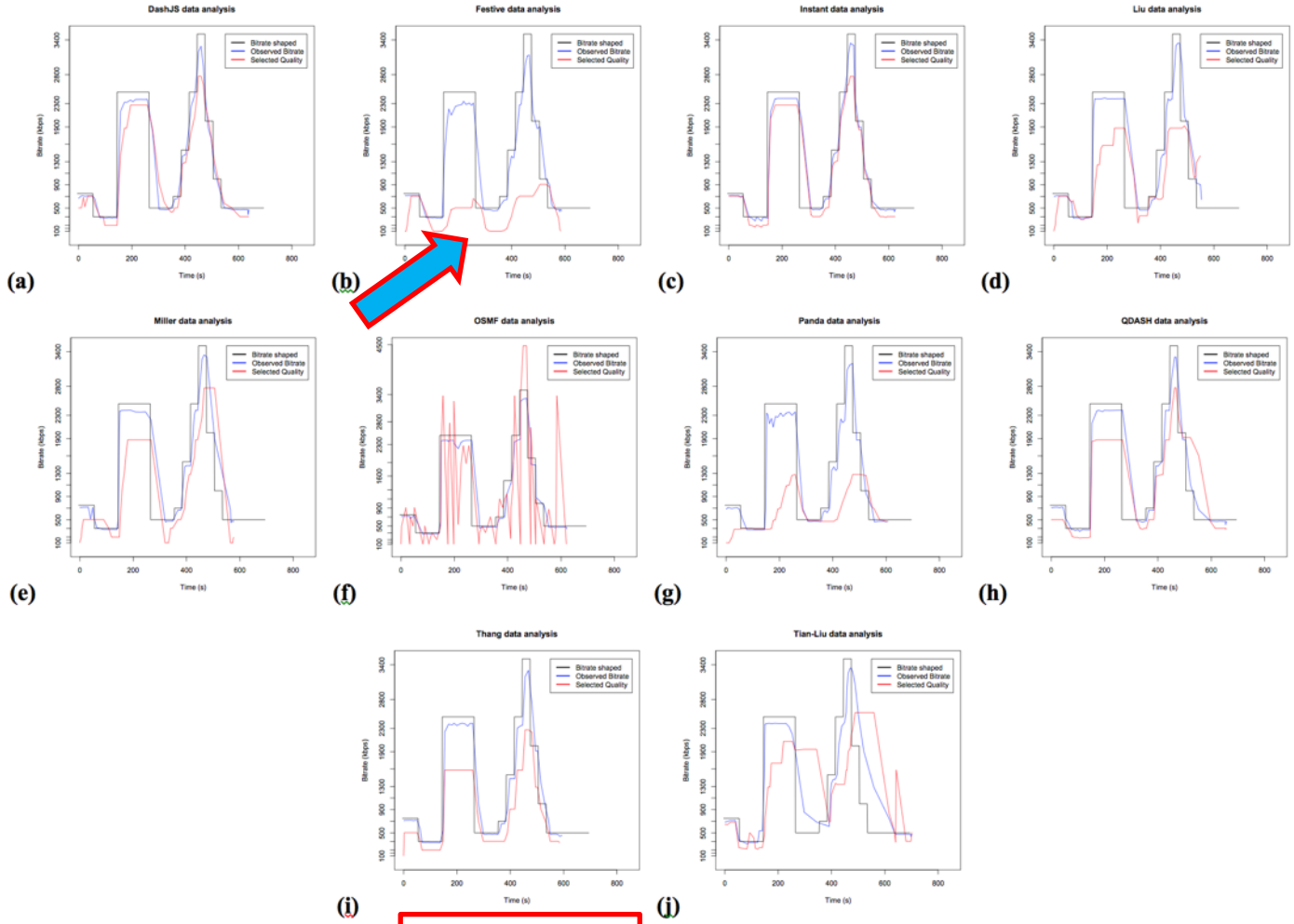
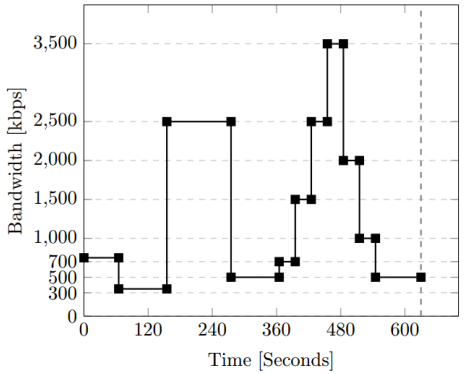
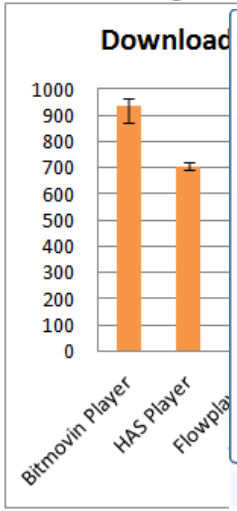


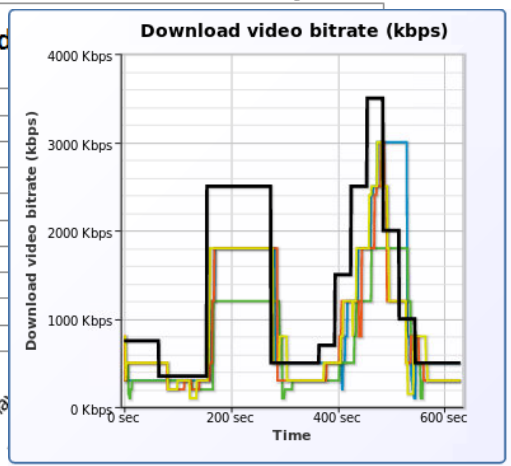
Figure 5. Bandwidth Adaptation with 10s segment size for (a) DASH-JS, (b) FESTIVE, (c) Instant, (d) Liu, (e) Miller, (f) OSMF, (g) PANDA, (h) QDASH, (i) Thang, and (j) Tian-Liu.

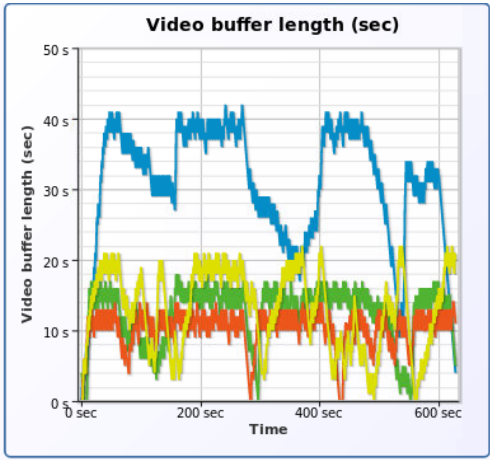
Comparison of eight DASH Players

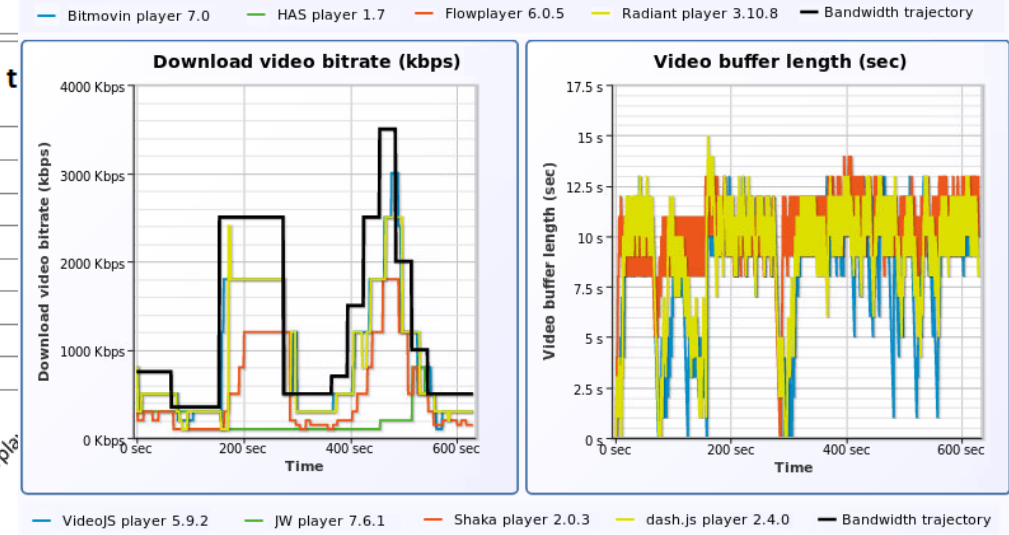
Number	Bitrate (kbps)	Resolution
1	100	400x224
2	150	400x224
3	200	512x288
4	300	512x288
5	500	512x288
6	800	640x360
7	1200	704x396
8	1800	704x396
9	2400	720x404
10	2500	720x404
11	2995	960x540
12	3000	1280x720
13	4500	1280x720
14	8000	1920x1080

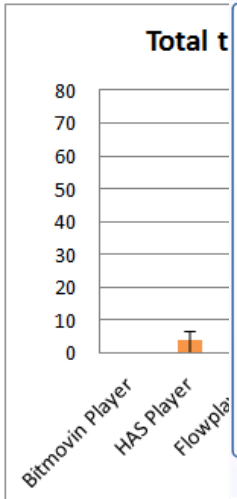












Conclusions

- MPEG-DASH defines formats only
  - Media Presentation Description (MPD)
  - Segment format: isobmff, m2ts
- MPEG-DASH is not
  - System, protocol, presentation, codec, interactivity, DRM, client specification
- Other standards required for a complete ecosystem
  - DASH-IF, WAVE, HMTL5, MSE, EME, 3GPP, DVB, etc.
- Do we need MPEG-DASH? (for adaptive media streaming)
  - Not necessarily: e.g., WebM + VPx + manifest & control end-to-end
  - Required to address heterogeneous environments to solve interop. problem
- Role of standards sometimes overrated but often underestimated
- CMAF and VR addressing new challenges for adaptive media streaming

Deployment Thoughts

- Proprietary ecosystems will disappear (Silverlight, Flash)
- No more plugins – HTML5!
  - MSE/EME available on all major browser platforms
  - Support for both DASH/HLS (+CMAF) and CENC
- Rich feature set: codecs, ads, DRM, multi-language/-audio, subtitles, VR/360, UHD, HFR, HDR, live, on-demand, analytics, …
- Common implementation issues: start-up, buffering, high-quality, seamless switching, platform support, cost-effective, …
- Solutions available for adaptive streaming, advertising, VR/360, live streaming, and DRM
  - Details available at https://bitmovin.com/