Advanced Web Technologies
Web & Media I

Stefan Pham | Open Distributed Systems | lecture winterterm 2016/17

Agenda

Datum		Inhalt
KW 43	27.10.2016	Introduction and framework
KW 44	3.11.2016	Web and Media I
KW 45	10.11.2016	Web and Media II
KW 46	17.11.2016	Web Technologies Basics
KW 47	24.11.2016	TV Apps
KW 48	1.12.2016	Multiscreen Technologies and Standards I
KW 49	8.12.2016	Multiscreen Technologies and Standards II
KW 50	15.12.2016	Data Mining & Recommender Systems
KW 51		Thema IX (oder Weihnachtsquiz)
KW 52		-
19.12.2016 - 02.01.2017		Weihnachtsferien
KW 01	5.1.2017	Web Of Things
KW 02	12.1.2017	WebSecurity and Privacy
KW 03	19.1.2017	Exkursion zum Fraunhofer FOKUS
		Treffpunkt um ### Uhr am Fraunhofer Institut FOKUS
KW 04	26.1.2017	Große Übung
KW 05 oder 06	9.2.2017	Schriftlicher Test (ca. 60 min)

Updates:

Per mail / in den VL Terminen

http://www.ods.tu-berlin.de/menue/lehre/wintersemester/vl_advanced_web_technologies/

Open Distributed Sytems
ODS

Agenda Web & Media I

- Motivation
- HTTP Adaptive Streaming & MPEG-DASH
- Browser-based MPEG-DASH Playback
  - Demo: „Silent TV” (Media Synchronization)

Web & Media I

Motivation

INTERNET DELIVERED MEDIA

By 2018 video traffic will be 79% of all consumer IP traffic. Each second nearly a million minutes of video will cross IP networks.

It would take over 5 million years to watch the amount of video that will cross global IP networks each month in 2018.

Video-on-demand traffic will double by 2018. The amount of VOD traffic in 2018 will be equivalent to 6 billion DVDs per month.

Source: Cisco Visual Networking Index Forecast and Methodology, 2013-2018

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INTERNET DELIVERED MEDIA

Where we are:

- Very popular commercial OTT streaming services, e.g. Netflix, Amazon Video, Watchever, Spotify, …

What we work with and where we start:

- Different device platforms & multi-screen functionality – *how to reach them all?*
- Other factors: *Scalability* (CDNs), *Monetization* (subscription, advertisement), *Regulatory* (DRM, parental control), *Quality*/UX (4K)

Outlook and our solutions:

⇒ ***The Web Browser nowadays represents the common app platform across devices***

⇒ *Plugin/NPAPI plugins (Flash, Silverlight) are replaced with* ***HTML5 <video>*** *and media extensions*

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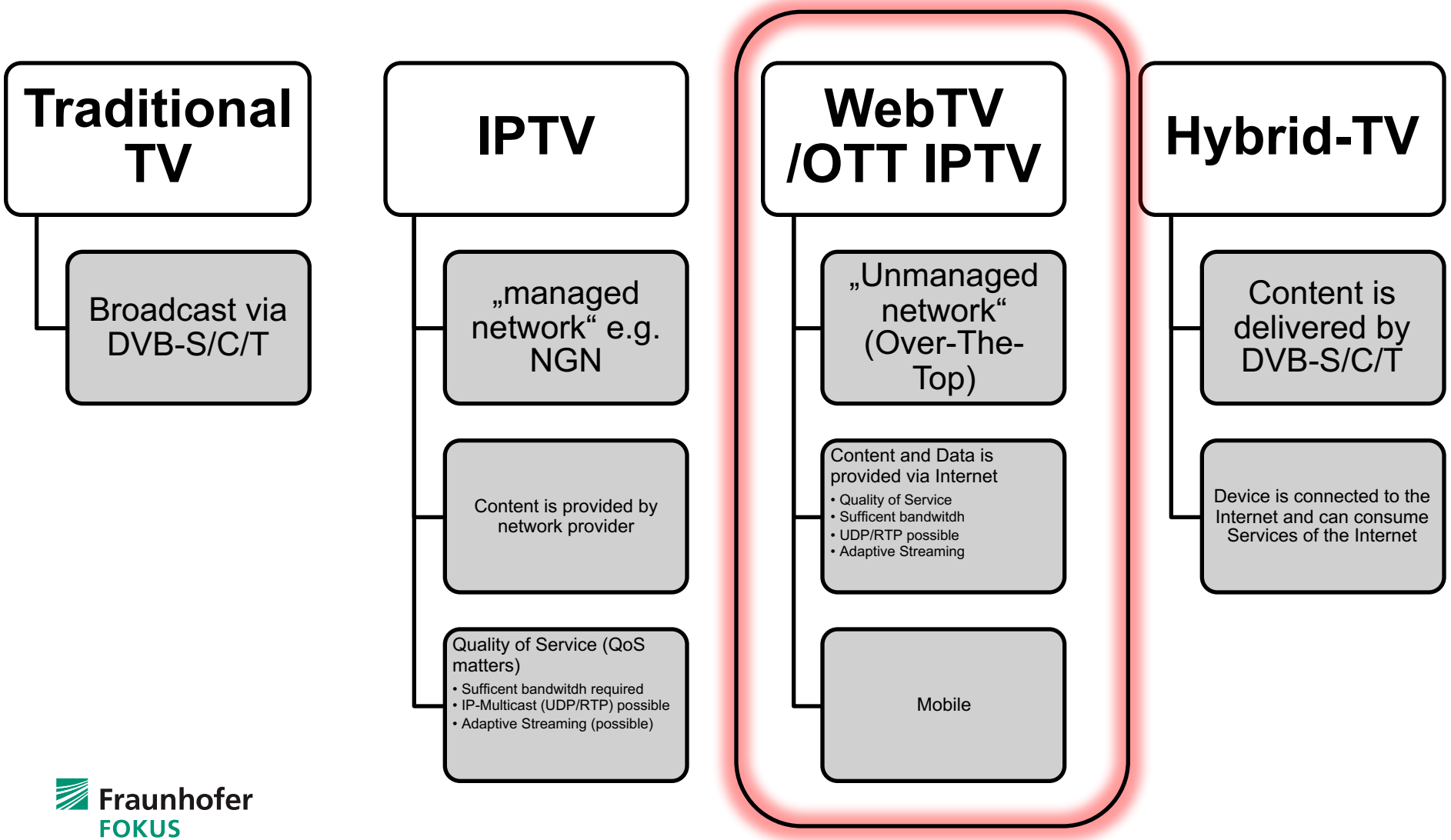
CHARACTERISTICS OF TV DISTRIBUTION



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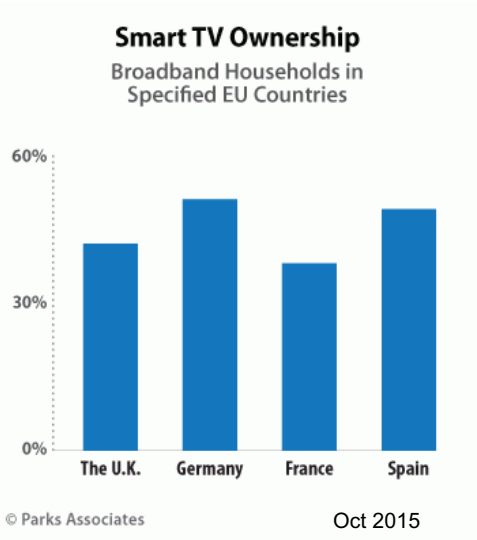
KEY FACTORS FOR INTERNET DELIVERED MEDIA

- IPTV, HybridTV and WebTV is nothing new, started many years ago.
- What has changed ? Why now?
  - Broadband widely available in households
    - sufficient bandwidth, affordable
    - Internet services are commodity
  - Devices
    - more powerful, ubiquitous computing, hybrid
    - Flat Screen, hi resolution
  - Evolved Web Standards & Tools
    - HTML, JS, CSS
  - Content went digital
    - audio & video are bits and bytes now ;-)



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KEY FACTORS FOR INTERNET DELIVERED MEDIA

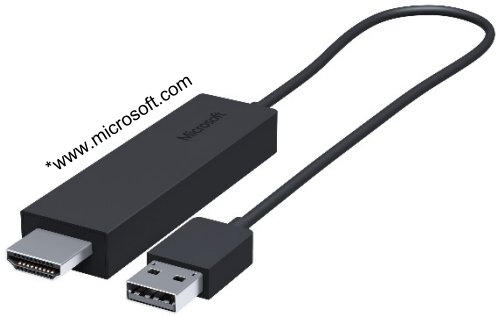
Device diversity

*www.apple.com

*www.sony.com

*www.google.com

*www.amazon.com



*www.microsoft.com

*wwwsony.com

*www.microsoft.com

HTML5 NEXT GEN TV TECHNOLOGY

- Today browsers are more than just HTML interpreter and render.
  - HTML, CSS, and JavaScript, A/V Codec
  - Plugins (Flash, Silverlight, ...)
  - NPAPI deprecation

- Some HTML5 Features
  - **HTML5 <video> and <audio> + extensions**
  - Text tracks
  - Canvas (2d shapes and bitmap images)
  - SVG
  - Advanced CSS3 features
  - Storage/offline applications
  - Websockets
  - Hardware acceleration (WebGL…)
  - …

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DELIVERING MEDIA: TECH TO UNDERSTAND

- **DASH** – MPEG **Dynamic Adaptive Streaming over HTTP** for live and on demand video
- **HLS** – Apple **HTTP Live Streaming** for live and on demand video
- **CENC** – MPEG **Common Encryption** for multi-DRM
- **MSE** – W3C **Media Source Extension** to trick-function HTML5 video-objects via JavaScript (control AV media streams)
- **EME** – W3C **Encrypted Media Extension** to play back DRM-protected media in standard browsers w/o the use of proprietary plug-ins
- **CDM** – **Content Decryption Module** - addition to the browser that provides functionality for one or more Key Systems

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STREAMING MEDIA STACK

Composition

- W3C Media Source Extensions (MSE)
- W3C Encrypted Media Extensions (EME)

AuthN-AuthZ

- W3C Web Crypto Extensions

Transport

- Dynamic Adaptive Streaming over HTTP

Encrypt

- Common Encryption for ISO-BMFF / MPEG-2 TS

Encode

- MPEG-DASH profiles ISO-BMFF / MPEG-2 TS / DASH264

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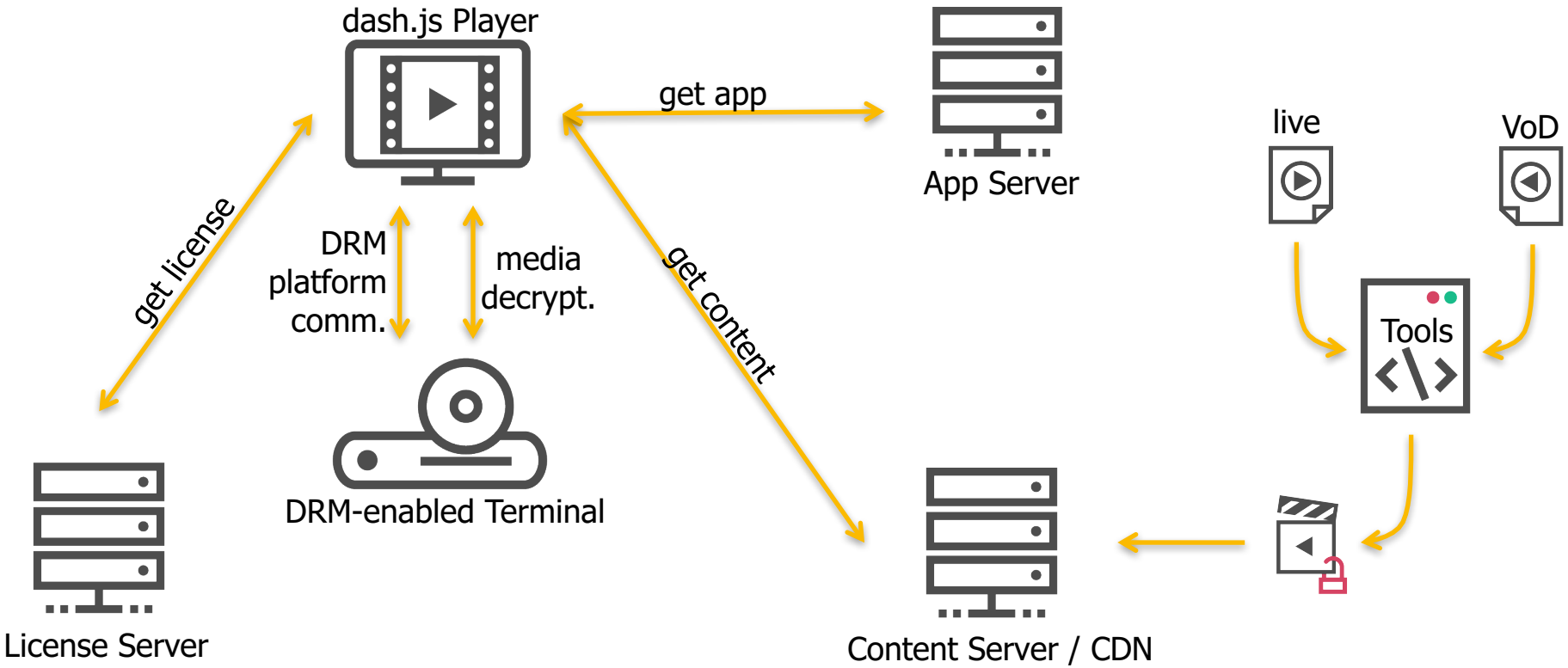
PLAYER ARCHITECTURE



INTERNATIONAL RELEVANCE

- **DASH/CFF/CENC**
  - part of HbbTV 1.5/2.0 / TNT 2.0 / DVB / DASHIF / Smart TV Alliance / IPTV Forum Japan etc. specifications
  - Integrated by many TV/STB vendors today
  - Supported by growing number of streaming solutions
  - Global relevance

- **MSE/EME/CDM**
  - All browser vendors have integrated HTML5 Premium Video Extensions
  - Seen as enabler for additional services, e.g. VoD, ad insertion
  - Mandatory feature in next gen CE devices from OTT players & managed IPTV players world wide to enable HTML5 based client implementations

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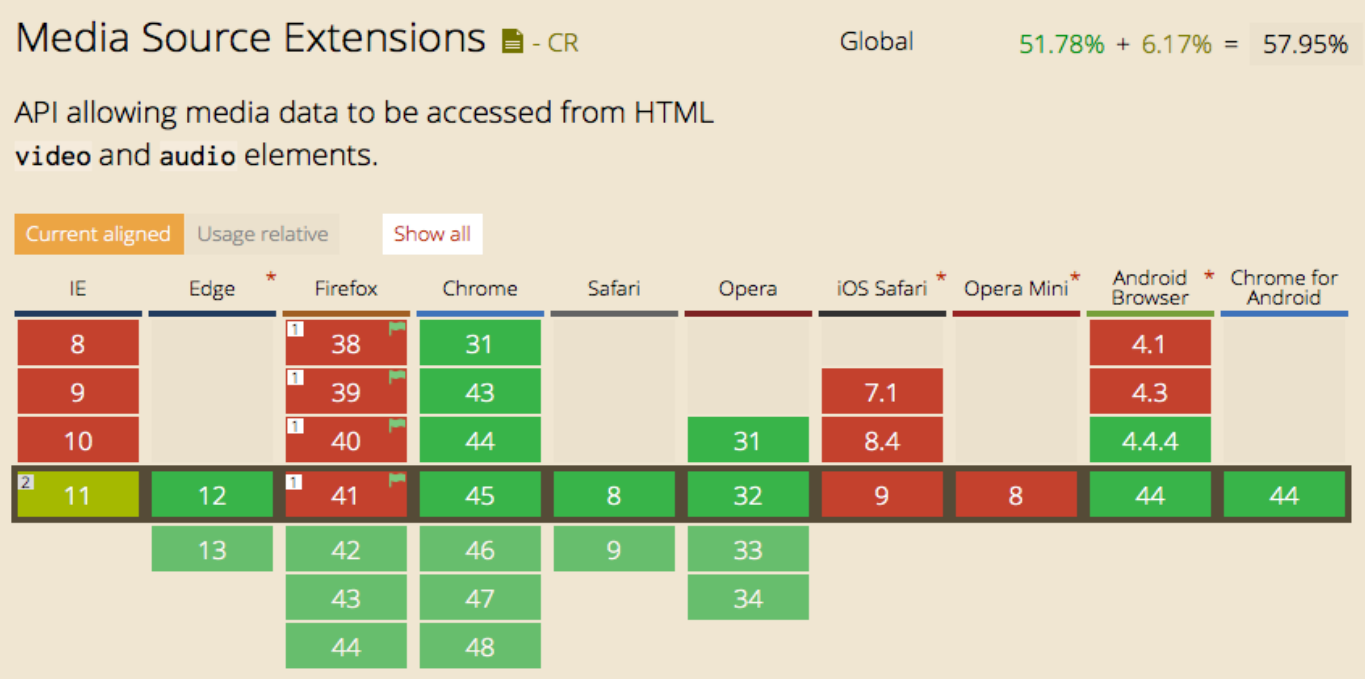
MSE/EME

Web Browsers with MSE support



http://caniuse.com/#search=media%20source

MSE/EME

Web Browsers with EME support

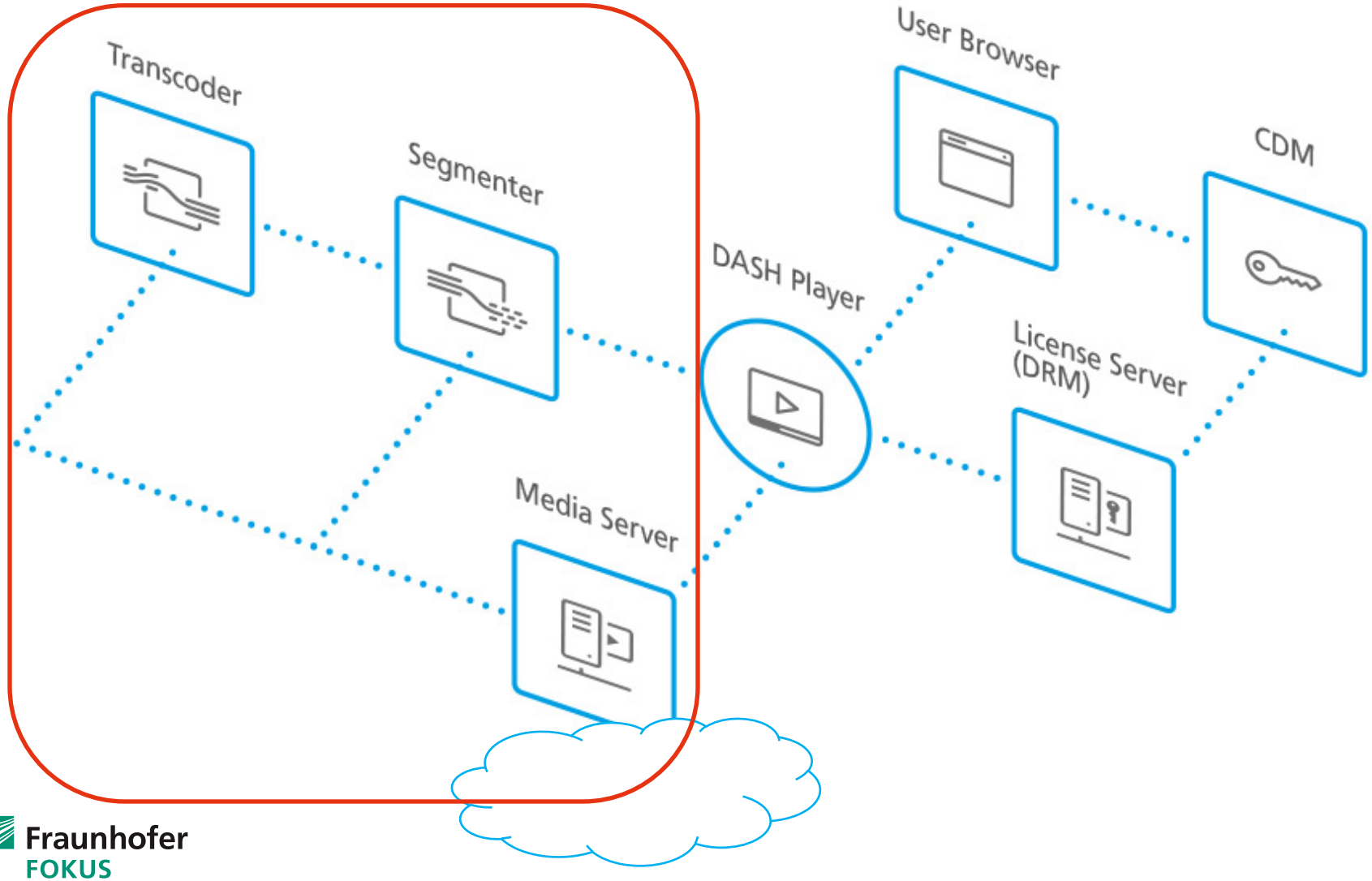
- In 2015 Chrome, Edge and Firefox have deprecated NPAPI (for Silverlight)
- By the end of 2016 Flash will be deprecated in Chrome
- Instead HTML5-based MSE & EME should be used

Browser	CDM
Chrome (Desktop/Android/TV)	Widevine
Chrome (Chromecast)	Widevine, PlayReady
Firefox	Adobe Access
IE/Edge	PlayReady
Safari (OSX)	Fairplay

Web & Media I

HTTP Adaptive Streaming & MPEG-DASH

OVERVIEW



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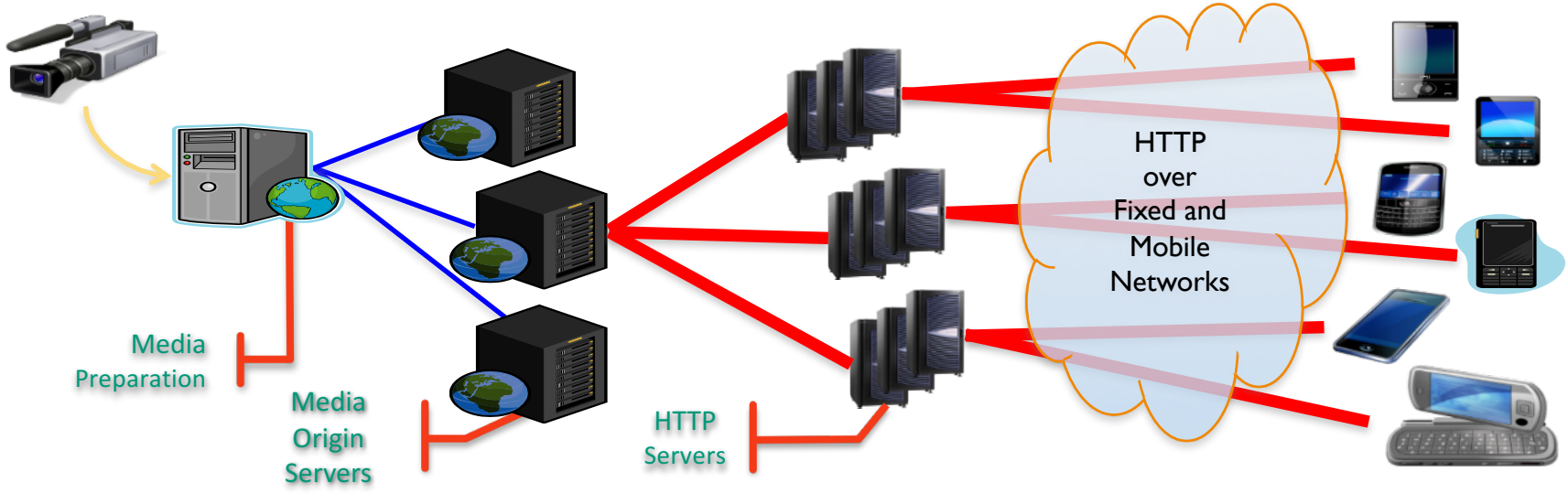
OVERVIEW OF HTTP STREAMING

- Short segments of video stored as movie fragments, requested with HTTP and spliced together by client.
  - Uses existing Internet CDNs
  - traverses NAT/Firewalls
  - fixed-mobile convergence.



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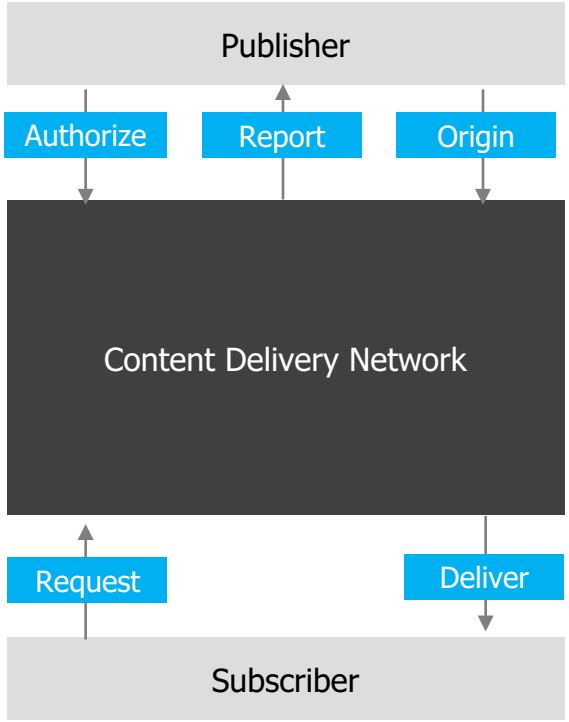
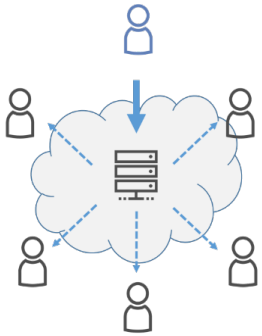
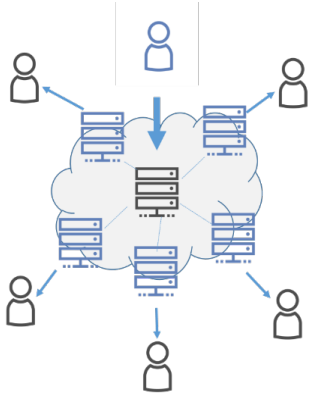
CONTENT DELIVERY NETWORKS

- A system of caches
  - containing copies of data,
  - placed at various points in a network
  - to maximize bandwidth for access from clients
- Clients accessess a copy of the data near to the client
  - Opposed to all clients accessing the same central server
- Load balancers manage the distribution of content and dynamically adjust routing according to business rules





One central web server



Content delivery etwork

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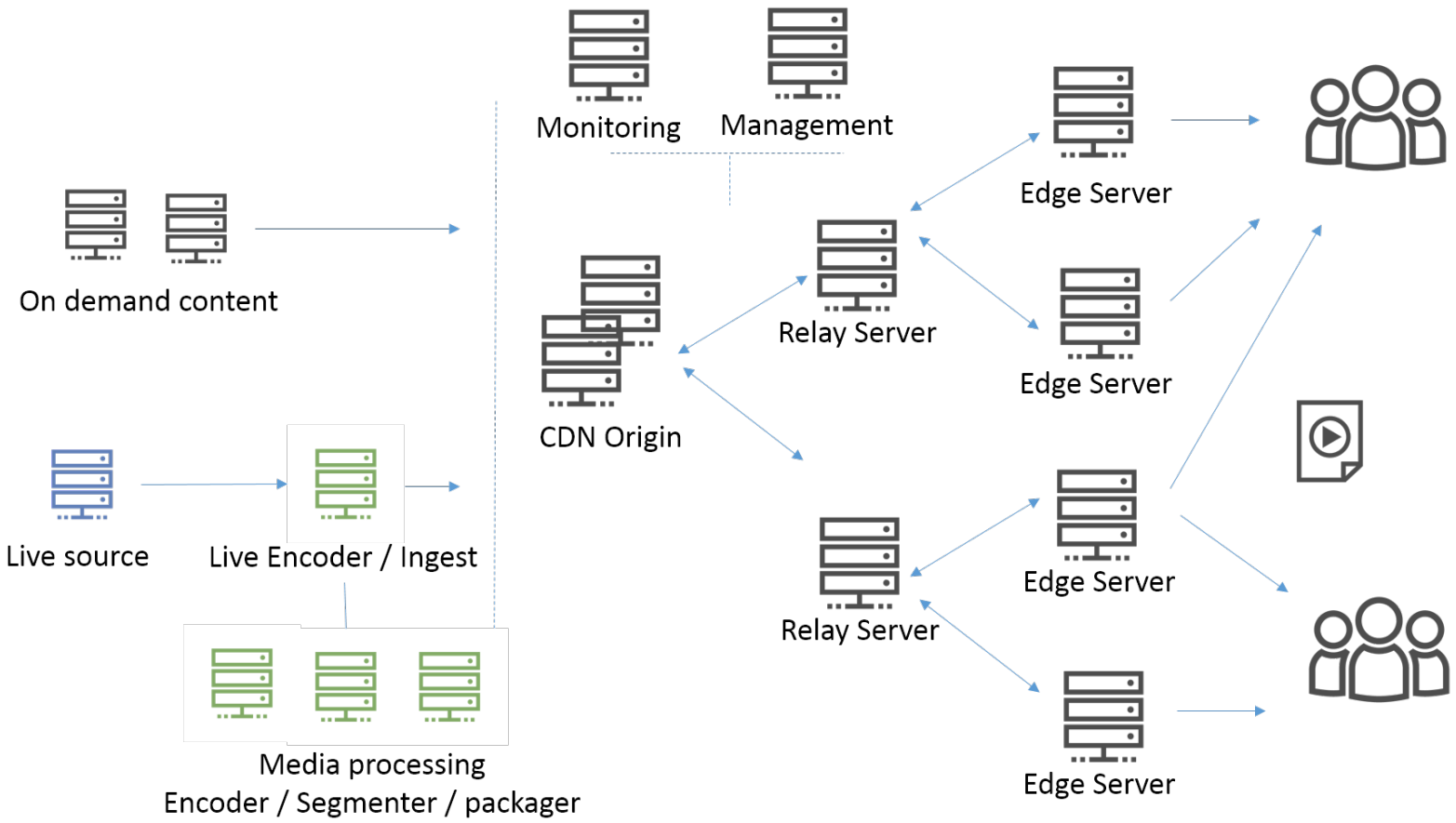
A TYPICAL TOPOLOGY TO SERVE MEDIA CONTENT



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ADAPTIVE STREAMING

- Origin stores different representations/qualities of video files
- Segments of those files are cataloged in a manifest file
- Clients dynamically decide which segment to request next
- Clients differentiate by the algorithms applied to select the segments
  - Buffer size
  - Available bandwith
  - Context prediction
  - Cost savings
  - Cooperation
  - …

- Existing solutions: Apple HLS, Microsoft Smooth Streaming, Adobe HDS, … and MPEG-DASH

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ABR RECOMMENDATIONS

H.264/AVC @ Netflix

Bitrate (kbps)	Resolution
235	320x240
375	384x288
560	512x384
750	512x384
1050	640x480
1750	720x480
2350	1280x720
3000	1280x720
4300	1920x1080
5800	1920x1080

http://techblog.netflix.com/2015/12/per-title-encode-optimization.html

HLS @ Apple

Bitrate (kbps)	Resolution
264	416x234
400	480x270
600	640x360
1200	640x360
3500	960x540
5000	1280x720
6500	1280x720
8500	1920x1080

https://developer.apple.com/library/ios/technotes/tn2224/_index.html#//apple_ref/doc/uid/DTS40009745-CH1-SETTINGSFILES

MPEG-DASH

- Dynamic Adaptive Streaming over HTTP (DASH) - ISO/IEC 23009
  - Part 1: Media presentation description and segment formats
  - Part 2: Conformance and reference software
  - Part 3: Implementation guidelines
  - Part 4: Segment encryption and authentication
  - Part 5: Server and network assisted DASH (SAND)
  - Part 6: DASH with Server Push and Web Sockets
- Standard for streaming multimedia over the internet
- Harmonize video delivery across the internet
- Similiar to vendor-specific solutions like MSS and HLS
- Extensions for common DRM-interoperable encryption and encoding
- DASH-IF promotes MPEG‘s DASH specification
  - Interoperability guidelines: DASH-264
- DASH profiles: DVB, HbbTV 1.5/2.0, ATSC etc.

HbbTV

DASH Industry Forum

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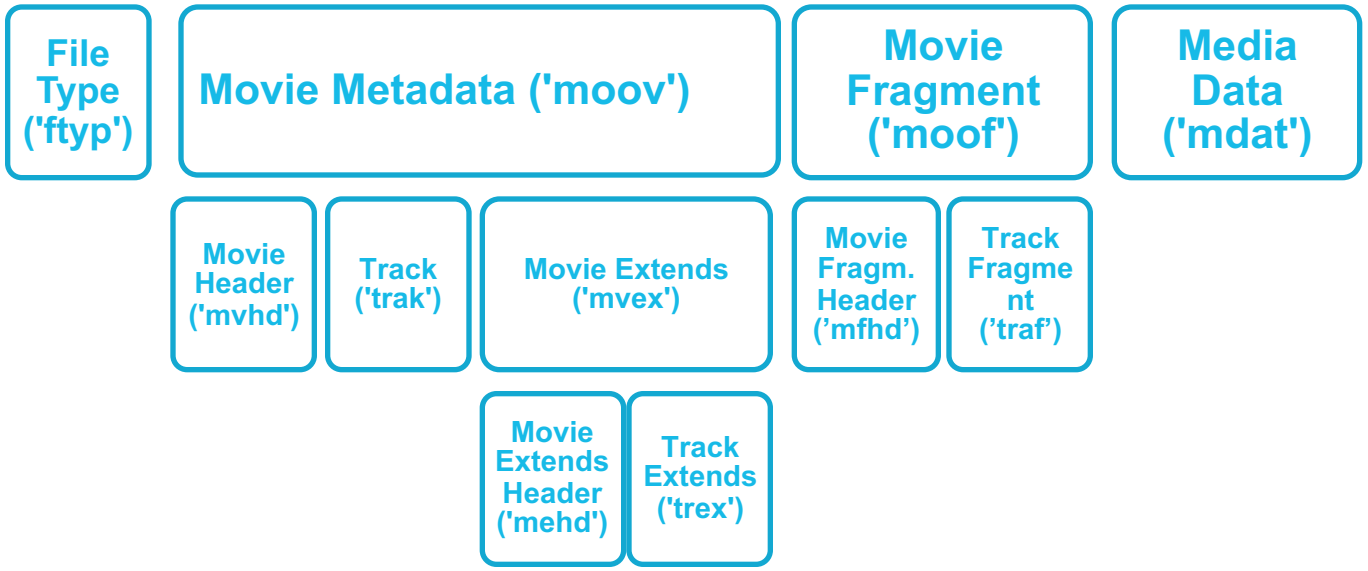
MPEG-DASH FILE FORMAT

- ISO base media file format (ISOBMFF) or MPEG2-TS
- Codec-agnostic

“Boxes” in ISOBMFF:



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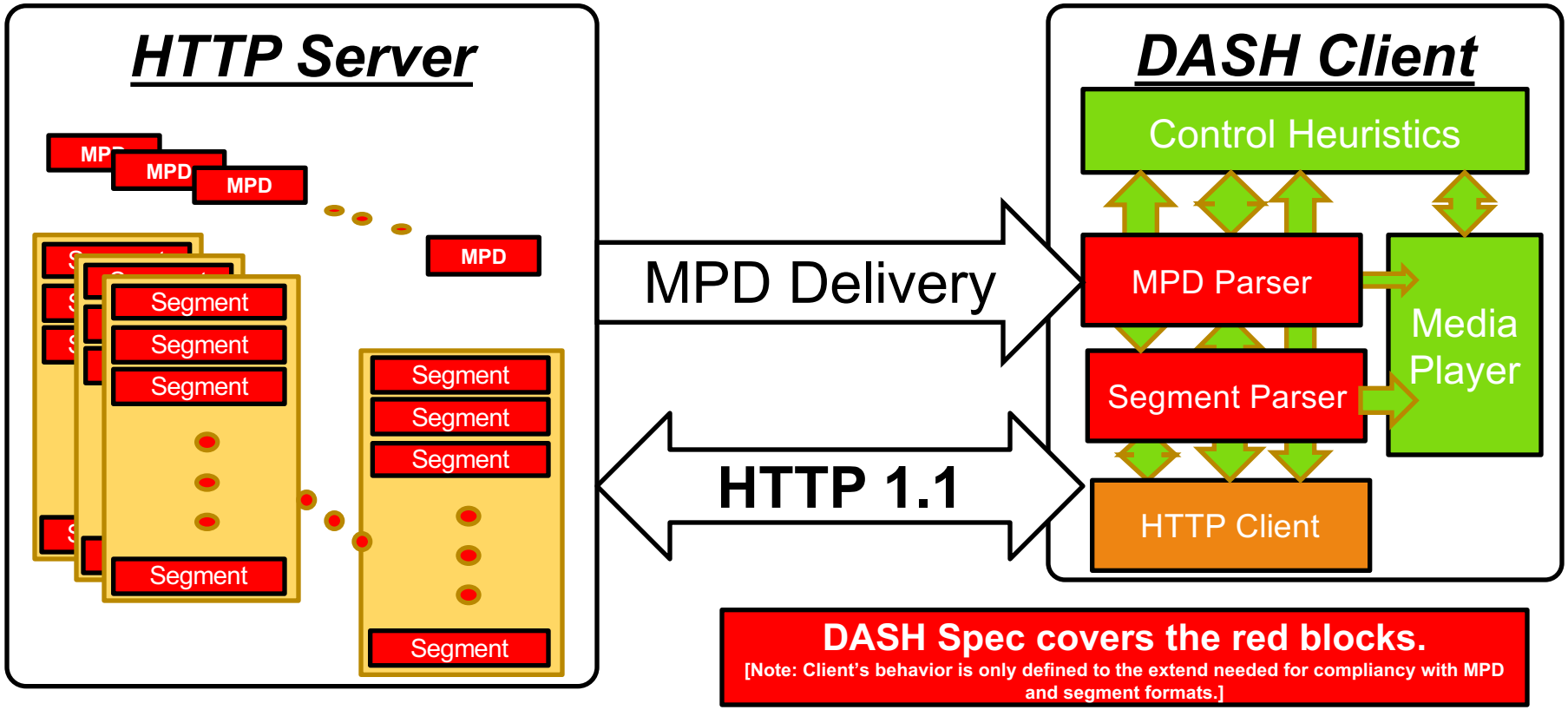
MPEG-DASH - SCOPE



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MPEG-DASH – MPD EXAMPLE

```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<MPD xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns="urn:mpeg:DASH:schema:MPD:2011"
xsi:schemaLocation="urn:mpeg:DASH:schema:MPD:2011 DASH-MPD.xsd" profiles="urn:mpeg:dash:profile:isoff-live:2011"
minBufferTime="PT1.5S" type="static" mediaPresentationDuration="PT1M47S" xmlns:mspr="urn:microsoft:playready"
xmlns:cenc="urn:mpeg:cenc:2013">
      <Period duration="PT1M47S" start="PT0S">
            <AdaptationSet segmentAlignment="true" subsegmentStartsWithSAP="1" mimeType="audio/mp4"
codecs="mp4a.40.2">
                  <SegmentTemplate initialization="audio/$Bandwidth$/FhG_FOKUS_segment_cenc_init.m4a"
media="audio/$Bandwidth$/FhG_FOKUS_segment_cenc_$Number$.m4s" startNumb                    "48000">
                        <SegmentTimeline>
                              <S t="0" d="191488" r="0"/>
                              <S t="191488" d="191488" r="0"/>
...

      <ContentProtection schemeIdUri="urn:mpeg:dash:mp4protection
      cenc:default_KID="48534144-6846-4647-4F4B-5553736F756E"/>
      <ContentProtection schemeIdUri="urn:uuid:9a04f079-9840-4286-ab92-e6                value="2.0">
      <mspr:pro>PABXAFIATQBIAEUAQQBEAEUAUgAgAHgAbQBsAG4AcwA9ACIAaAB0AHQAcAA6AC8ALwBzAGMAaABlAG0AYQBzAC4AbQBpAGMAcgBvA
HMAbwBmAHQALgBjAG8AbQAvAEQAUgBNAC8AMgAwADAANwAvADAAMwAvAFAAbABhAHkAUgBlAGEAZAB5AEgAZQBhAGQAZQByACIAIAB2AGUAcgBzAGkAbw
BuAD0AIgA0AC4AMAAuADAALgAwACIAPgA8AEQAQQBUAEEAPgA8AFAAUgBPAFQARQBDAFQASQBOAEYATwA+ADwASwBFAFkATABFAE4APgAxADYAPAAvAEs
ARQBZAEwARQBOAD4APABBAEwARwBJAEQAPgBBAEUAUwBDAFQAUgA8AC8A                APAAvAFAAUgBPAFQARQBDAFQASQBOAEYATwA+ADwATABB
AF8AVQBSAEwAPgBoAHQAdABwADoALwAvAHAAbABhAHkAcgBlAGEAZAP                AdABhAHAAcwAuAG4AZQB0AC8AcAByAC8AcwB2AGMAL
wByAGkAZwBoAHQAcwBtAGEAbgBhAGcAZQByAC4AYQBzAG0AeAA/AEA                AD0AMQAmAGEAbQBwADsAVQBzAGUAUwBpAG0AcABsAG
UATgBvAG4AUABlAHIAcwBpAHMAdABlAG4AdABMAGkAYwBlAG4AcwBlAD                QwBvAG4AdABlAG4AdABlAGUAeQA9ADUAMABwAHQAQQB
hAG8AYQByAHQAMwAyAGgAUAAzAC8AZQBGAEkAOABZAGcAPQA9ADwALwBMAEEA                +ADwASwBJAEQAPgBTAEYATgBCAFIARwBoAEcAUgBrAGQA
UABTADEAVgBUAGMAMgA5ADEAYgBnAD0APQA8AC8ASwBJAEQAPgA8AC8ARABBAFQAQQA+ADwALwBXAFIATQBIAEUAQQBEAEUAUgA+AA==</mspr:pro>
      </ContentProtection>
```

DASH segments

DRM system ID

DRM Header Object

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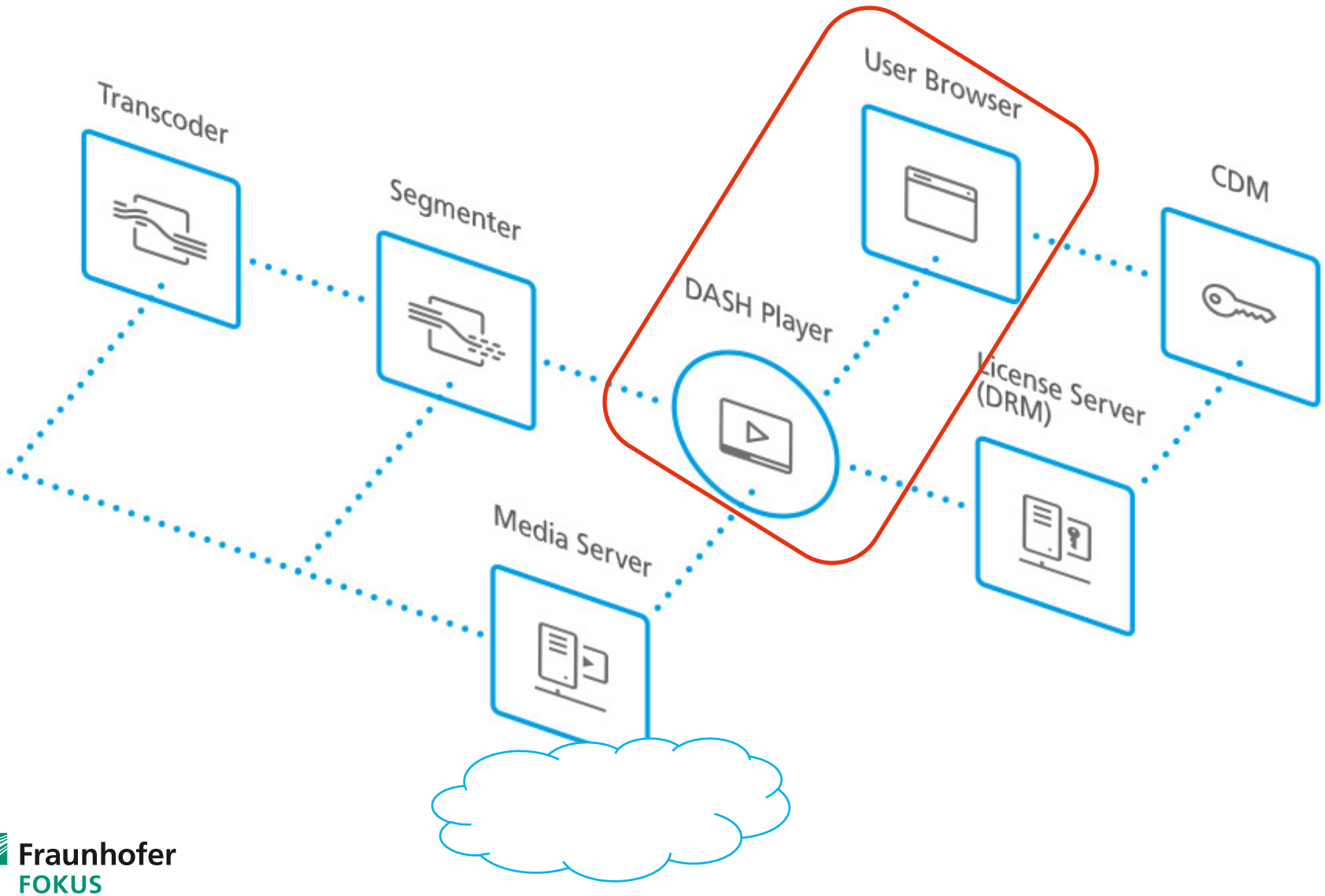
MPEG-DASH

- Highlighted Features

  - Adaptive on demand and live streaming.
  - Efficient use of existing CDNs, proxies, caches, NATs and firewalls.
  - Control of entire streaming session by the client.
  - Support of seamless switching of tracks.
  - Signaling, delivery, utilization of multiple DRM schemes.
  - Supports ad-insertion.
  - Segments with variable durations.

OVERVIEW



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Web & Media I

Browser-based MPEG-DASH Playback

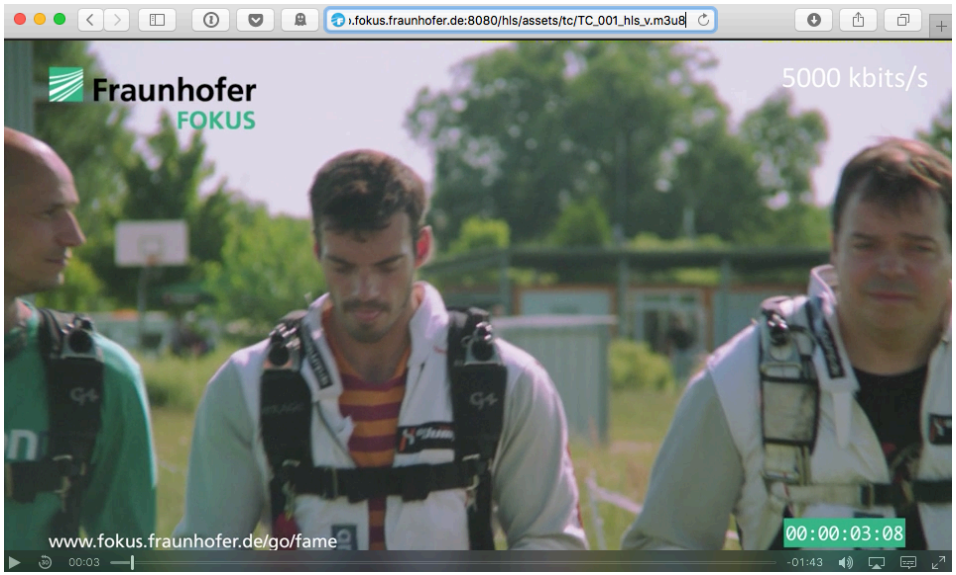
TYPES OF BROWSER-BASED DASH PLAYBACK

- Type 1: HTML5 <video>

```
<video id="video" controls width=1280 height=720
                src=”dash.mpd"></video>
```

- Type 2: HTML5 <video> + ABR API
- **Type 3: Media Source Extension (MSE)**

Source: http://blogs.windows.com/msedgedev/2015/07/02/moving-to-html5-premium-media/



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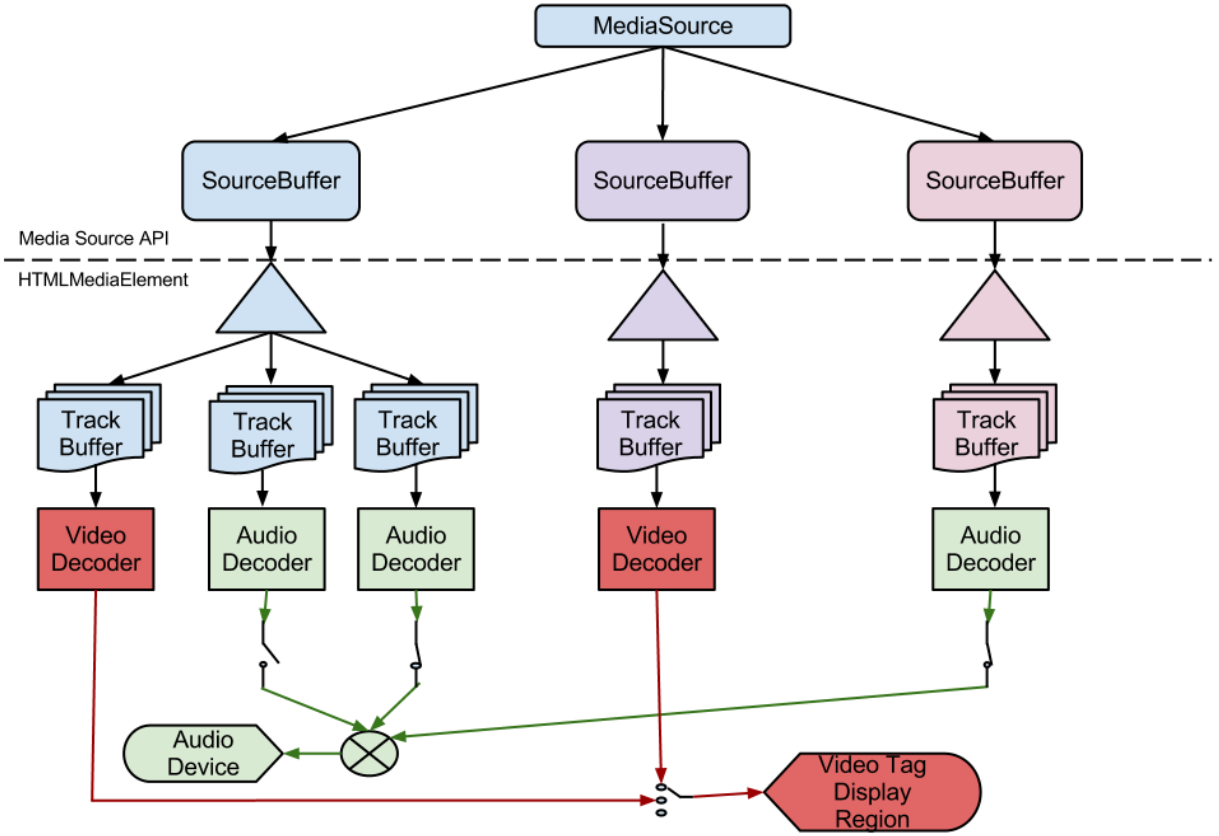
STANDARDS - DASH&DRM
W3C MEDIA SOURCE EXTENSIONS

- Candidate Recommentation (31 March 2015)
- https://dvcs.w3.org/hg/html-media/raw-file/tip/media-source/media-source.html



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W3C MSE – SIMPLIFIED CODE EXAMPLE

```
<html>
<video id='video‘ autoplay>empty</video>
</html>
...
<script>
[MPD parsing]
....

var mediaSource = new MediaSource();

var video = document.getElementById('video');
video.src = window.URL.createObjectURL(mediaSource);

mediaSource.addEventListener('sourceopen', function(videoTag, e) {
  ...
  var sourceBuffer = mediaSource.addSourceBuffer('video/mp4');
  sourceBuffer.appendBuffer(segment);
  ...
}, false);
</script>
```

Resolve segment URLs

MediaElement points to MediaSource now

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WIDE AVAILABILITY OF MSE DASH PLAYERS

- Dash.js: „A reference client implementation for the playback of MPEG DASH via Javascript and compliant browsers“
  - *https://github.com/Dash-Industry-Forum/dash.js*
- Shaka Player
  - https://github.com/google/shaka-player
- JWPlayer, rx-player, DASH PLAY, bitdash, video.js and many more

- Additional support for ad insertion, content protection etc.

DASH ANNEX D METRICS

In Annex D of MPEG DASH (ISO/IEC 23009) metrics are defined - also referenced in SAND (Part 5):

- TcpList
  - List of HTTP request/response transactions
    - Not available in browsers
- HttpList
  - List of HTTP request/response transactions
- RepSwitchList
  - List of Representation switch events (a switch event is the time at which the first HTTP request for a new Representation, that is later presented, is sent)

DASH ANNEX D METRICS

- PlayList
  - A list of playback periods. A playback period is the time interval between a user action and whichever occurs soonest of the next user action, the end of playback or a failure that stops playback

- BufferLevel
  - List of buffer occupancy level measurements during playout at normal speed

DASH.JS BITRATE ADAPTATION

- Dash.js Bitrate Adaptation makes use of these metrics
- General idea:
  - Define ruleset for each task:
    - Bitrate change?
    - request more segments?
    - find live edge
  - Each rule responds with a recommendation and a priority
    - Example: Bitrate change?
      - ThroughputRule → high throughput: (switch up, default prio)
      - InsufficientBufferRule → low buffer level: (don‘t switch, strong prio)

      → Don‘t switch

MPEG-DASH PART 5 – SAND - REPORTING

- SAND will specify a reporting scheme for above metrics
- Reporting will be added via MPD

```
<Metrics
metrics="BufferLevel,HttpList,RepSwitchList,PlayList">
<Reporting schemeIdUri="urn:mpeg:dash:sand:channel:2016"
value="http://example.url"/>
</Metrics>
```

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DASH IF WORK ON METRICS

- Startup time
  - time from when manifest is first requested, to when either audio or video is perceivable by the end user.
- Rebuffer count
  - the number of rebuffering incidents, of any duration, that have occurred from the start of playback to the time at which this data is requested, or playback has terminated, whichever is earlier
- Rebuffer rate
  - the change in rebuffer count that has occurred over a given time period
- Rebuffer percentage
  - the time spent in a rebuffer state over a given wall-clock interval

DASH IF WORK ON METRICS

- Average rendered video|audio|total bitrate
  - the average media bitrate rendered by the player from the start of the presentation to when the metric is requested or the presentation is complete, whichever is earlier
- bitrate switch count for audio|video
- Dropped frame count for video

DEMO: „SILENT TV” (MEDIA SYNCHRONIZATION)

Setup

- Demuxed A/V tracks (english/spanish)
- Node.js synchronization Server using WebSockets
- Synchronizes HTML5 <video> events

CONTACT

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THANKS FOR YOUR ATTENTION

Fraunhofer FOKUS