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**Title** Extensions for Hybrid Delivery using MPEG-2 TS and DASH  
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## **1 Introduction**

With the growing adoption of connected TVs or set-top boxes, it is worth investigating whether enhancement to broadcast services could be delivered through a broadband link; this would allow broadcasters to address their complete user base through their broadcast network, thereby minimizing their broadcast costs, while offering premium services of various kinds to specific users; we can cite many use cases:

- Enhancing a 2D service into a 3D one using MVC enhancements, service-compatible AVC or HEVC stream;
- Enhancing a SD/HD service into a HD/UHD using SVC or the upcoming HEVC Scalable standard;
- Switching views in a live sport event;
- Switching audio to any possible language or high definition version.

MPEG-DASH already has all the tools needed to handle synchronization of streams coming from different broadband servers, potentially with different timelines, and also provides a complete framework for 3D enhancements, scalable enhancements or free viewpoint video. This makes the DASH specification a good candidate to address the above scenario.

## **2 Problematic**

There are a few issues to face when trying to use an existing MPEG-2 TS broadcast in a DASH environment (or vice-versa), as described below.

### **2.1 MPD Delivery**

If the MPD is delivered through the TS program, then the MPD can clearly identify one program in the TS, for example if carried as a PMT descriptor. If completely carried out of band (no link from the TS to the MPD), the MPD will need an extra mechanism to identify the TS multiplex (satellite ID and position, frequency...), as well as a mechanism to identify which program in the TS is enhanced by the DASH session. Furthermore, it would require an out-of-scope mechanism to identify, from within a broadcast channel, where, if any, MPDs can be found to enhance the stream.

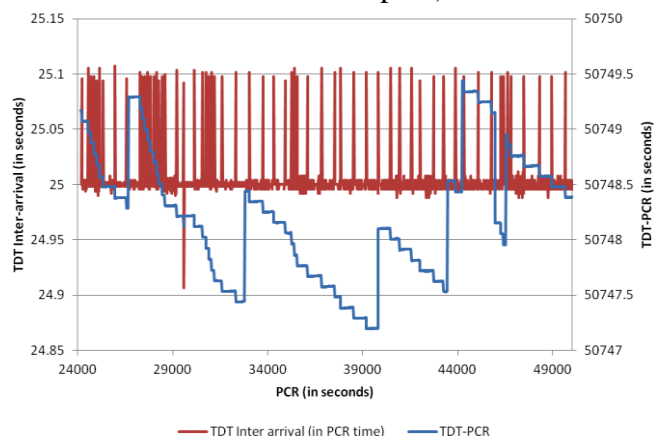
## 2.2 Media Component Identification

How can the media component from the TS program be identified in the MPD? Using PIDs seems like the natural way of doing so, since most DTV architectures use fixed PIDs in each of their multiplex. Relying on external SDOs tools, such as DVB componentId or triplet, might not help in DTV over IP networks.

## 2.3 Media Timeline recovery

How is the mapping between the broadcast timeline and the MPD timeline done? There has been quite a few experiments on broadcast enhancements [2][3] with synchronized broadband services, which can be summarized as follows:

- Estimate the media timeline of the broadcast through techniques such as fingerprinting [1][3]: these techniques are computationally heavy, but most importantly do not guarantee enough accuracy to enable frame-based synchronization, which rules out all scalable-coding based scenario envisioned.
- USE PCR information to map the timelines of the broadcast to the DASH timeline: while quite convenient as DASH already has tools dealing with PCR and timeline reconstruction, this technique is not practical in a real broadcast environment: the broadcaster equipment may change the PCR of the stream without the broadband content publisher knowing it; even in cases where PCR feedback could be used, a PCR discontinuity would imply a re-authoring of the MPD which should then be re-evaluated at the client at the exact time of the discontinuity ...
- Use UTC timing information present in the TS stream[4]: the TDT table sent in the TS multiplex carries the current UTC time and date for the media stream. However, investigations showed that the time of insertion of this table is not really precise and drifts a lot from the PCRs of the programs, up to a couple of seconds as shown in the following figure (stats on a French DVB-T multiplex).



Apart from the complexity of synchronizing the UTC clocks of both broadcast and broadband servers, achieving frame-synchronization with such techniques will imply major upgrade of the existing broadcast equipment to get rid of any possible drift in the TDT (or any other descriptor) insertion.

- Streaming the media timeline along with the broadcasted content[5]: this technique has been successfully demonstrated [3] for 3D enhancement or secondary screen enhancements. The principle is to use PES streaming of the media time of the current

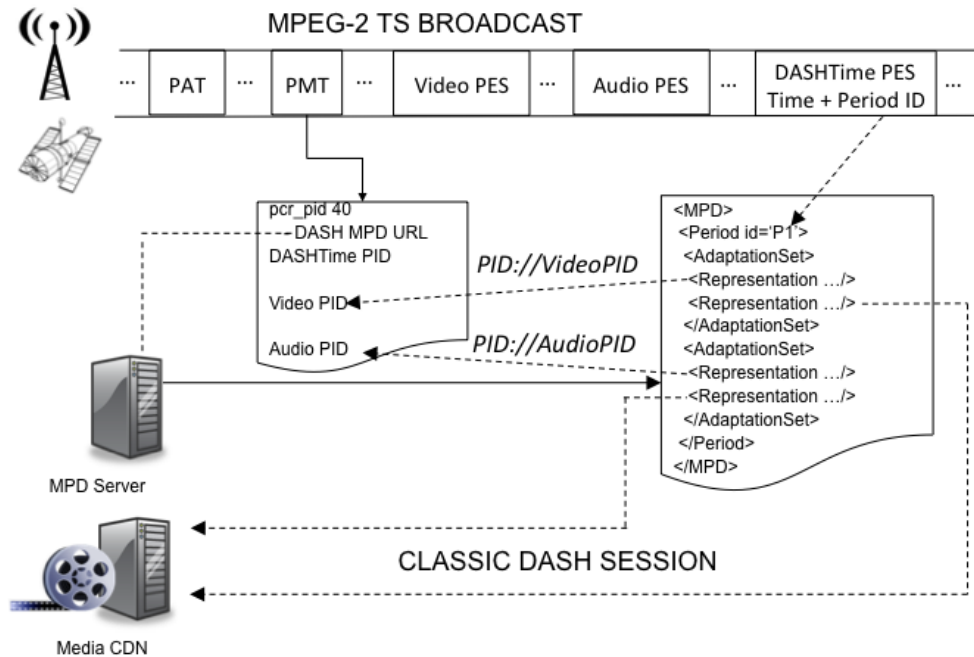
piece of content being broadcasted, including potential discontinuities due to ad insertions.

### 3 Proposal

We suggest to use PES timeline streaming as a general approach towards the problem of DASH-augmented broadcast, with the following design:

- MPD timeline of the broadcasted media components can be reconstructed from a PES packetized media timeline, synchronized with the PCR but unaffected by PCR discontinuities.
- Media Components in the broadcast can be identified through their PIDs in the DASH MPD. This avoids relying on other SDOs mechanism, which may not be relevant for all possible deployment cases of the intended framework.
- MPD is pointed to (by URL) by a descriptor carried in the PMT.
- In order to support splicing / ad insertion use cases, multiple periods within an MPD may be used, Period IDs and timeline values are streamed in a dedicated PID for each program of the TS multiplex.

Once the broadcasted content can be identified in the MPD, the client can process the MPD as usual, following DASH rules for representation selection and MPD updates, and a regular DASH session can, then take place for broadband media, as shown in the following figure.



The MPD is carried in the MPD\_Descriptor:

Syntax	No. of bits	Format
MPD_descriptor{		
descriptor_tag	8	uimsbf
descriptor_length	8	uimsbf
for (i = 0; i < N; i++){		
mpd_url	8	bslbf
}		
}		

The media streams in the TS program are identified in the MPD through a newly defined URL scheme **PID://**, specific to this hybrid context. For MPD not retrieved using this mechanism, a regular DASH client should ignore the PID URL and consider the MPD as invalid, or at least the Representation containing the broken URL. The complete program can be referred to as a single representation by using the PMT PID or PCR PID, as shown in example 1, or each component of the program can be referred to in dedicated representation using their PIDs, as shown in example2.

The **PID://** scheme shall only be used on SegmentBase elements in the media attribute. SegementBase elements using the **PID://** scheme in their media attribute shall not have any initialization segment related information. Indexing information may be used for time-shifting services, although this has not yet been investigated.

```
<Period id="P1">
  <AdaptationSet mimeType="video/mp2t" codecs="avc1.4D401F,mp4a" ... >
    <Representation id="R1">
      <SegmentBase media="PID://100" timescale="25000"/>
    </Representation>
  </AdaptationSet>
</Period>
```

**Example 1 – A representation for a complete broadcast MPEG-2 TS program in an MPD**

```
<Period>
  <AdaptationSet mimeType="video/mp2t" codecs="avc1.4D401F" ...>
    <Representation id="R1">
      <SegmentBase media="pid://110" timescale="25000"/>
    </Representation>
  </AdaptationSet>
  <AdaptationSet mimeType="video/mp2t" codecs="mp4a" ...>
    <Representation id="R2">
      <SegmentBase media="pid://120" timescale="25000"/>
    </Representation>
  </AdaptationSet>
</Period>
```

**Example 2 - A representation for individual PIDs of a broadcast stream in an MPD**

The MPD timeline is carried in a PES-packetized stream. The PES packet shall have a PTS set, the data\_alignment flag set to true and contain the following PES payload:

Syntax	No. of bits	Format
DASHTime_PES_Payload {		
period_switch_timer	32	uimsbf
presentation_time	64	uimsbf
for (i = 0; i < N; i++){		
period_id	8	bslbf
}		
}		

**period\_switch\_timer:** indicates the estimated time in milliseconds until the period identified by *period\_id* occurs. If not 0, the indicated period is not active but content from this period can be prefetched. If 0, the stream timeline is in the indicated period.

**presentation\_time:** associates the PTS indicated in the PES header of this packet to the media presentation time in the active period, expressed in the value of the timescale attribute of the SegmentBase element referring to this PID or to the PCR PID of the program . Let  $PTS_0$  be the PTS of the packet carrying presentation time  $MPT_0$ . Until a new *DASHTime* packet is received,

the PTS of subsequent PES packets of other PIDs in this program have a Media Presentation Time, relative to the period start (cf 7.2.1 of DASH spec), of:

$$\text{MPT (in seconds)} = (\text{PTS} - \text{PTS}_0) / 90000 + (\text{MPT}_0 - \text{@presentationTimeOffset}) / \text{SegmentBase.timescale}$$

If *period\_switch\_timer* is not 0, this value can be ignored.

**period\_id**: indicates the name of the current period of the program. When a DASH hybrid client detects a change in the period id, it shall switch to the indicated period\_id regardless of the current payback state of other broadband media. If this string is empty, this implies that no MPD is currently associated with the program.

## 4 Conclusion

In this contribution, we have presented some use cases for hybrid broadcasting, reviewed the different approaches towards solving these scenarios and explained how the MPEG-DASH standard provides most of the tools needed to fulfill them. We have proposed a light solution compatible with existing infrastructure ensuring a frame-accurate synchronization between broadcast and broadband stream, and suggest its adoption in the DASH and MPEG-2 TS standards.

## 5 References

- [1] J. Haitzma, T. Kalker, and J. Oostveen, "Robust Audio Hashing for Content Identification Robust Audio Hash Definition," in International Workshop on ContentBased Multimedia Indexing, 2001, vol. 4, no. 82, pp. 117–124.
- [2] <http://www.bbc.co.uk/blogs/researchanddevelopment/2012/01/implementing-startoffsettime-f.shtml>
- [3] C. Howson, E. Gautier, P. Gilberton, A. Laurent, and Y. Legallais, "Second screen TV synchronization," in *2011 IEEE International Conference on Consumer Electronics -Berlin (ICCE-Berlin)*, 2011, pp. 361-365.
- [4] C. Concolato, S. Thomas, R. Bouqueau, and J. Le Feuvre, "Synchronized delivery of multimedia content over uncoordinated broadcast broadband networks," in Proceedings of the 3rd Multimedia Systems Conference on - MMSys '12, 2012, p. 227
- [5] ETSI TS 102 823 "carriage of synchronized auxiliary data in DVB transport streams"