

DASH IN ATSC 3.0: BRIDGING THE GAP BETWEEN OTT AND BROADCAST

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ABSTRACT

ATSC 3.0 is the next-generation broadcast television suite of around 20 standards including transmission, audio, video, captioning, metadata, watermarking, companion devices, security, and personalization. Among others, ATSC 3.0 uses MPEG DASH delivery format for broadcast and broadband delivery of media and data. In order to fulfil the use cases and requirements of ATSC 3.0 including broadcast-only, broadband and hybrid (broadcast/ broadband) delivery, as well as a multitude of new features, DASH-IF developed a DASH interoperability profile specifically designed for ATSC 3.0 standard. This profile supports broadcast and broadband delivery, codec signalling (audio, video, subtitle), interactivity & events, metadata, targeted & personalized ad insertion, and advanced security & content protection schemes. By the choice of DASH formats and HTML-5 based applications, ATSC 3.0 services are expected to be consumable not only on vertically integrated devices such as TV sets, but also on other types of devices such as PCs, tablets, game consoles and mobile phones. This paper will introduce the rationales, benefits and opportunities of such an approach and provide an overview of the ATSC 3.0 DASH profile.

INTRODUCTION

ATSC 3.0 revolutionizes TV broadcast distribution. For the first time, a hybrid system is designed from day 1 in order to support broadcast and broadband distribution in an integrated manner and to target different receiver platforms. In order to leverage the advances in standardized OTT video distribution, ATSC has decided in ATSC A/331 Candidate Standard (1) to distribute the TV content with DASH-based media formats, for both broadcast and broadband distribution. In an ongoing collaborative effort, ATSC and DASH Industry Forum (DASH-IF) are developing a DASH profile for ATSC 3.0 use cases, addressing the convergence between broadcast and OTT content distribution. In addition, as DASH naturally interfaces with HTML-5 browsers, ATSC 3.0 convergence with the web world is also inherently achieved. In the remainder of this paper, the ATSC 3.0's architecture around DASH as well as the technical enablers are introduced.

ATSC 3.0 ARCHITECTURE AND PROTOCOL STACK

ATSC 3.0 not only supports broadcast services, but also integrates the ability to distribute parts of the service over unicast, primarily over an HTTP CDN. Figure 1 provides a high-level architecture that shows that both delivery paths, broadcast and broadband, terminate in a single DASH player. This is achieved by abstracting the broadcast transport to an object oriented protocol.

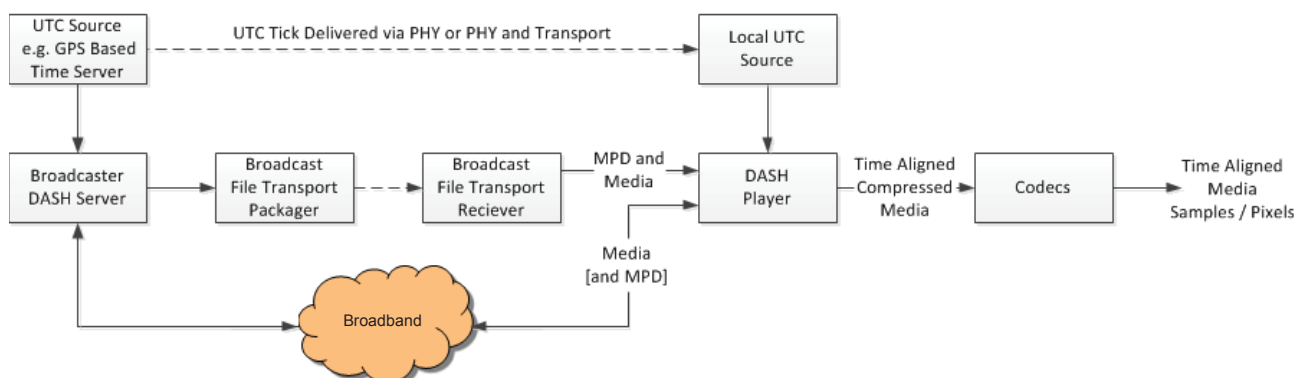


Figure 1 ATSC 3.0 Hybrid Delivery Architecture

According to the ATSC Delivery Specification A/331 (1), the protocol stack, as presented in Figure 2 defines the major components of the ATSC delivery system. In particular, DASH formats play a central role as the encapsulation and delivery format, in the context of ATSC3.0 for broadcast, broadband and hybrid delivery.

In case of broadcast delivery, the interface between the underlying delivery system and the DASH Player is conceptually based on an HTTP proxy that is included in the receiver. In addition to the interfaces to the transport system, the DASH Player also provides the functionality to playout media properly and to interface with native or downloadable applications, typically in a browser-centric environment.

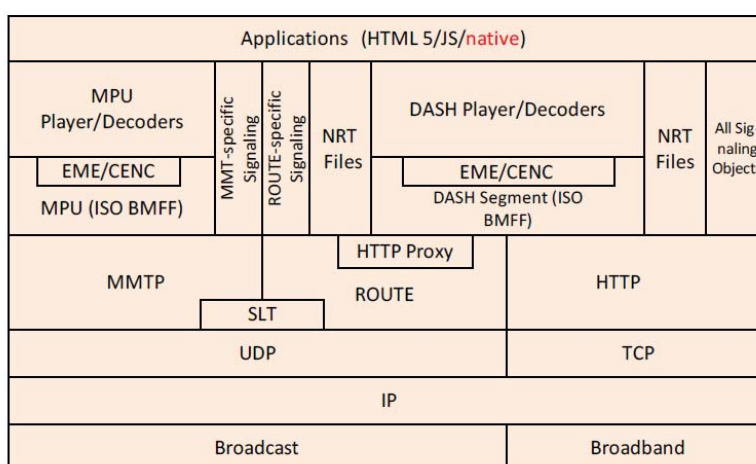


Figure 2 ATSC 3.0 Protocol Stack ©ATSC

By using DASH as the format for broadcast and unicast, a single encoding chain, media format and player can be used to support broadcast-only, broadband-only and hybrid services. Such an approach is unique to ATSC3.0 and enables convergence of broadcast and over-the-top/broadband services.

REFERENCE CLIENT

Architecture and Functions

Although ATSC 3.0 only defines an emission standard, the definition of a reference client was considered ultimately important in order to map the emission profile to decomposed functions on the client, to identify the functions included in the DASH client and those that are external. Figure 3 provides an overview of basic functions and interfaces (IF) that are established in order to de-compose the signaling and processing routines of the DASH Player.

The DASH Player acts as a component in the ATSC 3.0 receiver. The *ATSC 3.0 Physical Layer connections* and broadband connections provide the connection to the network and service provider to receive service signaling and data. *Transport ROUTE/UDP/IP and HTTP/TCP/IP* (4) both provide an object oriented protocol running on top of IP in order to receive DASH resources as well as other objects and files that are relevant for the service. A local *HTTP proxy* may be used to abstract the underlying physical and transport layer to the application, in particular to the DASH player. Also application specific data, transient service objects and non real-time (NRT) content may be provided through the HTTP proxy. *Low-Level Signaling* describes one or multiple services which may be used by the *Basic TV Function* in order to select services. *Service Signaling* picks up any service-related signaling for the specifically selected services in order to provide static and dynamic configuration of the service and is strongly aligned with 3GPP MBMS service signaling in TS 26.346 (3). The *cache* handles objects that are delivered through service signaling, typically the Media Presentation Description (MPD). The *basic TV function* provides at the minimum rendering capabilities for A/V services as well as a simple mean for interactivity, typically a remote control. The *Application/Interactive Presentation* function is provided by a native or downloaded application that makes use of ATSC 3.0 delivered objects in order to provide a potentially richer presentation to the end user. *ATSC Event function* consumes ATSC 3.0 events.

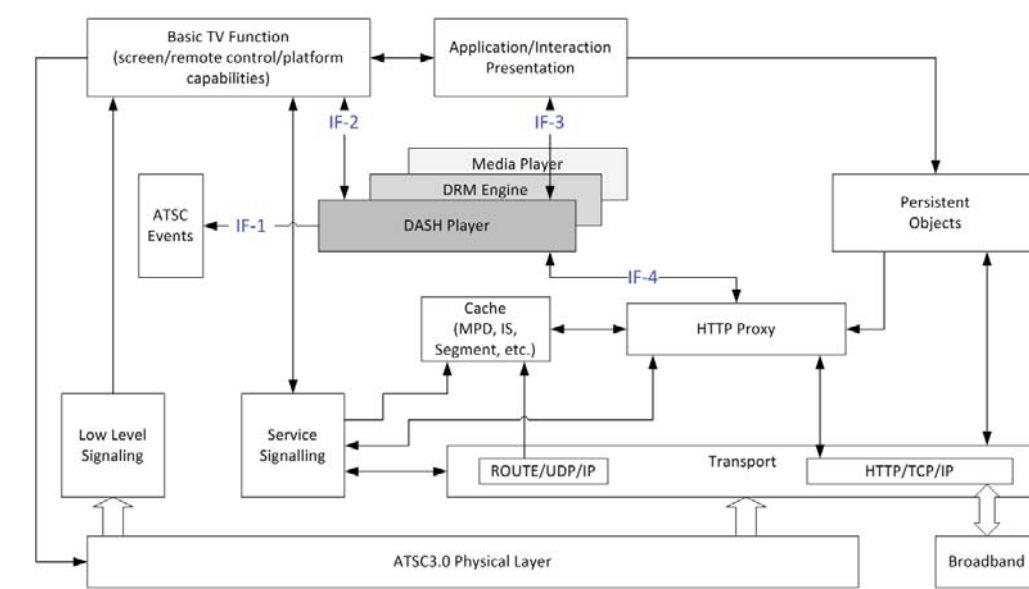


Figure 3 Client Reference Model

The *DASH Player* consumes MPDs and Segments and communicates with the environment to personalize the media experience based on platform capabilities, user preferences, and user interaction. The DASH Player also provides information to a DRM engine and media player in order to decrypt and decode media. *Persistent Service Objects* are typically non-real time object delivery services that may provide resources for a DASH Media Presentation through the HTTP Proxy.

Interfaces

The interfaces in Figure 3 enable a DASH Player to communicate with the environment in order to ensure a proper service consumption. The shown functions exchange information that supports the processing and playing out the media. The conceptual interfaces are: however some of them may exchange information in a more formalized manner using well-defined APIs.

- IF-1: If the DASH player receives ATSC3.0 specific events, the events are dispatched to the ATSC3.0 event application through this interface.
- IF-2: If the service metadata includes an MPD, the MPD is handed to the DASH player and the DASH player is initiated. In addition, the DASH player may exchange capability information with the TV platform, for example on rendering and DRM capabilities, as well as on user preferences and settings.
- IF-3: If the service is primarily app-based then the app and the DASH player communicates on different aspects, including capabilities, personalization, app-specific events and targeting.
- IF-4: A regular HTTP interface between the DASH player and the proxy that is available as `http://localhost`. The interface follows HTTP methods, but some extensions may be used for error robustness and network information.

Capabilities

In order for a DASH Player to select the appropriate streams, it needs to obtain information from the environment on the capabilities of the decoding and rendering system. For video, such capabilities include the supported codecs with profile and levels, the rendering capabilities (spatial and temporal resolutions, scan format, dynamic range and supported color space), 3D support, etc.. For audio, such capabilities also include the supported codec with profile and levels, rendering capabilities and environment (stereo, 5.1 speaker configuration, immersive sound system, binaural headphones, etc.), user preference and personalization (for example based on accessibility, rating or language settings) or based on user interaction and personalization. Language settings are typically also relevant for text and captioning, and certain devices may support image based subtitles. On transport level, receivers differentiate between broadcast reception only and combined broadcast and broadband reception. In addition, in case of broadband, the maximum supported access rate may be of relevance as well. Other capabilities may include the supported DRM systems on the device as well as the availability of personalization information.

DASH FEATURES FOR ATSC 3.0 USE CASES

Introduction

Based on a set of requirements for different categories developed by ATSC 3.0, a DASH profile was developed that addresses the use cases, but at the same time takes into account the convergence of ATSC 3.0 delivery formats with OTT delivery formats. As a baseline for the DASH formats, the DASH-IF Interoperability Point (5) is considered, with the available extensions for different media profiles. A DASH-IF inter-operability point (IOP) provides a basic DASH profile for MPDs and segments formats, specific recommendations for live services based on this profile, enablers for targeted ad insertion, content protection recommendations as well as media profiles for video, audio and captioning. However, in order to address all requirements for ATSC 3.0, extensions to the latest DASH-IF's IOP are necessary and the relevant ones, along with the key use cases, are provided in the following.

DASH Broadcast TV Profile for Broadcast and Hybrid Services

In Broadcast Distribution, the broadcast channel is the only communication channel available to the DASH Player. Therefore, the DASH Player can only receive MPDs and media segments through the broadcast channel. In contrast to hybrid delivery, no return channel capability is available. Key aspects for linear TV services, in particular, broadcast services, are end-to-end latency and rapid channel change times. The distribution format integrates with ROUTE/UDP/IP for broadcast. The distribution format needs to support synchronization of supplemental content, such as accessibility components, supplementary languages, etc. with primary content at the receiver, referred to as late binding. In addition to the broadcast channel, a broadband channel may also be available to the DASH Player. Since only a single MPD is used to signal details of Media Segments, the DASH Player may receive one MPD for entire program and then receives the corresponding Media Segments through the broadcast channel and/or the broadband channel.

Based on these requirements, a Broadcast TV profile is developed together with MPEG that addresses the use cases taking into account the following features beyond the DASH-IF IOP (5):

- In order to support low-latency, random access, adaptive switching, and highest compression efficiency, different segment types are defined in order to address the individual functionalities, namely delivery units, random access units and switching units. These segment types extend the DASH-IF IOP (5) as in the DASH-IF requirements, each Segment is at the same time delivery unit, random access unit and switch point. Whereas this simplified initial deployments, it did not address compression efficiency and latency requirements of ATSC. These extended segment types are also defined in DASH TV Broadcast profile, a new part of the upcoming 3rd edition of MPEG's DASH specification.
- Segment address and time signalling is restricted to Segment Timeline only in order to address different use cases, including switching and random access point signalling, gap signalling in case of losses, and support for redundant server setup.



- Segment addressing is primarily based on a number-based template in order to support efficient prediction on transport level and avoid repeated delivery of metadata.
- Extensions for metadata to support the codecs and requirements as documented in following.

Supporting ATSC 3.0 Video Codecs

The codecs and formats considered for ATSC 3.0 video support up to 3840 x 2160p at 120 fps are HEVC Main 10 or Scalable Main 10 Profile, Level 5.2, Main Tier. The HEVC coded video supports legacy SD video and Interlaced HD video for support of legacy content, and Progressive Video for new content. The legacy SD and Interlaced HD video formats are supported for the single rate delivery since the legacy content is not usually available in multiple adaptive bitrates. The ATSC 3.0 Progressive Video allows the full range of advanced features including high dynamic range (HDR), wide color gamut (WCG), 3D, and temporal layering. To support signalling of the different video features, DASH-IF IOP (5) needs extensions as follows:

- MPD signalling up to the profiles and levels for all supported codecs.
- Signalling of additional format properties, in particular legacy SD video and Interlaced HD video, dynamic range and WCG, and 3D capabilities. These are based on the signalling available in the Codec Independent Code Points and on the usage of DASH extensions mechanisms based on Essential and Supplemental property descriptors.
- Support for and signalling of temporal sub-layering to support HFR and regular frame rates in one bitstream.
- Support for scalable coding signalling in the MPD to support different use cases for static and dynamic adaptation using Scalable High Efficiency Coding (SHVC).
- Encapsulation of the media into the ISO Base Media File Format (BMFF) to support all use cases including switching, random access, delivery, as well as late-binding synchronization.

Supporting ATSC 3.0 Audio Codecs

The codecs and formats supported by ATSC 3.0 for audio are innovative and require extensions to DASH formats to support all use cases. The primary extensions of the formats are the use of Next Generation Audio codecs (AC-4 and MPEG-H Audio), which include channel-based audio and: object-based audio and, in the case of MPEG-H audio, scene-based audio. The use cases expect signalling support such that the client can select audio components based on e.g.: the audio language preference setting of the receiver, accessibility settings of the receiver, codec capabilities of the receiver output preference of the receiver (e.g. stereo vs. multichannel output), signalling of immersive and personalized content, or also the network connectivity if applicable (access to supplementary audio content such as foreign language audio via Broadband).

To support signalling of the different audio features, the DASH-IF IOP (5) needs extensions as follows:

- MPD signalling up to the profiles and levels for all supported codecs, AC-4 and MPEG-H audio
- Signalling of additional format properties, including object-based audio and scene-based audio, and audio rendering capabilities
- Signalling of metadata in a codec-independent manner to support selection of audio elements based on Preselections. A system model is provided in Figure 4, for which a main audio element contains music and effects and English dialogue, but in addition other audio elements (language, role) are provided and can be selected at the receiver base on presets (language, accessibility, capabilities on codec and network level, or user interactions).

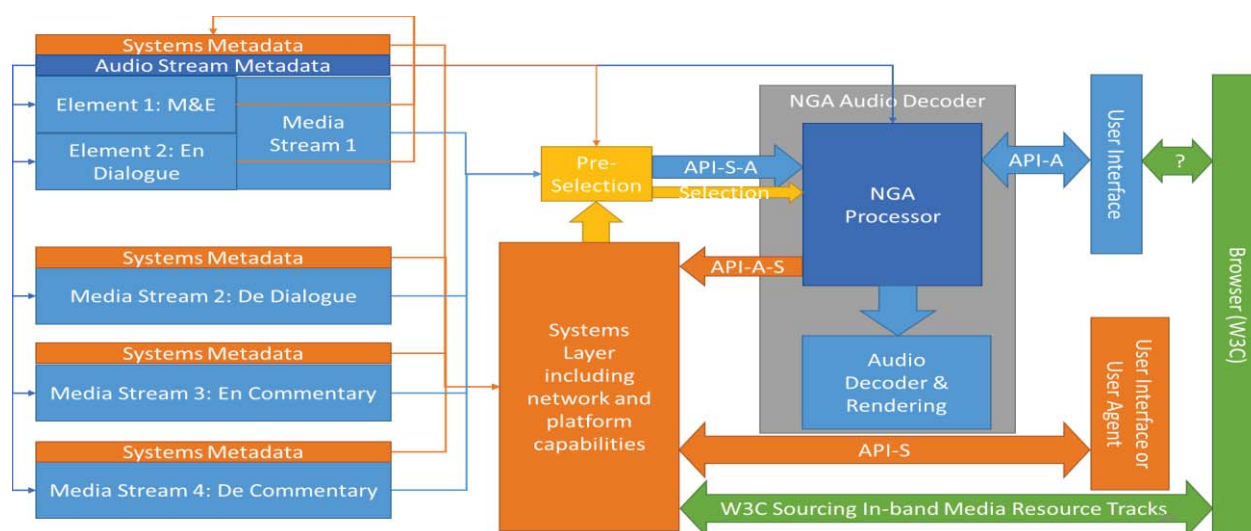


Figure 4 ATSC3.0 Audio Receiver Model

- Provision of label information for basic user interfaces, potentially in support with browsers.
- Encapsulation of the media into the ISO BMFF to support all use cases including switching, random access, delivery, as well as late-binding synchronization.

Note that the MPD extensions to support Next Generation audio are also proposed to the upcoming 3rd edition of MPEG DASH specification.

Captioning, Events and Metadata

In addition to the main codecs, additional extensions are necessary in the DASH-IOP to support different use cases for signalling and selection.

- The ATSC 3.0 subtitling and closed caption requirements need to be supported. Whereas DASH-IF IOP fulfils most of them with the support of Timed Text Markup Language (TTML) and CEA-608/708, ATSC 3.0 adapted signalling is necessary.



- ATSC 3.0 Events needs to be carried and forwarded to the appropriate handler. For this an ATSC event scheme is defined in order for the DASH player to appropriately treat those events and provide them to ATSC Event module.
- Support for all types of metadata specific to ATSC 3.0 is necessary. This includes program definition, rating schemes as well as information related to 24/7 programs.

Ad Insertion

Ad Insertion in ATSC 3.0 includes different functionalities that require extensions of the DASH-IF IOP (5), primarily as follows:

- Support for server side and client side ad splicing, including change of formats and codecs at the splice point. This is typically supported by the use of multiple Periods in DASH.
- Support of targeted ads based on communication with a broadcast application. This is typically supported by xlink, i.e. resolution of a data structure based on personalization, regional or targeting information.
- Support for just-in-time ad insertion, based on triggers from the content provider, for example using SCTE-35 messages.
- Support for splicing locally stored ads, ads that are available on broadband and are spliced, default ads or ads delivered in real-time through broadcast.

Note that the basic principles are all supported in the DASH-IF IOP (5), only some updates are necessary in order to provide consistent signalling.

Security

Requirements for security, conditional access, content protection, and Digital Rights Management (DRM) require extensions of the DASH-IF IOP (5), primarily as follows:

- Support for common encryption in order to ensure scalable and efficient delivery.
- Support for key rotation in order to address different live streaming use cases.
- Support for licences acquisition in broadcast-only and hybrid modes.
- Support for secure delivery over broadcast and broadband delivery addressing typical security threats such as man-in-middle attacks, spoofing, privacy violations, etc.

CONCLUSIONS AND NEXT STEPS

In a world where the way to watch TV content has dramatically changed, ATSC 3.0 takes into account new consumption model paradigms in its broadcast media distribution. The ATSC 3.0 specifications together with the DASH profile for ATSC 3.0 promise a convergence of broadband and broadcast, as well as with OTT, web and managed TV services. The ATSC 3.0 worldwide standard may serve as an example model for other standards and consortiums currently looking into IP-based distribution of broadcast TV services.

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