Application Oriented Proposal to manage Scalable Video for the Next-Generation of Brazilian DTV Broadcasting System

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ABSTRACT

This paper aims to introduce a new approach to play and control Scalable Video (high-quality video bitstream that also contains one or more subsets of bitstreams) in the next-generation Brazilian DTT (Digital Terrestrial Television) system, called TV 3.0. While current Brazilian DTT system (TV 2.5) is oriented by channel selection, TV3.0 aims to adopt an application-oriented approach, in which TV context is driven by application. This new scenario will allow TV broadcaster to improve quality of video content by applying Video Scalability in the Brazilian middleware for interactive applications (named as DTV Play). This paper proposes an extension of DTV Play API and presents a proof-of-concept in which a DTV Play application is able to select the Scalable Video content mapped in MPD (Media Presentation Description), so that videos may be presented with better quality when Scalable Video BL (Basic layer) is combined with EL (Enhancement layers).

KEYWORDS

Scalable Video, DTV Play, Rest-API, TV 3.0, Digital TV, Application-Oriented, Standardization

1 Introduction

The introduction of digital technology has revolutionized the way viewers watch and interact with TV. Ginga is the name of the middleware for the Brazilian DTV interactive system [21].

In 2018, new features to improve integration between broadcast and broadband services were added to Ginga middleware. Thus, Ginga evolved to a fully compliant IBB (Integrated Broadcast Broadband) standard and was renamed to DTV Play [9]. DTV Play is embedded in some TV receivers since 2021 [10].

In 2020, SBTVD Forum (*Fórum do Sistema Brasileiro de Televisão Digital*, Brazilian Digital Terrestrial Television System Forum), entity responsible to define the standard for DTT system used in Brazil, announced a CfP (call for proposals) for the next-generation Digital TV system, named TV 3.0. Through CfP, organizations like standardization bodies, universities and research labs were invited to propose solutions for the requirements defined for TV 3.0 in its various components, such as video coding and app coding [1].

Some TV 3.0 requirements include UHD (Ultra-High Definition) support, scalable video support, IP-based network protocol support and backward-compatibility with DTV Play.

After proposals were evaluated, ROUTE/DASH (Real-Time delivery over Unidirectional Transport - Dynamic Adaptative Streaming over HTTP (Hypertext Transfer Protocol)) was chosen as the transport layer protocol, and LCEVC (Low Complexity Enhancement Video Codec) as the scalable video technology [20].

There are some related approaches to improve the video quality by using scalable video technology. Jae-young Lee at al. [13] describes an ATSC (Advanced Television System Committee) 3.0 based system that is capable to send BL via broadcast and EL via broadband. Their work describes the use of broadband service to complement, improve, or even replace completely the broadcast transmission if reception area is shadowed.

Another work proposed by Hyun-Jeong Yim at al. [23] proposes an ATSC 3.0-based solution to provide 8K service that is compatible to legacy 4K receivers. In their approach, a BL with 4K resolution video is transmitted through RF (radiofrequency) signal using MMT (MPEG Media Transport) or ROUTE as transport protocol, while EL is received from broadband media using DASH protocol. In 8K receivers, BL can be combined with EL to provide 8K resolution video.

Both works provide ways to increase the output video resolution by combination of BL and EL. However, they do not address the scenario involving broadcast application nor establish a correlation between video enhancement control and its usage by applications.

This paper uses a different approach, in which an application selects an enhanced video stream in MPEG-DASH (Moving Picture Experts Group - Dynamic Adaptative Streaming over HTTP) descriptor file - named as MPD (Media Presentation Descriptor) – to be played. This paper proposes a way to play scalable video stream in a TV program, defining video quality by broadcaster's policy and by receiver profile. This could be done by

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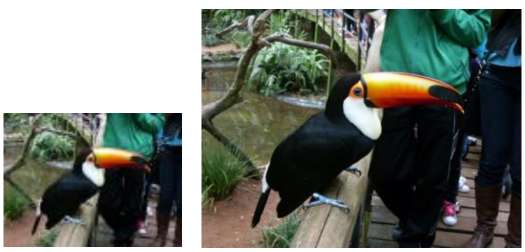
creating a DTV Play application that configures scalable video in MPD file. This paper is organized as follows: Section II provides background of video scalability and its advantages. Section III explains DTV Play, describes the MPD file format and proposes new Application Programming Interfaces (API) to add in DTV Play standard for TV 3.0. Section IV describes the proof-of-concept developed to evaluate the new API. Section V presents the results and Section VI concludes the paper.

2 Video Scalability Principles

Scalable video coding is a feature that encodes a video bitstream in two or more layers, each one carrying different quality of the same video content [6], [18]. The BL carries the lowest video quality, while the ELs are encoded referencing the BL to provide video enhancement [6]. Scientific literature classically defines three types of video scalability: spatial, temporal, and quality [6].

The spatial scalability offers an opportunity to decrease spatial resolution [6], [12], allowing the extraction of bitstreams with different resolutions from the full bitstream.

While the BL conveys the main content encoded with low resolution, the EL carries the information for decoding full resolution image, as shown in Figure 1.



Low Resolution (BL) / High Resolution (EL)

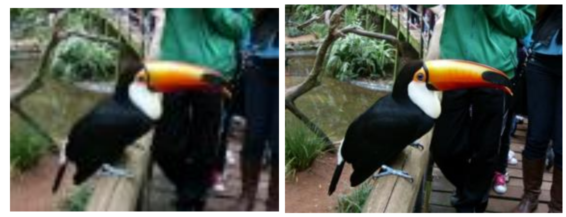
Figure 1: Spatial Scalability

The temporal video scalability affords possibility of reducing video frame rate [6], [12], allowing the extraction of bitstreams with different temporal resolutions (frame rate) from the full bitstream. In this case, the BL conveys the video content encoded with LFR (Low Frame Rate), and the EL carries data to increase the video frame rate, as shown in Figure 2.

Low Frame Rate (BL) / High Frame Rate (EL)

Figure 2: Temporal Scalability

SNR (Signal to Noise Ratio) scalability extends potential to decrease the video detail or fidelity [6], [12]. It is also known as quality scalability because the decoding error is related to the image perceptual quality, as shown in Figure 3.



Low Quality / High Quality

Figure 3: Quality Scalability

Figure 4 illustrates the two layers scalable video adopted in TV 3.0, where the decoder 1 receives only the BL, and decodes basic quality video sequence, while the decoder 2 receives the BL + EL, and is able to decode high-quality video sequence [18], [7], [12].

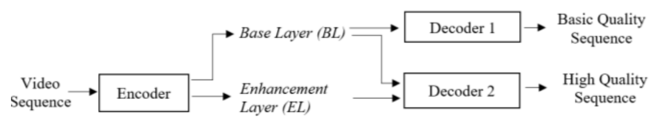


Figure 4: Video Sequence Flow: Scalable Video Coding Block Diagram

In TV 3.0, BL is delivered to TV receiver through TV broadcasting channel, using ROUTE protocol, while ELs may be delivered through Internet streaming, using MPEG-DASH service [11]. In this way, a low-profile TV receiver is able to decode BL and display a video with standard quality, while a high-profile TV receiver may display the same content with higher quality video by composing BL with corresponding ELs.

Moreover, it can offer bandwidth reduction compared to simulcasting scenario, in which content is broadcasted in videos of different resolutions. Once BL is transmitted, broadcaster does not need to deliver full video content to provide a better quality, like in simulcasting. The EL - which contains only the information needed to improve video quality from BL - can be sent instead [17], [23]. ROUTE/DASH protocols are responsible for time synchronization of both video layers.

3 DTV Play API Extension: Enabling MPD Video Scalable Selection

The ROUTE/DASH, transport layer protocol chosen for TV 3.0, uses MPD file to describe metadata required by client to construct appropriate HTTP-URLs (Uniform Resource Locators) and access media segments to play streaming service [8]. Figure 5 depicts the MPD structure [9].

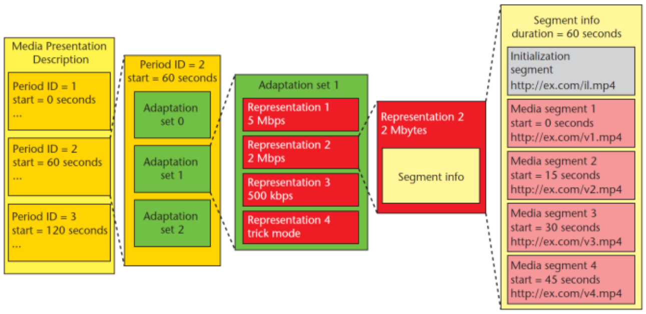


Figure 5: MPD Structure - The MPEG-DASH Standard for Multimedia Streaming Over the Internet [22]

In a traditional frequency-oriented system, each channel is linked to a frequency in TV broadcasting spectrum [2]. When the viewer selects a channel, TV tunes to the corresponding frequency and the audiovisual program modulated in that frequency is played [2]. TV 3.0 will be application-oriented [1]. In this scenario it's expected that the viewer selects the application provided by broadcaster to be launched. Such application will be able to handle the presentation of all media content delivered by broadcaster, including audiovisual program modulated in broadcaster frequency [1].

For Application coding layer, the backward compatibility with current DTV system must also be preserved, so DTV Play applications and middleware implemented for TV 2.5 can be reused [1]. DTV Play is the commercial name given to the Ginga Profile D [8], designed to enable seamless navigation through DTT and Internet, thus improving user experience [10], as presented in Figure 6 [5].

Figure 6: DTV Play Application broadcasted by TV Record [5]

ATSC 3.0 system provides a process, defined in A/344 document [4], to select video tracks in MPD file. DTV Play specification should be extended to provide the same feature in TV 3.0.

The core of DTV Play is a Web server with REST (Representational State Transfer) APIs, named Ginga CC Web Services [3]. This service can manage media players and handle MPEG-DASH media if the TV receiver has support to it.

DTV Play specification defines two operations in the route:

- http(s)://<host>/dtv/mediaplayers/<playerid>.

The **GET** operation retrieves media player information, and if player has support for MPEG-DASH, the **formatsSupported** field will return the value **dash** as one of its elements. The **POST** operation controls the media player, and player configuration is described in the message body.

The **url** attribute will point out to the URL of the MPD file that can be obtained by the application, similarly to ATSC3.0 in **Query Signaling Data API** described in A/344 [4]. The adaptation of **Query Signaling Data API** A/344 API for the DTV Play will be discussed in a future work, follow the bullet with **url** parameter of an already receiver buffered MPD:

- **url**: http://<ip>/manifest.mpd

This paper proposes an extension of ABNT 15606-11 [3], **control API for a specific media player**, to be applied in the TV 3.0, by adding a new attribute named **adaptationSet**, in message body to choose one of the adaptation sets defined in MPD file for media player. So, if MPD file defines scalable video in adaptation set 1, this attribute will be assigned as "**1**".

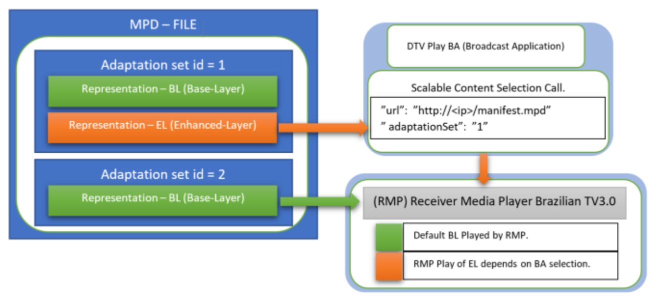


Figure 7: Proposal DTV Play selection of Scalable Content in MPD file

Figure 7 details about a DTV Play application sending an URL to the REST-API prepared to handle the additional Adaptation Set id parameter related to scalable content. Even after video selection succeeds, media player must evaluate whether video can be played, based on the available bitrate, and supported video formats. If the DTV Play application selects a scalable content to replace the video that is currently being played, but content cannot be played due to low network speed or unsupported video format, the receiver will return an error code and shall not perform the requested action [4].

4 Practical Use Case of DTV Play Extended API

The DTV Play extended API was proposed to allow user to select video resolution in a scalable video declared by a MPD file. To validate this proposal, a proof-of-concept was developed in a Linux environment.

The complete data flow of the proof-of-concept is described in Figure 8.

A web server was provided locally by a lightweight, native and python-based library called http-server [16]. Flask, a micro web framework, [15] was used to implement the DTV Play REST API with the proposed extension. To simulate a TV broadcast application, an HTML (HyperText Markup Language) page was created and placed on the web server. The main purpose of this page is to showcase the capability of the proposed API extension.

MPV media player [14] was chosen as the software for video playback, allowing easy customization. It accepts video selection commands in real time, during the operation and has a built-in support for reading MPD files, what is enough for proof-of-concept.

The MPD file (manifest.mpd) contains two adaptation sets. The adaptation set 1 provides low resolution video and declares base layer only. The adaptation set 2 provides high-resolution video and declares both base layer and enhanced layer.

Two buttons are presented in HTML page, when one of the buttons is pressed, the application will connect to REST server and send **POST** operation by the following route:

- http(s)://<host>/dtv/mediaplayers/<playerid>

The route receives the **url** and **adaptationSet** values in message body of **POST**:

The REST server receives the command, extracts the **url** and **adaptationSet** values from **POST** message body and requests REST API to treat the command:

- Button "Set Base Layer":
  - **url**: ’http://<ip>/manifest.mpd’,
  - api_mpd_adaptation_set: ’1’
- Button "Set Improved Layer":
  - **url**: ’http://<ip>/manifest.mpd’,
  - api_mpd_adaptation_set: ’2’

The REST-API selects adaptation set from the MPD file defined in "url" parameter and plays the selected media. The playback operation is handled by MPV Media Player. MPV starts playing a video in a loop. When REST API receives the command to handle media player, it uses the Linux socat utility [19] to relay data to MPV. In this way, adaptation set can be changed on-the-fly, while video is already being played.

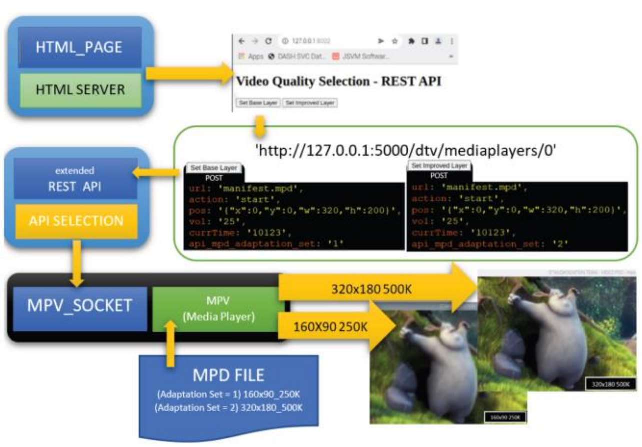


Figure 8: Proof-of-concept structure for validating DTV Play API extension

5 Results

The proof-of-concept developed to validate the DTV Play API extension was successful in selecting scalable video tracks in a MPD file that has already been processed. The setup allowed seamless switching between different video tracks, without delay or buffering effects. Considering that the MPD can represent the same content in its various sizes and complexities, this proof-of-context is able to switch among the representations efficiently.

By taking A/344 standard as reference to propose the DTV Play API extension, and by developing the proof-of-concept described in this paper based on that extension, it was demonstrated that Brazilian next-generation TV can support scalable video selection in the same way as ATSC 3.0, with a very small change in a DTV Play specification.

Once TV 3.0 is able to select scalable video tracks, broadcasters will be able to offer a differentiated service for users that are willing to pay to watch TV contents - like movies, sport events or music shows - in superior visual quality and optimized use of internet bandwidth.

6 Conclusion

Next-Gen of Brazilian DTV system is under development and opens opportunities for broadcasting with the advent of new technologies to deliver enhanced experiences to the viewers. The launch of TV 3.0 is scheduled for 2025. This paper brings a proposal to enhance video quality in TV 3.0 beyond the limitations of broadcast channel.

It was proved to be feasible by applying concepts and technologies already defined for this new TV system, with a slight adjustment in DTV Play standard. Scalable video will be supported, which means that the availability of enhancement layers can provide a better video quality when they are composed with base layer. Both base layer and enhanced layers can be declared in MPEG-DASH, which is part of the adopted transport layer protocol (ROUTE/DASH). TV 3.0 will be application-oriented, which means that an application will be launched when a channel is selected, and this application can define how video will be played. Application coding layer will be backward compatible with DTV Play: to select whether base layer will compose with enhancement layer to provide a better video quality or not, application should be able to define adaptation set media player should use. This can be done by adding a new parameter in one DTV Play API. This extension may be proposed in SBTVD Forum during the progress of TV 3.0 standardization process. This feature paves the way for broadcasters to offer the same content available on TV channel with higher quality for premium users and displays by providing enhancement layer through alternative channels. This proof of concept used spatial video scalability and was executed with video 160x90 resolution for the BL and 320x180 for the EL, using previously prepared video content, since it is targeted to validate the extension of ABNT 15606-11 proposed to select desired adaptationSet field in the MPD file. However, it supports 4K/8K video resolution, other types of video scalability, and live video. In this case, it is necessary to real time encode video content in such resolutions and properly configure MPD file with such features. A future work is to explore the possibility to evaluate a test environment as close as possible to a real user scenario. A real DTV Play application will be developed using the API extension proposed in this paper. Test setup will support both OTA (over-the-air) and OTT (over-the-top) reception, and scalable video layers will be carried by different channels. Other factors like synchronization, latency and transition between different videos qualities will be investigated.

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