ATSC Standard: 3DTV Terrestrial Broadcasting, Part 4 – Service Compatible Hybrid Delivery 3D using Broadband or ATSC NRT

Doc. A/104 Part 4
13 April 2015

Advanced Television Systems Committee
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Washington, D.C. 20006
202-872-9160

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Specifically, ATSC is working to coordinate television standards among different communications media focusing on digital television, interactive systems, and broadband multimedia communications. ATSC is also developing digital television implementation strategies and presenting educational seminars on the ATSC standards.

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Revision History

Version	Date
Document elevated to Candidate Standard	5 December 2014
Document elevated to Proposed Standard	3 March 2015
Initial version of this standard approved	13 April 2015

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ATSC Standard: 3DTV Hybrid Broadcasting, Part 4 – Service Compatible Hybrid Delivery 3D using Broadband or ATSC NRT

1. SCOPE

This document provides the detailed specification of the parameters of the Service Compatible Hybrid Delivery 3D using Broadband or ATSC NRT. This specification includes the video encoder input scanning formats, the service multiplex, the video synchronization, and the transport layer characteristics and the normative requirements.

1.1 Documentation Structure

This document provides a general overview, a technical description of Service Compatible Hybrid Delivery 3D using Broadband, a technical description of Service Compatible Hybrid Delivery 3D using ATSC NRT and a list of reference documents.

1.2 Introduction and Background

Compared with 2D broadcast services, 3D broadcast services require much more bandwidth (approximately two times more in the case of service compatible 3D). Service Compatible Hybrid Delivery 3D using Broadband or ATSC NRT was designed for accommodating 3D Broadcast Service without requiring any additional bandwidth from the ATSC Terrestrial Network. There are two mechanisms involved. The first is Service Compatible Hybrid Delivery 3D using Broadband and the second is Service Compatible Hybrid Delivery 3D using ATSC NRT. Figure 1.1 shows the outline of the scheme. The base view is transmitted over the ATSC Terrestrial Network, and the additional view is transmitted over Broadband or ATSC NRT. So, the additional view does not require additional bandwidth from the Terrestrial Network.

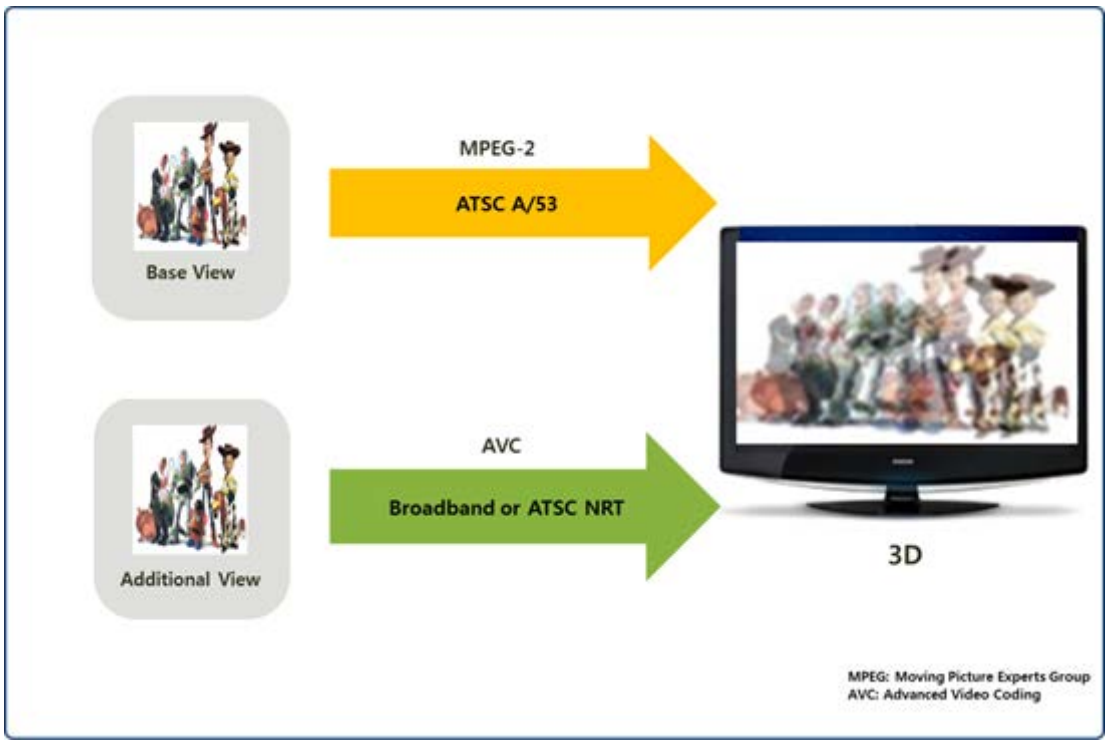

Figure 1.1 Service Compatible Hybrid Delivery 3D using Broadband or ATSC NRT Broadcast System.

1.3 Organization

This document is organized as follows:

- Section 1 – Scope of this document and a general introduction.
- Section 2 – List of references and applicable documents.
- Section 3 – Definition of terms, acronyms, and abbreviations for this document.
- Section 4 – Description of Service Compatible Hybrid Delivery 3D using Broadband
- Section 5 – Description of Service Compatible Hybrid Delivery 3D using ATSC NRT

2. REFERENCES

All referenced documents are subject to revision. Users of this Standard are cautioned that newer editions might or might not be compatible.

2.1 Normative References

The following documents, in whole or in part, as referenced in this document, contain specific provisions that are to be followed strictly in order to implement a provision of this Standard.

[1] IEEE/ASTM: "Use of the International Systems of Units (SI): The Modern Metric System," Doc. SI 10-2002, Institute of Electrical and Electronics Engineers, New York, N.Y.

[2] ATSC: "ATSC Digital Television Standard, Part 3 – Service Multiplex and Transport Subsystem Characteristics," Doc. A/53 Part 3:2013, Advanced Television Systems Committee, Washington, D.C., 7 August 2013.

[3] ATSC: "ATSC Digital Television Standard, Part 4 – MPEG-2 Video System Characteristics," Doc. A/53 Part 4:2009, Advanced Television Systems Committee, Washington, D.C., 7 August 2009.

[4] ATSC: "Use of AVC in the ATSC Digital Television System, Part 1 – Video System Characteristics," Doc. A/72 Part 1:2008, Advanced Television Systems Committee, Washington, D.C., 29 July 2008.

[5] ATSC: "Program and System Information Protocol for Terrestrial Broadcast and Cable," Doc. A/65:2009, Advanced Television Systems Committee, Washington, D.C., 3 August 2009.

[6] ATSC: "ATSC Parameterized Services Standard," Doc. A/71:2007, Advanced Television Systems Committee, Washington, D.C., 26 March 2007.

[7] ITU-T Recommendation H.262 | ISO/IEC 13818-2: "Information technology – Generic coding of moving pictures and associated audio information: Video."

[8] ITU-T Recommendation H.264 | ISO/IEC 14496-10:2010: "Information technology – Coding of audio-visual objects – Part 10: Advanced Video Coding."

[9] ITU-T Recommendation H.222.0 | ISO/IEC 13818-1:2013, "Information technology -- Generic coding of moving pictures and associated audio information: Systems."

[10] CEA: "Digital Television Closed Captioning: 3D Extensions," Doc. CEA-708.1, Consumer Electronics Association, Arlington, VA, 2012.

[11] ATSC: "Use of AVC in the ATSC Digital Television System, Part 2 – Transport Subsystem Characteristics," Doc. A/72 Part 2:2008, Advanced Television Systems Committee, Washington, D.C., 29 July 2008.

[12] ATSC: "3D-TV Terrestrial Broadcasting, Part 2 – Service Compatible Hybrid Coding Using Real-Time Delivery" Doc. A/104 Part 2:2012, Advanced Television Systems Committee, Washington, D.C., 26 December 2012.

[13] ATSC: "Non-Real-Time Content Delivery" Doc. A/103:2012, Advanced Television Systems Committee, Washington, D.C., 9 May 2012.

[14] ISO/IEC 23009-1:2014, "Information technology – Dynamic adaptive streaming over HTTP (DASH) – Part 1: Media presentation description and segment formats."

[15] RFC 2616: Hypertext Transfer Protocol – HTTP/1.1, June 1999.

[16] RFC 5905: Network Time Protocol Version 4: Protocol and Algorithms Specification, June 2010.

3. DEFINITION OF TERMS

With respect to definition of terms, abbreviations, and units, the practice of the Institute of Electrical and Electronics Engineers (IEEE) as outlined in the Institute's published standards [1] shall be used. Where an abbreviation is not covered by IEEE practice or industry practice differs from IEEE practice, the abbreviation in question will be described in Section 3.3 of this document.

3.1 Compliance Notation

This section defines compliance terms for use by this document:

shall – This word indicates specific provisions that are to be followed strictly (no deviation is permitted).

shall not – This phrase indicates specific provisions that are absolutely prohibited.

should – This word indicates that a certain course of action is preferred but not necessarily required.

should not – This phrase means a certain possibility or course of action is undesirable but not prohibited.

3.2 Treatment of Syntactic Elements

This document contains symbolic references to syntactic elements used in the audio, video, and transport coding subsystems. These references are typographically distinguished by the use of a different font (e.g., restricted), may contain the underscore character (e.g., sequence_end_code) and may consist of character strings that are not English words (e.g., dynrng).

3.2.1 Reserved Elements

One or more reserved bits, symbols, fields, or ranges of values (i.e., elements) may be present in this document. These are used primarily to enable adding new values to a syntactical structure without altering its syntax or causing a problem with backwards compatibility, but they also can be used for other reasons.

The ATSC default value for reserved bits is '1.' There is no default value for other reserved elements. Use of reserved elements except as defined in ATSC Standards or by an industry standards setting body is not permitted. See individual element semantics for mandatory settings and any additional use constraints. As currently-reserved elements may be assigned values and meanings in future versions of this Standard, receiving devices built to this version are expected to ignore all values appearing in currently-reserved elements to avoid possible future failure to function as intended.

3.3 Acronyms and Abbreviation

The following acronyms and abbreviations are used within this document.

ATSC – Advanced Television Systems Committee

SCHC – Service Compatible Hybrid Coded 3D

SCHCBB – Service Compatible Hybrid Coded 3D using Broadband

SCHCNRT – Service Compatible Hybrid Coded 3D using ATSC NRT

3.4 Terms

The following terms are used within this document.

Additional view video – Stereoscopic 3D video component added to the Base view video to compose stereoscopic 3D video.

Base view video – Stereoscopic 3D video component which is used for legacy 2DTV service.

Hybrid Delivery of SCHC using Broadband – 3D TV broadcast service using two different video codecs, where base view video is transmitted via an MPEG-2 video stream per ATSC A/53 Part4 [3], and the additional view video processed by a different codec is transmitted via Broadband.

Hybrid Delivery of SCHC using ATSC NRT – 3D TV broadcast service using two different video codecs, where one image is transmitted via an MPEG-2 video stream per ATSC A/53 Part 4 [3], and the second image processed by a different codec is transmitted via ATSC A/103 [13].

left view – Video provided for the left eye.

reserved – An element that is set aside for use by a future Standard.

right view – Video provided for the right eye.

Service compatible – 3D TV broadcasting service composed of two or more compressed video images, where at least one of them is the legacy 2D TV image having the same resolution as the production resolution.

Stereoscopic 3D video – Video composed of a left view and a right view.

4. SERVICE COMPATIBLE HYBRID DELIVERY 3D USING BROADBAND (SCHCBB)

4.1 Overall Description of SCHCBB

SCHCBB is composed of two delivery systems. As illustrated in Figure 4.1, one involves the transmission of the base view over terrestrial broadcast network, and the other involves the delivery of an additional view over Broadband.

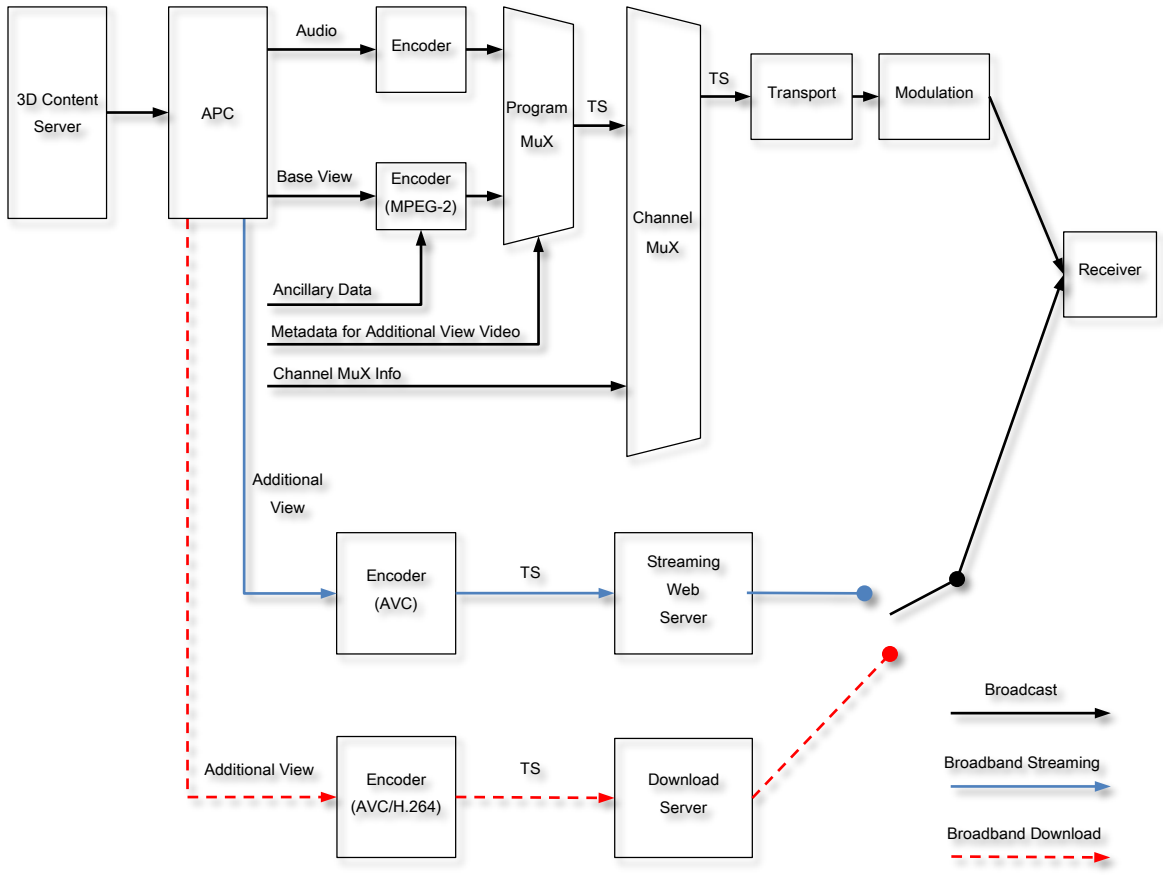

Figure 4.1 Overview of SCHCBB system.

The 3D Content Server controls the transmission of the base view video and the additional view video. The base view video and the additional view video are sent to the MPEG-2 Encoder and the AVC/H.264 Encoder, respectively. The MPEG-2 Encoder encodes the base view video, which is then multiplexed with PSIP data at Channel Mux. The base view video stream is transmitted over the ATSC terrestrial network to a receiver. The AVC/H.264 Encoder encodes the additional view video and generates transport stream and delivered to a Streaming Web Server or

Download Server, to be transmitted to a receiver over Broadband. The blue line in Figure 4.1 shows the real time delivery of additional view video and the red dotted line in Figure 4.1 shows the non-real time delivery of additional view video

The 3D Content Server controls the transmission of the base view video and the additional view video. The base view video and the additional view video are sent to the MPEG-2 Encoder and the AVC/H.264 Encoder respectively. The MPEG-2 Encoder encodes the base view video, which is then multiplexed with PSIP data at Channel Mux. The base view video stream is transmitted over the ATSC terrestrial network to a receiver. The AVC/H.264 Encoder encodes the additional view video and generates transport stream and delivered to a Streaming Web Server or Download Server, to be transmitted to a receiver over Broadband. The blue line in Figure 4.1 shows the real time delivery of additional view video and the red dotted line in Figure 4.1 shows the non-real time delivery of additional view video

4.2 Encoding and Decoding for SCHCBB

The compression format of the base view video shall conform to MPEG-2 video Main Profile @ High Level or Main Profile @ Main Level [7], while the compression format of the additional view video shall conform to AVC/H.264 Main Profile @ Level 4.0 or High Profile @ Level 4.0 [8].

With the exception of video compression formats, additional constraints for video compression of base view and additional view video shall conform to ATSC A/53 Part 4 [3] and ATSC A/72 Part 1 [4] respectively.

4.3 Video Format for SCHCBB

The compression format for the base view video and the additional view video of SCHCBB service shall be one of the formats listed in Table 4.1. The compression format of both views shall be identical.

Table 4.1 Video Compression Formats

Vertical Size	Horizontal Size	Display Aspect Ratio / Sample Aspect Ratio	Frame Rate	Progressive/ Interlaced
1080	1920	16:9 / square sample	23.976, 24, 29.97, 30	P
1080	1920	16:9 / square sample	29.97, 30	I
720	1280	16:9 / square sample	23.976, 24, 29.97, 30, 59.94, 60	P

4.4 The delivery format of additional view video

Regardless of protocols used for the delivery of additional view video over Broadband as described in the section 4.1, additional view video shall be formatted with MPEG-2 TS with the constraints specified in ATSC A/72 Part 2 [11].

4.5 The delivery of additional view video

The additional view video of SCHCBB shall be transmitted using TS main profile of ISO/IEC 23009-1:2014 [14] for a streaming service and RFC 2616 [15] for a download service.

4.6 Closed Captioning for SCHCBB

Closed captioning data is transported in the base view video in compliance with ATSC A/53 Part 4 [3]. Closed captioning commands to support z-axis placement of caption windows (e.g. disparity data) shall be formatted in accordance with CEA-708.1 [10] and carried in the cc_data() specified in Sec. 6.2.3.1 of ATSC A/53 Part 4 [3].

4.7 Multiplexing for SCHCBB

Video multiplexing of views in SCHCBB shall comply with ATSC A/53 Part 3 [2].

4.8 Video Frame Synchronization for SCHCBB

Playback of SCHCBB service is based on the PTS of the base view video transmitted over the ATSC terrestrial broadcast network. In Hybrid Network environment, the PTS of base view can be different from that of additional view. To solve this problem, media paring information as specified in 4.9.1.3.1 of this specification shall be used to synchronize the base view video and the additional view video.

4.9 Signaling for SCHCBB

4.9.1 PSI

4.9.1.1 stream_type

The base view video and the additional view video of an SCHCBB service shall be signaled using stream_type value 0x02 and stream_type value 0x23 respectively. The video frame synchronization metadata of SCHCBB shall be signaled using a stream_type value of 0x06 (media_pairing_information()) and the referencing information of the additional view video shall be signaled using a stream_type 0x05 (Referenced_media_information()) as defined in ISO/IEC 13818-1:2013 [9].

4.9.1.2 Program and Program Element Descriptors

The Stereoscopic_program_info_descriptor() and Stereoscopic_video_info_descriptor() as specified in [9] shall be used in the signaling of a SCHCBB program.

4.9.1.2.1 Stereoscopic_program_info_descriptor

Stereoscopic_program_info_descriptor() as specified in [9] shall be present in the loop following the program_info_length field in the PMT to signal the existence of an SCHCBB program. For an SCHCBB service, the stereoscopic_service_type shall be set to '011'.The stereoscopic_service_type can be set to '001' to indicate that the base view and the additional view video elementary streams of the SCHCBB program are carrying the same video.

4.9.1.2.2 Stereoscopic_video_info_descriptor

Stereoscopic_video_info_descriptor() as specified in [9] shall be present in the loop following the ES_info_length field in the PMT to identify the view component of a SCHCBB program; i.e., the base view video stream and the additional view video stream.

4.9.1.3 Metadata for SCHCBB

4.9.1.3.1 Media Pairing Information (MPI)

In SCHCBB, the additional view video may have a different PTS from that of the base view video. When PTSs are different, media_paring_information() shall be provided to pair up the corresponding frames of the base view video and the additional view video. Media_paring_information() is carried by PES packets to be multiplexed with the base view video stream. For the additional view video, media_paring_information() is multiplexed only for the SCHCBB streaming service.

The PES Packet structure carrying the media_pairing_information() is specified in [9], with the constraints shown in Table 4.2.

Table 4.2 PES Packet Structure Constraints

Field	Value
stream_id	0xBD
data_alignment_indicator	'1' Note: '1' means the start of media paring information shall be aligned with the start of PES payload.
PES_packet_data_byte	It is contiguous bytes of data from the elementary stream indicated by the packet's stream_id or PID PES_data_field for PES_packet_data_byte for this specification is defined in Table 4.3

Table 4.3 PES_data_field() Syntax

Syntax	No. of bits	Format
PES_data_field() {		
data_identifier	8	uimsbf
media_pairing_information()	var	
}		

data_identifier – This field shall identify the private stream PES for SCHCBB and its value shall be 0x33.

media_pairing_information() – This field shall provide the media pairing information to be used for the synchronization between the base view video and the additional view video. Its syntax shall be as defined at Table 4.4.

Table 4.4 media_pairing_information() Syntax

Syntax	No. of Bits	Format
media_pairing_information() {		
referenced_media_filename_length	8	uimsbf
for(i=0;i<referenced_media_ filename_length;i++){		
referenced_media_ filename_byte	8	uimsbf
}		
reserved	7	'1111111'
frame_number	25	uimsbf
}		

referenced_media_filename_length – This field shall provide the length of the referenced_media_ filename_byte in bytes. This field shall be set to '0' for SCHCBB streaming service.

referenced_media_ filename_byte – This field shall provide the URI of the referenced media (the additional view video stream or file).

frame_number – This field shall indicate the frame number of SCHCBB streams. The frame number starts with '0' at the beginning of the video stream and shall be incremented monotonically.

4.9.1.4 Referenced Media Information (RMI)

The referenced_media_information() provides access and playback information of the additional view video associated with the base view video. Referenced_media_information() shall be provided as

stream_type 0x05 (private section) as specified in [9] for the additional view video stream information.

The structure of private_section() carrying referenced_media_information() is shown in Table 4.5 and the constraints are shown in Table 4.6.

Table 4.5 private_section() Syntax

Syntax	No. of Bits	Format
private_section() {		
table_id	8	'0x41'
section_syntax_indicator	1	bslbf
private_indicator	1	bslbf
reserved	2	bslbf
private_section_length	12	uimsbf
If (section_syntax_indicator == '0') {		
for (i = 0; i < N; i++) {		
private_data_byte	8	bslbf
}		
}		
}		

Table 4.6 private_section() Constraints

Field	Value
table_id	0x41 (user private).
section_syntax_indicator	'0' referened media information() follows private_section_length
private_indicator	'1'
private_data_byte	Follows referenced_media_information() specified in Table 4.7

Table 4.7 referenced_media_information() Syntax

Syntax	No. of Bits	Format
referenced_media_information() {		
version_number	8	uimsbf
num_hybrid_service_programs	8	uimsbf
for(i=0; i< num_hybrid_service_programs ; i++){		
additionalview_availability_indicator	1	bslbf
reserved	7	'1111111'
num_reference_media_files	8	uimsbf
for(i=0; i< num_reference_media_files ; i++){		
referenced_media_play_start_time	32	uimsbf
referenced_media_filesize	32	uimsbf
referenced_media_files_URI_length	8	uimsbf
for(i=0;i<referenced_media_files_URI_length;i++){		
referenced_media_ files_URI_byte	var	8*N
}		
referenced_media_codec_info	4	uimsbf
referenced_media_expiration_time	32	uimsbf
}		
}		

version_number – This field shall provide the version number of the referenced_media_information(). It shall monotonically increase as the information in the referenced_media_information() changes.

num_hybrid_service_programs – This field shall indicate the number of SCHCBB services provided.

additionalview_availability_indicator – This field shall indicate the availability of the additional view video. '0' indicates the streaming service where the additional view and the base view are provided at the same time. In case of network delay, the base view can buffered to be synchronized with the additional view. '1' indicates the download service where the additional view has been completely downloaded and available at the local storage of the receiver to be synchronized when the 3D program starts.

Table 4.8 additionalview_availability_indicator

Value	Description
0	additional view is available for streaming at the program start time
1	additional view has been completely downloaded before the program start time

num_referenced_media_files – This field shall provide the number of referenced media files that form the additional view video. For a streaming service, this field shall be set to '1' since there shall exist only 1 MPD file.

reference_media_play_start_time – This field shall provide the time that the MPD is available for a streaming service or the presentation start time of each referenced media file for a download service. For a streaming service, it shall be identical to the start time of the program. For a download service, each referenced media file shall be completely downloaded before the corresponding reference_media_play_start_time. The value of this field shall be a time formatted according to NTP timestamp format in [16] that is based on a wall clock synchronized to the one used to generate the MPD or reference media files.

reference_media_filesize – This field shall provide the size of each referenced media file in bytes. For a streaming service, the value shall be set to '0'

referenced_media_files_URI_length – This field shall provide the URI length of the referenced media or MPD file.

referenced_media_files_URI_byte – This field shall provide the URI information of the referenced media or MPD file.

referenced_media_codec_info – This field shall provide the codec information of the additional view video. For this version of the specification, only AVC/H.264 Main Profile @ Level 4.0 or High Profile @ Level 4.0 shall be used.

Table 4.9 referenced_media_codec_info

Value	Description
00	AVC/H.264 Main Profile @ Level 4.0
01	AVC/H.264 High Profile @ Level 4.0
10~11	Reserved for future use

reference_media_expiration_time – This field shall provide the expiration time of the MPD or referenced media files. The value shall be identical to the program end time. The value of this field shall be a time formatted according to NTP timestamp format in [16] that is based on a wall clock synchronized to the one used to generate the MPD or reference media files.

4.9.2 PSIP

4.9.2.1 Virtual Channel Signaling

A virtual channel that carries an SCHCBB service shall be identified by service_type set to 0x09 (Extended Parameterized Service) in the TVCT or CVCT. In addition, the following descriptors shall be present in the descriptor loop following the descriptors_length field of the terrestrial_virtual_channel_table_section() or cable_virtual_channel_table_section().

Table 4.10 shows the example of TVCT for SCHCBB

Table 4.10 TVCT Composition Example

TVCT

…

for (i<num_channels_in_section) {

…

major_channel_number = 0x003

minor_channel_number = 0x002

…

program_number = 0x0002

…

service_type = 0x09 (extended parameterized service)

…

service_location_descriptor()

parameterized_service_descriptor()

…

}

The service_location_descriptor() shall provide the PID of the additional view video elementary stream of the SCHCBB service. The parameterized_service_descriptor() with application_tag = 0x01 shall provide information about the type of 3D service carried. This information can facilitate the behaviour of the 3DTV receivers in displaying Stereoscopic 3D video.

The parameterized_service_descriptor() as defined in [6] shall be used for the delivery of parameters specific to a particular application. For channels containing 3D content, the value of application_tag shall be 0x01. The application_data() for application_tag value 0x01 shall be as shown in Table 4.11. As shown, additional bytes following the last defined field may be present.

Table 4.11 Bit Stream Syntax of Application Data for Application Tag 0x01

Syntax	No. of Bits	Format
application_data(0x01) {		
Reserved	3	Uimsbf
3D_channel_type	5	Uimsbf
for (i=0; i<N; i++) {		
Reserved	8	Bslbf
}		
}		

3D_channel_type – This 5-bit unsigned integer field shall indicate the type of 3D service carried in the Virtual Channel associated with this Parameterized Services Descriptor. For SCHCBB, this value shall be set to 0x04 [6].

4.9.2.2 Event Information Table

The stereoscopic program info descriptor as specified in [9] shall be placed in the descriptor loop of the 3D event in the EIT in order to indicate the future event is in 3D. See the example in Table 4.12.

Table 4.12 EIT Example

EIT
...
for (j < num_events_in_section) {
event_id
start_time
…
length_in_seconds
…
stereoscopic_program_info_descriptor()
…
}

4.9.3 Signaling at 2D/3D Boundaries

Signaling at 2D/3D Boundaries shall follow Section 4.6.3 in ATSC A/104 Part2 [12].

4.10 System Target Decoder Model

System Target Decoder Model for SCHCBB streaming service shall follow Annex B of this specification.

5. SERVICE COMPATIBLE HYBRID 3D DELIVERY USING ATSC NRT (SCHCNRT)

5.1 Overall Description of SCHCNRT

SCHCNRT transmits the base view in real time and transmits the additional view using ATSC A/103 [13]. An overview of the system is illustrated in Figure 5.1.

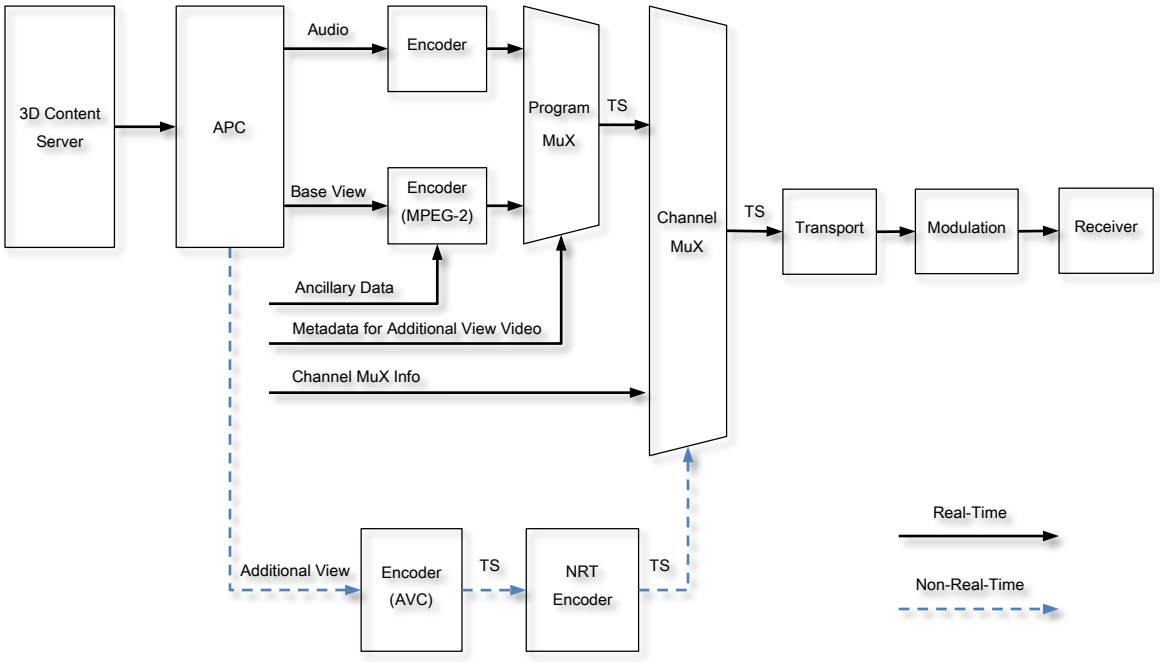

Figure 5.1 Overview of SCHCNRT system.

The 3D Content Server controls the transmission of the base view video streams and the additional view video streams. The base view video streams and the additional view video streams are sent to the MPEG-2 Encoder and the AVC/H.264 Encoder, respectively. The MPEG-2 Encoder encodes the base view, which is then multiplexed with PSIP data at Channel Mux. The AVC/H.264 Encoder encodes the additional view video and generates transport stream and delivered to the NRT encoder to be transmitted to a receiver over the terrestrial broadcast network. In Figure 5.1, the solid line shows the real time delivery of base view video, and the dotted line shows the non-real time delivery of additional view video. Both view video streams are transmitted over the ATSC terrestrial broadcast network to a receiver.

5.2 Encoding and Decoding for SCHCNRT

The compression format of the base view video shall conform to MPEG-2 video Main Profile @ High Level or Main Profile @ Main Level [7], while the compression format of the additional view video shall conform to AVC/H.264 Main Profile @ Level 4.0 or High Profile @ Level 4.0 [8].

With the exception of video compression formats, additional constraints for video compression of base view and additional view video shall conform to ATSC A/53 Part 4 [3] and ATSC A/72 Part 1 [4] respectively.

5.3 Video Format for SCHCNRT

The compression format for the base view video and the additional view video of SCHCNRTBB service shall be one of the formats listed in Table 4.1 of Section 4.3. The compression format of both views shall be identical.

5.4 File format of additional view video

The additional view video shall be formatted with MPEG-2 TS file as a wrapper type specified in Section 8 of ATSC A/103 [13].

5.5 Closed Caption for SCHCNRT

Closed caption data is transported in the base view video in compliance with ATSC A/53 Part 4 [3]. Closed captioning commands to support z-axis placement of caption windows (e.g. disparity data) shall be formatted in accordance with CEA-708.1 [10] and carried in the cc_data() specified in Sec. 6.2.3.1 of ATSC A/53 Part 4 [3].

5.6 Multiplexing for SCHCNRT

Video multiplexing of the both views of SCHCNRT shall comply with ATSC A/53 Part 3 [2] and ATSC A/103 [13].

5.7 Video Frame Synchronization for SCHCNRT

In SCHCNRT, the additional view video may have a different PTS from that of the base view video. When PTSs are different, MPI as specified in 4.9.1.3.1 of this specification shall be used to synchronize the base view video and the additional view video.

5.8 Signaling for SCHCNRT

5.8.1 PSI

5.8.1.1 stream_type

The base view video and the additional view video of an SCHCNRT service shall be signaled using stream_type value 0x02 and stream_type value 0x23 respectively as defined in [9]. The additional view video of SCHCNRT service shall be signaled using stream_type value 0x0D (DSMCC-Addressable Section) as defined in Section 4 of ATSC A/103 [13]. The MPI of SCHCNRT shall be signaled using a stream_type value of 0x06 as defined in [9].

5.8.1.2 Program and Program Element Descriptors

The Stereoscopic_program_info_descriptor() and Stereoscopic_video_info_descriptor() as specified in [9] shall be used in the signaling of a SCHCNRT program.

5.8.1.2.1 Stereoscopic_program_info_descriptor

Stereoscopic_program_info_descriptor() as specified in [9] shall be present in the loop following the program_info_length field in the PMT to signal the existence of an SCHCNRT program. For an SCHCNRT service, the stereoscopic_service_type shall be set to '011'.

5.8.1.2.2 Stereoscopic_video_info_descriptor

Stereoscopic_video_info_descriptor() as specified in [9] shall be present in the loop following the ES_info_length field in the PMT to identify the view component of a SCHCNRT program; i.e., the base view video stream and the additional view stream.

5.8.1.3 Metadata for SCHCNRT

5.8.1.3.1 Media Pairing Information

In SCHCNRT, the additional view video may have a different PTS from that of the base view video. When PTSs are different, media_paring_information() shall be provided to pair up the corresponding frames of the base view video and the additional view. Media_paring_information() is carried by PES packets to be multiplexed with the base view video stream.

The PES Packet structure carrying the media_pairing_information() is specified in [9], with the constraints shown in Table 5.1.

Table 5.1 PES Packet Structure Constraints

Field	Value
stream_id	0xBD
data_alignment_indicator	'1' Note: '1' means the start of media paring information shall be aligned with the start of PES payload.
PES_packet_data_byte	It is contiguous bytes of data from the elementary stream indicated by the packet's stream_id or PID PES_data_field for PES_packet_data_byte for this specification is defined in Table 5.2

Table 5.2 PES_data_field() Syntax

Syntax	No. of bits	Format
PES_data_field() {		
data_identifier	8	uimsbf
media_pairing_information()	var	
}		

data_identifier – This field shall identify the private stream PES for SCHCBB and its value shall be 0x33.

media_pairing_information() – This field shall provide the media pairing information to be used for the synchronization between the base view video and the additional view video. Its syntax shall be as defined at Table 5.3.

Table 5.3 media_pairing_information() Syntax

Syntax	No. of Bits	Format
media_pairing_information() {		
referenced_media_filename_length	8	uimsbf
for(i=0;i<referenced_media_ filename_length;i++){		
referenced_media_ filename_byte	8	uimsbf
}		
reserved	7	'1111111'
frame_number	25	uimsbf
}		

referenced_media_filename_length – This field shall provide the length of the referenced_media_ filename_byte in bytes.

referenced_media_ filename_byte – This field shall provided the URI of the referenced media file

frame_number – This field shall indicate the frame number of SCHCNRT streams. The frame number starts with '0' at the beginning of the service and shall be incremented monotonically.

5.8.2 NRT

5.8.2.1 SMT and NRT-IT

NRT service signaling shall use SSC (Service Signaling Channel) to transmit SMT (Service Map Table) and NRT-IT (Non-Real-Time Information Table). The SMT provides information on NRT service and the NRT-IT provides content item information to form NRT service. SSC, SMT, and NRT-IT shall comply with Section 6 of ATSC A/103 [13].

5.8.2.2 capability_code

capabilities_descriptor() as specified in Section 8.3 of ATSC A/103 [13] can be used to indicate that the services in SMT service level or the contents in NRT-IT content level are the additional view of service-compatible 3D video.
Receivers can utilize this information to notice whether the service/content is the additional view of service-compatible 3D video or not, and decide whether the service/content should be downloaded or not for future 3D program consumption depending on 3D display capabilities.

For SCHCNRT service, the following capability_code values shall be used in capabilities descriptor for the additional view of SCHCNRT signaling.

Table 5.4 Capability Codes

Value	Description
0x42	AVC high definition video
0x52	Additional view of Service-compatible 3D video (Not available for independent 2D service)
0x53	Additional view of Service-compatible 3D video (Available for independent 2D service)

The capability code 0x52 indicates that the downloaded additional view of Service-compatible 3D video shall not be used as an independent 2D service, whereas 0x53 indicated video can be used as an independent 2D service.

5.8.3 PSIP

5.8.3.1 Virtual Channel Signaling

A virtual channel that carries an SCHCNRT service shall be identified by service_type set to 0x09 (Extended Parameterized Service) in the TVCT. For the additional view delivery, the virtual channel signaling shall follow Section 4.1 of ATSC A/103 [13]. In addition, the following descriptors shall be present in the descriptor loop following the descriptors_length field of the terrestrial_virtual_channel_table_section() or cable_virtual_channel_table_section().
Table 5.5 shows the example of TVCT for SCHCNRT

Table 5.5 TVCT Composition Example

TVCT
…
for (i<num_channels_in_section) {
…
major_channel_number = 0x003
minor_channel_number = 0x002
…
program_number = 0x0002
…
service_type = 0x09 (extended parameterized service)
…
service_location_descriptor()
parameterized_service_descriptor()
…
}

The service_location_descriptor() shall provide the PID of the additional view video elementary stream of the SCHCNRT service. The parameterized_service_descriptor() with application_tag = 0x01 shall provide information about the type of 3D service carried. This information can facilitate the behaviour of the 3DTV receivers in displaying Stereoscopic 3D video.

The parameterized_service_descriptor() as defined in [6] shall be used for the delivery of parameters specific to a particular application. For channels containing 3D content, the value of application_tag shall be 0x01. The application_data() for application_tag value 0x01 shall be as shown in Table 5.6. As shown, additional bytes following the last defined field may be present.

Table 5.6 Bit Stream Syntax of Application Data for Application Tag 0x01

Syntax	**No. of Bits**	**Format**
application_data(0x01) {		
Reserved	3	Uimsbf
3D_channel_type	5	Uimsbf
for (i=0; i<N; i++) {		
Reserved	8	Bslbf
}		
}		

3D_channel_type – This 5-bit unsigned integer field shall indicate the type of 3D service carried in the Virtual Channel associated with this Parameterized Services Descriptor. For SCHCBB, this value shall be set to 0x05 [6].

5.8.3.2 Event Information Table

The stereoscopic program info descriptor as specified in [9] shall be placed in the descriptor loop of the 3D event in the EIT in order to indicate the future event is in 3D. See the example in Table 5.7.

Table 5.7 EIT Example

EIT
...
for (j < num_events_in_section) {
event_id
start_time
…
length_in_seconds
…
stereoscopic_program_info_descriptor()
…
}

5.8.4 Signaling at 2D/3D Boundaries

Signaling at 2D/3D Boundaries shall follow Section 4.6.3 in ATSC A/104 Part2 [12].

Annex A: Service Scenarios and Receiver Behaviors

A.1 INTRODUCTION

In this version of specification, there are two service scenarios. The first scenario is streaming service that delivers both views of a 3D content at the scheduled program time, and the second scenario is download service that delivers the additional view of the pre-recorded 3D content in advance of the scheduled program start time to be stored on the local storage of the receiver. SCHCBB is used for both scenarios and SCHCNRT is used for the second scenario only.

The basic assumptions for these service scenarios are as follows.

- The base view shall be transmitted over terrestrial broadcast network
- The additional view shall be transmitted over Broadband (SCHCBB) or terrestrial broadcast network using NRT (SCHCNRT).
- For the download service, the additional view shall be completely downloaded and stored on the local storage of the receiver before the scheduled program start time.

This annex provides descriptions of the service scenarios mentioned above and associated receiver behaviors.

A.2 SCHCBB STREAMING SERVICE

Figure A.1 shows the service scenario for streaming service. The service uses ATSC terrestrial broadcast network for the base view contents broadcasting and Broadband for the additional view contents streaming.

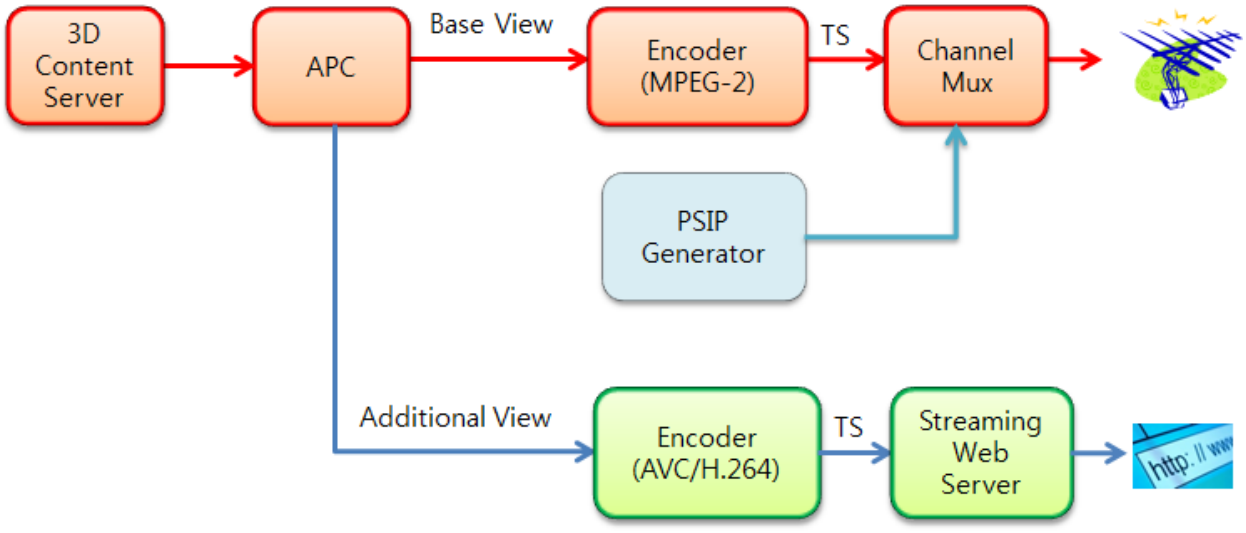

Figure A.1 Service Scenario for SCHCBB Streaming Service.

The receiver discovers SCHCBB streaming service and presents 3D video using following steps:

1) The receiver acknowledge the presence of SCHCBB streaming service via VCT and referenced_media_information() by parsing PSIP, PSI, and PMT.
2) By parsing PSI and PMT, the receiver extracts private_section() data containing referenced_media_information() and downloads MPD over Broadband when it is available,

indicated by referenced_media_play_start_time, using the URI information provided in referenced_media_information().

3) When the 3D service starts, the receiver parses MPD and starts streaming request – a user intervention may be required – of the segmented TS files listed in MPD.
4) While receiving segmented TS files, the receiver buffers the terrestrial broadcast network transmitted base view TS for the duration H_b specified in Annex C.
5) After buffering, the receiver de-multiplexes the base view and the additional view TS.
6) Using media_pairing_information() carried in both base view and additional view TS, the receiver maps PTSs of the base view video onto the additional view video for synchronization and send the videos to the renderer for presentation.

A.3 SCHCBB DOWNLOAD SERVICE

Figure A.2 shows the service scenario for SCHCBB download service. The service uses ATSC terrestrial broadcast network for the base view contents broadcasting and Broadband for the additional view contents downloading.

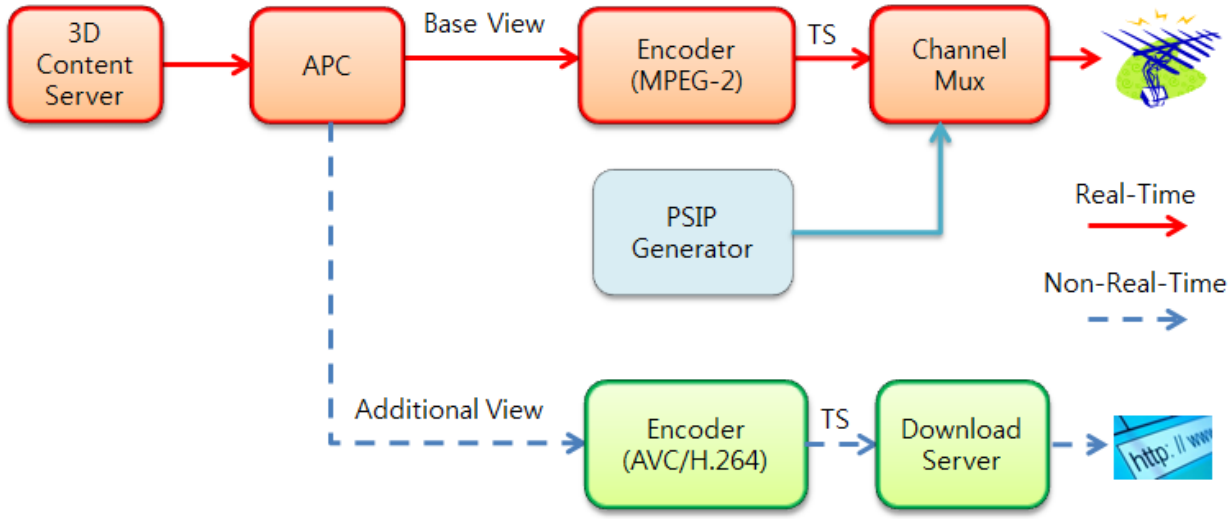

Figure A.2 Service Scenario for SCHCBB download service.

The receiver discovers SCHCBB download service and presents 3D video using following steps:

1) The receiver acknowledge the presence of SCHCBB download service via VCT and referenced_media_information() by parsing PSIP, PSI, and PMT.
2) By parsing PSI and PMT, the receiver extracts private_section() data containing referenced_media_information() and downloads the additional view TS file(s) of 3D service over Broadband when it is available – a user intervention may be required – using the URI information provided in referenced_media_information() and store the video onto the local storage. The additional view TS files shall be downloaded completely before the service start time indicated by referenced_media_play_start_time.
3) When the 3D service starts, using media_pairing_information() carried in the base view TS, the receiver maps PTSs of the terrestrial network transmitted base view video onto the locally

stored additional view video for synchronization and send the videos to the renderer for presentation.

A.4 SCHCNRT SERVICE

Figure A.3 shows the service scenario for SCHCNRT service. The service uses ATSC terrestrial broadcast network for both the base view contents and the additional view contents broadcasting.

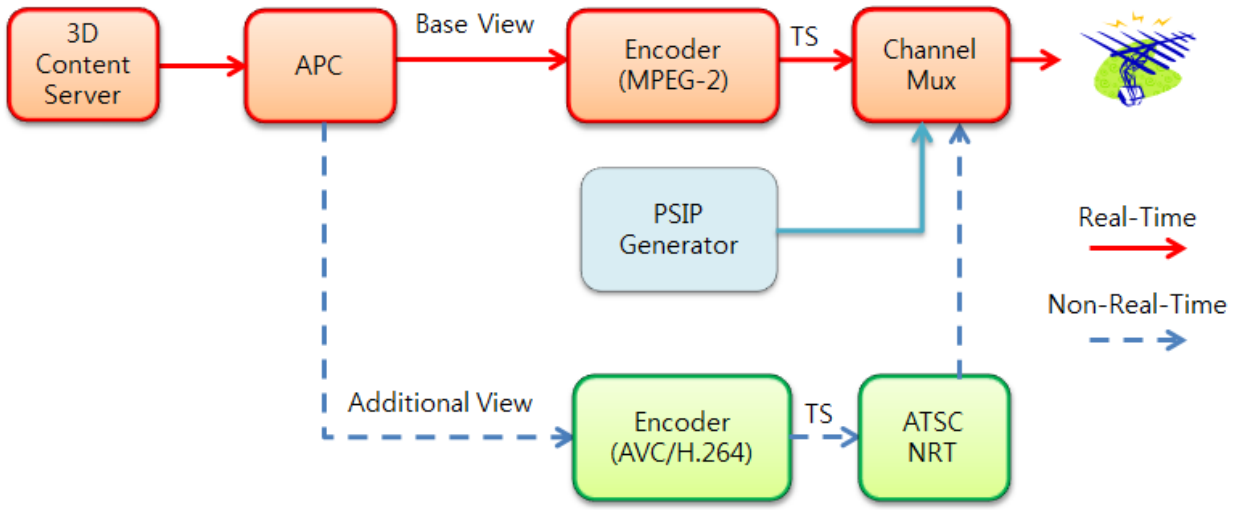

Figure A.3 Service Scenario for SCHCNRT service

The receiver discovers SCHCNRT service and presents 3D video using following steps:

1) The receiver acknowledges the presence of SCHCNRT service via VCT by parsing PSIP.
2) By parsing capability_code values in capabilities_descriptor() as specified in Section 8.3 of ATSC A/103 [13], the receiver acknowledges that the services in SMT service level or the contents in NRT-IT content level are the additional view of service-compatible 3D video and downloads the additional view TS of 3D service over terrestrial network when it is available – an user intervention may be required – and store the video onto the local storage.
3) When the 3D service starts, using media_pairing_information() carried in the base view TS, the receiver maps PTSs of the terrestrial network transmitted base view video onto the locally stored additional view video for synchronization and send the videos to the renderer for presentation.

Annex B: SCHCBB T-STD (System Target Decoder) Model

B.1 INTRODUCTION

The SCHCBB service is inclusive of streaming service and download service. The streaming service uses terrestrial broadcast network for the base view contents (video, audio, etc.,) delivery and ISO/IEC 23009-1:2014 [14] over Broadband for the additional view delivery. However, due to the transmission network and protocol differences, the content arrival time to the receiver may also be different, hence, buffering model is necessary for the successful 3DTV service.

B.2 SCHCBB STREAMING SERVICE T-STD MODEL

The SCHCBB streaming service uses MPEG-DASH [14] over Broadband to transmit the additional view stream. The TS output of AVC/H.264 encoder is delivered to Streaming Web Server where it is converted into temporally segmented TS files following the MPEG-DASH specification [14] with the duration, S_d, specified by the operator. Since the Streaming Web Server cannot start transmission before the completion of a segmented TS file conversion, initial transmission delay is inevitable. Furthermore, the additional view cannot be decoded before the completion of a segmented TS file reception. Therefore, Hybrid Buffer, *HB*, shall be used before the T-STD model specified in ISO/IEC 13818-1:2013 [9] to buffer terrestrial broadcast network transmitted base view contents (Figure B.1).

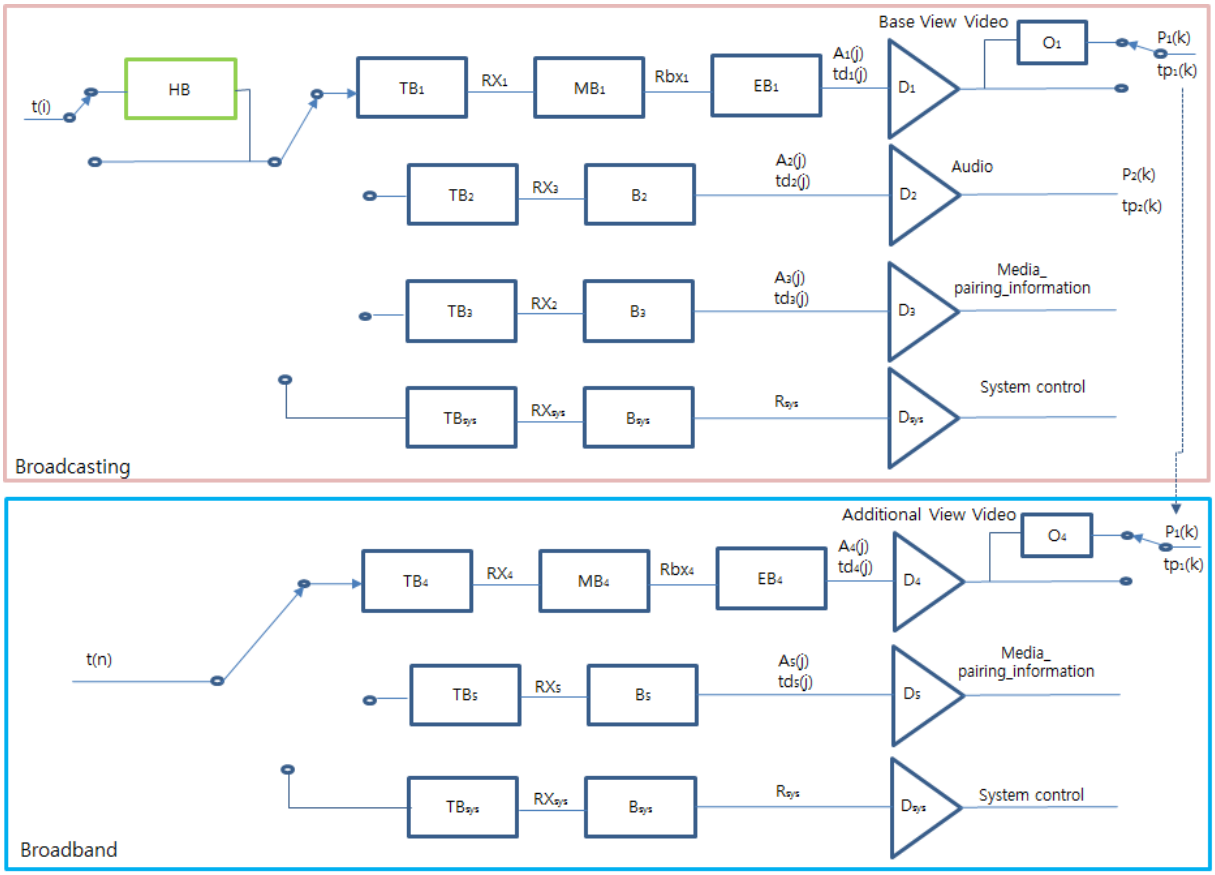

Figure B.4 T-STD model for SCHCBB streaming service.

The minimum size of HB can be calculated by multiplying the bandwidth of base view TS with the buffering time, H_b

$$H_b = S_d + \alpha + minbufferTime$$

S_d = Segment duration (variable); this delay is due to server-end pre-transmission TS segment buffering.

α = Streaming web server processing delay after AVC/H.264 encoder. $0 < \alpha < 1$.

minbufferTime = Specified in MPD (Media Presentation Description) of [14].

Reference [14] states that *minbufferTime* shall be assigned by the operator, however, there is no analytical guideline to set this value. The minimum *minbufferTime* can be estimated by

$$minbufferTime = S_d + \beta$$

S_d is required so that a segmented TS file can be received completely before it is passed onto the decoder. β is the MPD processing delay of the receiver. $0 < \beta < 1$. *minbufferTime* shall be assigned by the operator considering minimum *minbufferTime* and network condition to assure continuous playout.