

# **Guidelines for Implementation: DASH-AVC/264 Test cases and Vectors**

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# 1 Scope

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- 2 This document provides background and reference on the DASH-IF provided test cases and test
- 3 vectors in order to support the definition of the DASH-IF Interoperability Points.

# 1 Disclaimer

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2 The document is intended to enable creating test cases and test vectors that include re-  
3 strictions and combinations of MPEG-DASH, system and codec technologies to spur basic  
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## 32 Acronyms, abbreviations and definitions

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33 For acronyms, abbreviations and definitions refer to DASH-264/AVC part 1 [1].

1 In addition, the following abbreviations and acronyms are used in this document:

2	AAC	Advanced Audio Coding
3	AVC	Advanced Video Coding
4	DRM	Digital Rights Management
5	DTV	Digital Television
6	FCC	Federal Communications Commission
7	GOP	Group-of-Pictures
8	KID	common Key IDentification
9	IDR	Instantaneous Decoder Refresh
10	PPS	Picture Parameter Set
11	PS	Parametric Stereo
12	SBR	Spectral Band Replication
13	SD	Standard Definition
14	SMPTE	Society of Motion Picture and Television Engineers
15	SPS	Sequence Parameter Set
16	TT	Timed Text
17	TTML	Timed Text Markup Language



# 1. Introduction

This document defines the test cases and test vectors for the DASH-IF Interoperability Points [1]. The test vectors are verified by the DASH-IF conformance software [2]. The document includes test cases and test vectors for DASH-264/AVC in section 4, DASH-264/AVC HD in section 5 and DASH-264/AVC multichannel extensions in section 6.

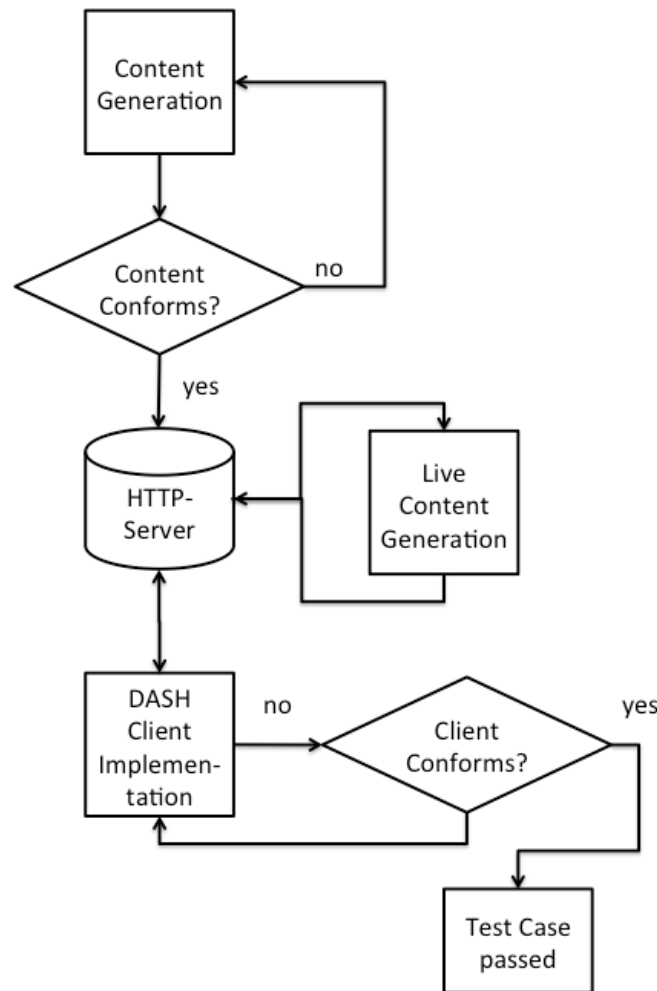
Clients that claim conformance to any interoperability point in [1] are expected to pass the tests in this document.

## 2. Background

### 2.1. Test Content Generation and Testing Process

The general process for DASH-264/AVC-based interoperability testing follows the process in Figure 1:

- Content Generation: this includes encoding, encryption, encapsulation, MPD generation as well as segmentation. For details on content generation refer to Annex B.
- Verification of content by conformance software to conform against MPEG DASH, DASH-264/AVC and other rules. The conformance software details are provided in DASH-IF Part 2 [2].
- The test content is categorized and associated to certain feature tests
- The content is made available as dynamic and static content on public HTTP servers
- Test scenarios and conditions are defined
- Client implementations may be verified against the test content
- Tests may be executed to verify if the client passes the test criteria.



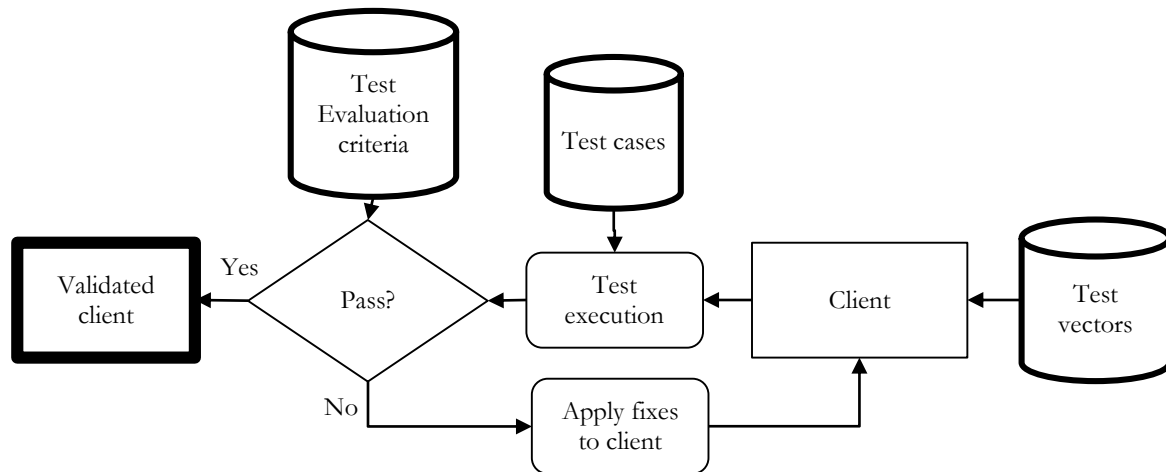
**Figure 1 Interoperability Testing Process**

## **2.2. General Test Procedure**

### **2.2.1. General**

Clients may be validated against the test cases as specified in the following sections. The test execution setup is shown in Figure 2. The proposed testing procedure is as follows:

1. Each of the test vectors included in the test vector collection and as provided online at <http://dashif.org/testvectors> [5] is accessed by a DASH client under test.
2. The test is executed according to the procedure defined in Section 2.2.2. Some specific execution aspects are provided along with each test case.
3. The output is compared to the test evaluation and passing criteria as documented in Section 2.2.3.
4. If the client does not pass a test, fixes should be applied to the client and the procedure should be repeated from step 1 above.
5. If the client passes all the tests, the client may be considered validated against one or different DASH-264/AVC interoperability points as defined [1].



**Figure 2 Test Execution Setup**

### 2.2.2. Test Execution

Following steps are for each given test vector and the behaviour is observed according to the general test criteria depicted in Section 2.2.3:

1. The client accesses the MPD as specified for the test case.
2. For On-Demand Content, i.e. content available with **MPD@type="static"**
  - a. Playback is started from the beginning of the Media Presentation. The playback continues till the end of presentation.
  - b. Playback is started by seeking to two-third of the presentation.
  - c. Playback is started by seeking to one-third of the presentation.
3. For live presentations with **MPD@type="dynamic"**, playback is started at the live edge. If **@mediaPresentationDuration** is provided, the client is tested till the end of the presentation. If **@mediaPresentationDuration** is not provided, the client is tested at least for 180 seconds.

### 2.2.3. General Test Passing Criteria

The general test passing criteria (which may be augmented by additional, test case-specific criteria) is specified in the following.

1. When accessing the MPD, the content starts playing within at most 5 seconds
2. Without network impairment the sequence (at least audio and video) is continuous played and no rebuffering is observed despite access bandwidth variations
3. The Media Presentation is played until the end.
4. Audio and video are presented, no lip synchronization issues are observed
5. If multiple representations are provided in an adaptation set, representation switching is carried out in order to adapt to varying channel conditions and the switching is seamless as

described above. Guidelines on how to artificially add bandwidth variation is provided in section 8.

6. Seamless Representation switching as defined in section 3.2 is observed. This applies for all switching operations within one Adaptation Set.

## 3. Definitions

### 3.1. Switch Points

Switch Points in DASH-264/AVC are defined as Stream Access Points with type one or two that are either signalled in the MPD using the startsWithSAP flag set 1 or 2, or in the Segment Index with a subsegmentStartsWithSAP set to 1 or 2 and the segmentAlignment or subSegmentAlignment is set to true.

### 3.2. Seamless Switching

A key functionality is the ability that the DASH-264/AVC client can seamlessly switch across different Representations of the same media component without severely impacting the user experience.

Assume two Representations A and B. A *switch* from Representations A to Representation B at media time  $t$  is considered *seamless*, if the result of the presentation after this switch is applied is identical as if Representation A is decoded from the beginning and presented up to time  $t$  and Representation B is decoded from the beginning and presented from time  $t$  onwards.

In DASH-264/AVC, Media Presentations may provide different Representations in one Adaptation Set representing the same media component. If such Representations are properly time-aligned (as expected by the Media Presentation), then DASH clients may apply seamless switching across different Representations provided in one Adaptation Set at any time  $t$  to obtain a perceptually continuous experience.

## 4. Test Cases for DASH-264/AVC

### 4.1. Introduction

The following high-level test cases and feature clusters are defined for DASH-264/AVC and DASH-264/AVC SD:

1. Basic On-Demand
2. Multi-resolution Video
3. Multiple Audio Representations
4. Addition of Timed Text
5. Multiple Periods
6. Encryption and key rotation
7. Dynamic Segment Offering

1        8. Dynamic Offering with MPD Update

2        9. Trick Mode

## 3    **4.2. Test Case 1: DASH-264/AVC Basic On-Demand**

### 4    **4.2.1. Typical Use Case**

5    In this case a DASH client accesses content that is offered with as Video On-Demand. The video  
6    is provided as conforming to DASH-264/AVC. The video is offered in different bitrates and switch  
7    points are provided in regular distance. This allows the client to adapt and switch in a seamless  
8    manner.

### 9    **4.2.2. Content Offering**

10   For this test case content is offered with the following features

- 11        • Static content offering, **MPD@type** is set to 'static'
- 12        • Segments conform to ISO BMFF On-Demand Profile or ISO BMFF Live profile, i.e. one  
13        of the three options
  - 14            – Restrictions in addressing to **BaseURL** and **sidx** (Content also offered with Ba-  
15            seURL@byteRange)
  - 16            – Using number-based templates and **@duration**
  - 17            – Using time-based templates and **SegmentTimeline**
- 18        • The content is provided as a single Period
- 19        • at least 2 Adaptation Sets are provided
  - 20            – Video Adaptation Set
    - 21                • multiple video representations all same codec according to DASH-  
22                264/AVC
    - 23                • Each Adaptation Set contains the same spatial resolution
  - 24            – Audio Adaptation Set
    - 25                • Single Audio Representation
    - 26                • Codec is HE-AAC v2

### 27   **4.2.3. Test Cases**

28   The following more detailed test cases are defined

- 29        • Test Case 1a: Features from above for BaseURL and **sidx**
- 30        • Test Case 1b: Features from above for number template
- 31        • Test Case 1c: Features from above for time template

### 32   **4.2.4. Test Execution**

33   The test is executed according to the procedure defined in section 2.2.

#### 4.2.5. Test Vectors

The test vectors are provided here: <http://www.dashif.org/testvectors#SRMR>.

### 4.3. Test Case 2: Multi-resolution Video

#### 4.3.1. Typical Use Case

In this case the content author encodes the video not only at the target display resolution, but for compression efficiency reasons also in lower resolution. It is expected that the client can seamlessly switch across Representations.

#### 4.3.2. Content Offering

The following features are tested

- Static content offering, **MPD**@type is set to 'static'
- Complies to ISO BMFF On-Demand Profile or ISO BMFF Live profile, i.e. one of the three options
  - Restrictions in addressing to **BaseURL** and **sidx** (Content also offered with **BaseURL@byteRange**)
  - Using number-based templates and @duration
  - Using time-based templates and **SegmentTimeline**
- Single Period
- at least 2 Adaptation Sets
  - Video Adaptation Set
    - multiple video representations all same codec
    - The Adaptation Set contains different spatial resolutions, i.e. the @width and the @height attribute differ.
  - Audio Adaptation Set
    - Single Audio Representation
    - Codec is HE-AAC v2

#### 4.3.3. Test Case

The following test cases are defined

- Test Case 1a: Features from above for BaseURL and **sidx**
- Test Case 1b: Features from above for number template
- Test Case 1c: Features from above for time template

#### 4.3.4. Test Execution

The test is executed according to the procedure defined in section 2.2.

### 4.3.5. Test Vectors

The test vectors are provided here: <http://www.dashif.org/testvectors#MRMR>.

## 4.4. Test Case 3: Multiple Audio Representations

### 4.4.1. Features

The following features are tested

- Static content offering
- Complies to ISO BMFF On-Demand Profile or ISO BMFF Live profile, i.e. one of the three options
  - Restrictions in addressing to **BaseURL** and `sidx` (Content also offered with `BaseURL@byteRange`)
  - Using number-based templates and `@duration`
  - Using time-based templates and **SegmentTimeline**
- Single Period
- at least 2 Adaptation Sets
  - Video Adaptation Set
    - at most one video representation with codec Main Profile 3.0
  - Audio Adaptation Set
    - Multiple Audio Representation
    - Codec is HE-AAC v2

### 4.4.2. Test Case

The following test cases are defined:

- Test Case 3a: Audio only
- Test Case 3b: Audio with a single video Representation

### 4.4.3. Test Execution

The test is executed according to the procedure defined in section 2.2.

### 4.4.4. Test Vectors

The test vectors are provided here: <http://www.dashif.org/testvectors#MAR>.

## 4.5. Test Case 4: Addition of Timed Text

### 4.5.1. Features

The following features are tested

- Static content offering

- Complies to ISO BMFF On-Demand Profile or ISO BMFF Live profile, i.e. one of the three options
  - Restrictions in addressing to **BaseURL** and `sidx` (Content also offered with `BaseURL@byteRange`)
  - Using number-based templates and `@duration`
  - Using time-based templates and **SegmentTimeline**
- Single Period
- at least 4 Adaptation Sets
  - Video Adaptation Set
    - Multiple video representations,
  - Audio Adaptation Set
    - Multiple Audio Representation
  - Subtitle Adaptation Set 1
  - Subtitle Adaptation Set 2

#### 4.5.2. Test Case

The following test cases are defined

Test Case 4a:

- subtitles encapsulated in ISO BMFF

Test Case 4b:

- subtitles with XML encapsulation

#### 4.5.3. Test Execution

The test is executed according to the procedure defined in section 2.2.

#### 4.5.4. Test Vectors

The test vectors are provided here: <http://www.dashif.org/testvectors#ATT>.

### 4.6. Test Case 5: Multiple Periods

#### 4.6.1. Features

The following features are tested

- Static content offering for basic On-Demand profile
- Complies to ISO BMFF On-Demand Profile or ISO BMFF Live profile, i.e. one of the three options
  - Restrictions in addressing to **BaseURL** and `sidx` (Content also offered with `BaseURL@byteRange`)
  - Using number-based templates and `@duration`



- Using time-based templates and **SegmentTimeline**
- At least 2 Periods with each at least including the 2 Adaptation Sets
  - Video Adaptation Set
    - Multiple video representations,
  - Audio Adaptation Set
    - Multiple Audio Representation
    - Codec is HE-AAC v2
- At least 2 Periods are contained in the Media Presentation

#### 4.6.2. Test Case

The following test cases are defined

- Test Case 5a: 2 independent Periods
- Test Case 5b: 3 Periods, 3rd is continuation of first, 2nd is ad insertion

#### 4.6.3. Test Execution

The test is executed according to the procedure defined in section 2.2.

In addition it is expected that the client continues seamless playout across Period boundaries.

#### 4.6.4. Test Vectors

The test vectors are provided here: <http://www.dashif.org/testvectors#MP>.

### 4.7. Test Case 6: Encryption and Key Rotation

#### 4.7.1. Features

The following features are tested

- Static content offering for basic On-Demand profile
- Complies to ISO BMFF On-Demand Profile or ISO BMFF Live profile, i.e. one of the three options
  - Restrictions in addressing to **BaseURL** and `sidx` (Content also offered with `BaseURL@byteRange`)
  - Using number-based templates and `@duration`
  - Using time-based templates and **SegmentTimeline**
- At least 2 Periods with each at least including the 2 Adaptation Sets
  - Video Adaptation Set
    - Multiple video representations,
    - some/all Representations are encrypted with the test DRM defined above
  - Audio Adaptation Set

- Multiple Audio Representation
- Codec is HE-AAC v2
- The test DRM is provided.

#### 4.7.2. Test Case

The test cases are aligned with the use cases in [1].

- Test Case 6a: single key, pssh and tenc in Initialization Segment only using ISO BMFF On-Demand profile
- Test Case 6b: pssh and tenc in MPD and Initialization Segment using ISO BMFF On-Demand profile with encrypted ISO BMFF Live profile, no key rotation (segmented content)
- Test Case 6c: pssh and tenc in MPD and Initialization Segment using ISO BMFF On-Demand profile with encrypted ISO BMFF Live profile and key rotation (segmented content)
- Test Case 6d: Periods with encrypted and unencrypted content

#### 4.7.3. Test Execution

The test is executed according to the procedure defined in section 2.2.

#### 4.7.4. Test Vectors

The test vectors are provided here: <http://www.dashif.org/testvectors#EKR>.

### 4.8. Test Case 7: Dynamic Segment Offering

#### 4.8.1. Features

The following features are tested

- Dynamic content offering, i.e. **MPD**@type="dynamic"
- Complies to ISO BMFF Live profile with using number-based and time-based templates
- One or multiple Periods with 2 Adaptation Sets
  - Video Adaptation Set
    - Multiple video representations,
  - Audio Adaptation Set
    - One or Multiple Audio Representation
    - Codec is HE-AAC v2
- MPD does not contain @minimumUpdatePeriod, only @mediaPresentationDuration

#### 4.8.2. Test Cases

- Test case 7a: Number-based templating with @duration
- Test case 7b: Time-based templating with **SegmentTimeline**

### 4.8.3. Test Execution

The test is executed according to the procedure defined in section 2.2.

### 4.8.4. Test Vectors

The test vectors are provided here: <http://www.dashif.org/testvectors#DSO>.

## 4.9. Test Case 8: Dynamic Offering with MPD Update

### 4.9.1. Features

The following features are tested

- Dynamic content offering, i.e. **MPD**@type="dynamic"
- Complies to ISO BMFF Live profile with using number-based and time-based templates
- One or multiple Periods with 2 Adaptation Sets
  - Video Adaptation Set
    - Multiple video representations,
    - each with codec is Main Profile 3.0
  - Audio Adaptation Set
    - One or Multiple Audio Representation
    - Codec is HE-AAC v2
- MPD does contain @minimumUpdatePeriod
- Value of @mediaPresentationDuration is NOT a multiple of @duration
- MPD does contain @suggestedPresentationDelay

### 4.9.2. Test Cases

Test case 7a: Number-based templating with @duration and @timeShiftBuffer >= @mediaPresentationDuration

Test case 7b: Time-based templating with **SegmentTimeline**

Test case 7c: Number-based templating with @duration with @timeShiftBuffer (approx 2\*@duration) << @mediaPresentationDuration start at the beginning

Test case 7d: Number-based templating with @duration with @timeShiftBuffer (approx 2\*@duration) << @mediaPresentationDuration start arbitrary (random access)

Test case 7e: Time-based templating with **SegmentTimeline** with @timeShiftBuffer (approx 2\*@maxSegmentDuration) << @mediaPresentationDuration start arbitrary (random access)

### 4.9.3. Test Execution

The test is executed according to the procedure defined in section 2.2.

#### 4.9.4. Test Vectors

The test vectors are provided here: <http://www.dashif.org/testvectors#DSOWMPDU>.

### 4.10. Test Case 9: Trick Mode

#### 4.10.1. Features

The following features are tested

- Static content offering
- Complies to ISO BMFF On-Demand Profile or ISO BMFF Live profile, i.e. one of the three options
  - Restrictions in addressing to **BaseURL** and `sidx` (Content also offered with `BaseURL@byteRange`)
  - Using number-based templates and `@duration`
  - Using time-based templates and **SegmentTimeline**
- Single Period
- at least 2 Adaptation Sets
  - Video Adaptation Set
    - multiple video representations all same codec
    - Codec is H.264 Main Profile level 3.0
    - Each Adaptation Set contains the same spatial resolution
    - At least one Representation is IDR-frame only, i.e. `@codingDependency` is set to 'false'
  - Audio Adaptation Set
    - Single Audio Representation
    - Codec is HE-AAC v2

#### 4.10.2. Test Execution

The test is executed according to the procedure defined in Section 2.2. In addition:

1. Presentation is paused in the middle of the presentation for 5 seconds and then resumed.
2. Fast Forward is done from the middle of the presentation.
3. Reverse playback is done from the middle of the presentation.

#### 4.10.3. Test Vectors

The test vectors are provided here: <http://www.dashif.org/testvectors#ATM>.

## 5. Test Cases for DASH-264/AVC HD

### 5.1. Introduction

The following test cases are defined for DASH-264/AVC HD:

1. Basic On-Demand
2. Multi-resolution Video

### 5.2. Test Case 10: DASH-264/AVC HD Basic On-Demand

#### 5.2.1. Features

The following features are tested

- Static content offering
- Compliance to ISO BMFF On-Demand Profile or ISO BMFF Live profile, i.e. one of the three options
  - Restrictions in addressing to **BaseURL** and `sidx` (Content also offered with `BaseURL@byteRange`)
  - Using number-based templates and `@duration`
  - Using time-based templates and **SegmentTimeline**
- Single Period
- at least 2 Adaptation Sets
  - Video Adaptation Set
    - multiple video representations all same codec according to DASH-264/AVC HD
    - Each Adaptation Set contains the same spatial resolution
  - Audio Adaptation Set
    - Single Audio Representation
    - Codec is HE-AAC v2

#### 5.2.2. Test Cases

The following more detailed test cases are defined

- Test Case 1a: Features from above for `BaseURL` and `sidx`
- Test Case 1b: Features from above for number template
- Test Case 1c: Features from above for time template

#### 5.2.3. Test Execution

The test is executed according to the procedure defined in section 2.2.

#### 5.2.4. Test Vectors

The test vectors are provided here: [http://www.dashif.org/testvectors#SRMR\\_HD](http://www.dashif.org/testvectors#SRMR_HD).

### 5.3. Test Case 11: Multi-resolution including HD Video

#### 5.3.1. Features

The following features are tested

- Static content offering
- Complies to ISO BMFF On-Demand Profile or ISO BMFF Live profile, i.e. one of the three options
  - Restrictions in addressing to **BaseURL** and `sidx`
  - Using number-based templates
  - Using time-based templates
- Single Period
- at least 2 Adaptation Sets
  - Video Adaptation Set
    - multiple video representations all same codec
    - The Adaptation Set contains different spatial resolutions
  - Audio Adaptation Set
    - Single Audio Representation
    - Codec is HE-AAC v2

#### 5.3.2. Test Case

The following test cases are defined

Test Case 2a:

- the addressing scheme is number-based addressing
- the spatial resolutions are 1080p, 720p, 480p, 360p, 240p

Test Case 2b:

- the addressing scheme is number-based addressing
- the spatial resolutions are 1080p, 720p, 480p, 360p, 240p

Test Case 2c: Features from above for time template

#### 5.3.3. Test Execution

The test is executed according to the procedure defined in section 2.2.

#### 5.3.4. Test Vectors

The test vectors are provided here: [http://www.dashif.org/testvectors#MRMR\\_HD](http://www.dashif.org/testvectors#MRMR_HD).

## **6. Test Cases for DASH-IF Multichannel Audio Extensions**

### **6.1. Dolby**

#### **6.1.1. Test Case 12: 6-Channel ID**

##### **6.1.1.1. Features**

Contains 5.1-channel Dolby Digital Plus content. A single audio track to identify the correct 5.1 speaker setup, supported by a single video track providing the stream description.

##### **6.1.1.2. Test Cases**

Test case 1: Playback of Audio/Video, with audio being output through the correct speaker. The content is for a 5.1 surround setup.

##### **6.1.1.3. Test Execution**

The test is executed according to the procedure defined in Section 3.2. In addition:

- All audio channels are expected to be played from the correct speaker

##### **6.1.1.4. Test Vectors**

The test vectors are provided here: [http://www.dashif.org/testvectors#MCA\\_DOLBY](http://www.dashif.org/testvectors#MCA_DOLBY).

#### **6.1.2. Test Case 13: 8-Channel ID**

##### **6.1.2.1. Features**

Contains 7.1-channel Dolby Digital Plus content. A single audio track to identify the correct 7.1 speaker setup, supported by a single video track providing the stream description.

##### **6.1.2.2. Test Cases**

Test case 2: Playback of Audio/Video, with audio being output through the correct speaker. The content is for a 7.1 surround setup. The speaker setup is common for Blu-Ray configurations.

##### **6.1.2.3. Test Execution**

The test is executed according to the procedure defined in Section 3.2. In addition:

- All audio channels are expected to be played from the correct speaker

##### **6.1.2.4. Test Vectors**

The test vectors are provided here: [http://www.dashif.org/testvectors#MCA\\_DOLBY](http://www.dashif.org/testvectors#MCA_DOLBY).

#### **6.1.3. Test Case 14: Single Stereo Audio Track**

##### **6.1.3.1. Features**

Contains two-channel Dolby Digital Plus content. A single audio track to identify the correct two-channel speaker setup, supported by a single video track providing the stream description.

##### **6.1.3.2. Test Cases**

Test Case 3: Playback of Audio/Video, with audio being output through the correct speaker. The content is for a two-channel stereo setup.

### 6.1.3.3. Test Execution

The test is executed according to the procedure defined in Section 3.2. In addition:

- All audio channels are expected to be played from the correct speaker

### 6.1.3.4. Test Vectors

The test vectors are provided here: [http://www.dashif.org/testvectors#MCA\\_DOLBY](http://www.dashif.org/testvectors#MCA_DOLBY).

## 6.1.4. Test Case 15: Multiple Adaptation Sets

### 6.1.4.1. Features

Contains multiple bit-rate streams. Multiple audio tracks in an Adaptation Set with a single video Representation. Audio Adaptation Sets are 7.1 surround with three different audio bitrates 348 kbps, 448 kbps and 768 kbps.

### 6.1.4.2. Test Cases

Test Case 4: Playback and seamless switching of multichannel audio content with multiple bitrates while maintaining A/V sync.

### 6.1.4.3. Test Execution

The test is executed according to the procedure defined in Section 3.2. In addition:

- Seamless switching of audio Representations without losing A/V sync

### 6.1.4.4. Test Vectors

The test vectors are provided here: [http://www.dashif.org/testvectors#MCA\\_DOLBY](http://www.dashif.org/testvectors#MCA_DOLBY).

## 6.2. DTS

### 6.2.1. Test Case 1: Single Multichannel Audio Track

#### 6.2.1.1. Features

The following features are tested

- Static content offering
- Complies to ISO BMFF Live profile using number-based templates
- Single period
  - Video adaptation set
    - Single video representation compliant with DASH-264/AVC baseline
  - Audio adaptation set
    - Single 5.1 channel audio representation
    - DTS-HD audio using four DTS profiles (one per test vector):
      - DTS core 768 Kbits/sec
      - DTS Express 192 Kbits/sec
      - DTS-HD High Resolution 2 Mbits/sec



- DTS-HD Master Audio 16-bit lossless

#### **6.2.1.2. Test Cases**

- Test case 1a: Verify delivery and playback of DTS 5.1 channel track with SD Video
- Test case 1b: Verify delivery and playback of DTS Express 5.1 channel track with SD Video
- Test case 1c: Verify delivery and playback of DTS-HD High Resolution 5.1 channel track with SD Video
- Test case 1d: Verify delivery and playback of DTS-HD Master Audio 5.1 channel track with SD Video

#### **6.2.1.3. Test Execution**

The test is executed according to the procedure defined in Section 2.2.

#### **6.2.1.4. Test Vectors**

The test vectors are provided here: [http://www.dashif.org/testvectors#MCA\\_DTS](http://www.dashif.org/testvectors#MCA_DTS).

### **6.2.2. Test Case 2: Single Stereo Audio Track**

#### **6.2.2.1. Features**

The following features are tested

- Static content offering
- Complies to ISO BMFF Live profile using number-based templates
- Single period
- Video adaptation set
  - Single video representation compliant with DASH-264/AVC baseline
- Audio adaptation set
  - Single stereo audio representation
  - DTS-HD audio using three DTS profiles (one per test vector):
    - DTS core 192 Kbits/sec
    - DTS Express 128 Kbits/sec
    - DTS-HD Master Audio 24-bit lossless

#### **6.2.2.2. Test Cases**

- Test case 2a: Verify delivery and playback of a DTS stereo audio track SD Video
- Test case 2b: Verify delivery and playback of a DTS Express stereo track with SD Video
- Test case 2c: Verify delivery and playback of a DTS-HD Master Audio stereo track with SD Video

#### **6.2.2.3. Test Execution**

The test is executed according to the procedure defined in Section 2.2.

#### 6.2.2.4. Test Vectors

The test vectors are provided here: [http://www.dashif.org/testvectors#MCA\\_DTS](http://www.dashif.org/testvectors#MCA_DTS).

### 6.2.3. Test Case 3: Multiple Adaptation Sets

#### 6.2.3.1. Features

The following features are tested

- Static content offering
- Complies to ISO BMFF Live profile using number-based templates
- Single period
- Video adaptation set
  - Single video representation compliant with DASH-264/AVC baseline
- Audio adaptation set
  - Two 5.1 channel audio representations
  - DTS-HD audio using four DTS profiles (two per test vector):
    - DTS core
      - 762 Kbits/sec
      - 1524 Kbits/sec
    - DTS Express
      - 192 Kbits/sec
      - 384 Kbits/sec
    - DTS-HD High Resolution 2 Mbits/sec
      - 2 Mbits/sec
      - 3 Mbits/sec
    - DTS-HD Master Audio 16-bit lossless
      - 16-bit lossless
      - 24 bit lossless

#### 6.2.3.2. Test Cases

Test case 3a: Verify delivery and playback of DTS 5.1 channel track and the ability to switch seamlessly between two bit rates, with SD Video

Test case 3b: Verify delivery and playback of DTS Express 5.1 channel track and the ability to switch seamlessly between two bit rates, with SD Video

Test case 3c: Verify delivery and playback of DTS-HD High Resolution 5.1 channel track and the ability to switch seamlessly between two bit rates, with SD Video

Test case 3d: Verify delivery and playback of DTS-HD Master Audio 5.1 channel track and the ability to switch seamlessly between two bit rates, with SD Video

#### 6.2.3.3. Test Execution

The test is executed according to the procedure defined in Section 2.2.

#### 6.2.3.4. Test Vectors

The test vectors are provided here: [http://www.dashif.org/testvectors#MCA\\_DTS](http://www.dashif.org/testvectors#MCA_DTS).

### 6.3. HE-AACv2 Multichannel

HE-AACv2 multichannel is fully compatible with the DASH-264/AVC baseline, i.e. all stereo baseline content can be decoded and hence no individual stereo test cases are necessary for this extension.

#### 6.3.1. Test Case 1: 6-Channel ID

##### 6.3.1.1. Features

A single audio track to identify the correct 5.1 speaker setup, supported by a single video track visualizing the corresponding speaker.

##### 6.3.1.2. Test Cases

Test case 1: Playback of Audio/Video, with audio being output through the correct speaker. The content is for a 5.1 surround setup.

##### 6.3.1.3. Test Execution

The test is executed according to the procedure defined in Section 2.2. In addition:

- All audio channels are expected to be played from the correct speaker

##### 6.3.1.4. Test Vectors

The test vectors are provided here: [http://www.dashif.org/testvectors#MCA\\_AAC](http://www.dashif.org/testvectors#MCA_AAC).

#### 6.3.2. Test Case 2: 8-Channel ID

##### 6.3.2.1. Features

A single audio track to identify the correct 7.1 speaker setup, supported by a single video track visualizing the corresponding speaker. The speaker setup is expected to be in common Blu-Ray configuration [3].

##### 6.3.2.2. Test Cases

Test case 2: Playback of Audio/Video, with audio being output through the correct speaker. The content is for a 7.1 common Blu-Ray surround setup

##### 6.3.2.3. Test Execution

The test is executed according to the procedure defined in Section 2.2. In addition:

- All audio channels are expected to be played from the correct speaker

##### 6.3.2.4. Test Vectors

The test vectors are provided here [http://www.dashif.org/testvectors#MCA\\_AAC](http://www.dashif.org/testvectors#MCA_AAC).

### **6.3.3. Test Case 3: Multiple Audio Representations**

#### **6.3.3.1. Features**

Multiple audio tracks in an Adaptation Set with a single video Representation. Audio Adaptation Sets are available in 5.1 and 7.1 surround.

#### **6.3.3.2. Test Cases**

Test Case 3: Playback and seamless switching of multichannel audio content with multiple bitrates while maintaining A/V sync.

#### **6.3.3.3. Test Execution**

The test is executed according to the procedure defined in Section 2.2. In addition:

- Seamless switching of audio Representations without losing A/V sync

#### **6.3.3.4. Test Vectors**

The test vectors are provided here: [http://www.dashif.org/testvectors#MCA\\_AAC](http://www.dashif.org/testvectors#MCA_AAC).

## **6.4. MPEG Surround**

HE-AAC multichannel is fully compatible with the DASH-264/AVC baseline, i.e. all stereo baseline content can be decoded and hence no individual stereo test cases are necessary for this extension.

### **6.4.1. Test Case 1: 6-Channel ID**

#### **6.4.1.1. Features**

A single audio track to identify the correct 5.1 speaker setup, supported by a single video track visualizing the corresponding speaker.

#### **6.4.1.2. Test Cases**

Test case 1: Playback of Audio/Video, with audio being output through the correct speaker. The content is for a 5.1 surround setup.

#### **6.4.1.3. Test Execution**

For each of the above test cases, clients supporting this test case are expected to behave as follows:

- All audio channels are expected to be played from the correct speaker

### **6.4.2. Test Case 2: Multiple Audio Representations**

#### **6.4.2.1. Features**

Multiple audio tracks in an Adaptation Set with a single video Representation. Audio Adaptation Sets are available in 5.1 surround.

#### **6.4.2.2. Test Cases**

Test case 2: Playback and seamless switching of multichannel audio content with multiple bitrates while maintaining A/V sync.

#### **6.4.2.3. Test Execution**

For each of the above test cases, clients supporting this test case are expected to behave as follows:

- Seamless switching of audio Representations without losing A/V sync

#### 6.4.2.4. Test Vectors

The test vectors are provided here: [http://www.dashif.org/testvectors#MCA\\_MPS](http://www.dashif.org/testvectors#MCA_MPS).

## 7. DASH-IF Negative Test Cases

### 7.1. Introduction

The following test cases are defined for Negative DASH-264/AVC test cases:

1. Essential Property
2. Content Protection

### 7.2. Test Case 1: Negative Essential Property

#### 7.2.1. Features

This test case provides Essential Property element(s) with unknown schemeIdUri for representation(s). A client should ignore and hence not play such representation(s). For the test case, other features selected are:

- Static content offering
- Compliance to ISO BMFF On-Demand Profile with restrictions in addressing to **BaseURL** and **sidx** (Content also offered with **BaseURL@byteRange**)
- Single Period
- at least 2 Adaptation Sets
  - Video Adaptation Set
    - multiple video representations all same codec according to DASH-264/AVC HD
    - Each Adaptation Set contains the same spatial resolution
  - Audio Adaptation Set
    - Single Audio Representation
    - Codec is HE-AAC v2

#### 7.2.2. Test Execution

The test is executed according to the procedure defined in section 2.2. The representation with the unknown Essential Property should not play.

#### 7.2.3. Test Vectors

The test vectors are provided here: <http://www.dashif.org/testvectors#NEGE>.

## 7.3. Test Case 2: Negative Content Protection

### 7.3.1. Features

This test case provides Content Protection element(s) with unknown schemeIdUri for representation(s). A client should ignore and hence not play such representation(s). For the test case, other features selected are:

- Static content offering
- Compliance to ISO BMFF On-Demand Profile with restrictions in addressing to **BaseURL** and **sidx** (Content also offered with BaseURL@byteRange)
- Single Period
- at least 2 Adaptation Sets
  - Video Adaptation Set
    - multiple video representations all same codec according to DASH-264/AVC HD
    - Each Adaptation Set contains the same spatial resolution
  - Audio Adaptation Set
    - Single Audio Representation
    - Codec is HE-AAC v2

### 7.3.2. Test Execution

The test is executed according to the procedure defined in section 2.2. The representation with the unknown Content Protection element should not play.

### 7.3.3. Test Vectors

The test vectors are provided here: <http://www.dashif.org/testvectors#NEGC>.

## 8. Guidelines for Network Emulation

### 8.1. Introduction

Tests may be run in the presence of the following Network Emulation Profiles. The client accesses the content from a DASH server via the network emulator as shown as Figure 3.



**Figure 3: Configuration of modules for Network Emulation**

Interface 1 in Figure 3 is preferably a high capacity wired network interface. Interface 2 can be a wired or wireless network. Both interfaces should cause negligible impairment compared to the impairment imposed by the test.

## 8.2. Test Content

Test content from Section 4 will be testing with network emulation test patterns. Currently, for DASH-264/AVC Basic On-Demand, test cases 1, 2, and 3 are found to be suitable for this testing. The features in the rest of the test cases do not get influenced by network emulation.

## 8.3. Network Emulation Profiles

Different Network Emulation Profiles are defined in this section to evaluate the impact on client performance by different types of network impairments (e.g. bandwidth, delay, loss, etc.) and their combinations.

### 8.3.1. Profile 1 – Reference Profile (No Impairment)

The client experiences no measurable network impairment in terms of bandwidth, delay, and losses. Purpose: Serve as a reference point for rest of the profiles.

Test Case	Network Emulator Profile	Test Pattern
4b	1	Reference Profile (No Impairment)
5a	1	Reference Profile (No Impairment)
5b	1	Reference Profile (No Impairment)
6a	1	Reference Profile (No Impairment)
6a	1	Reference Profile (No Impairment)
6b	1	Reference Profile (No Impairment)
6c	1	Reference Profile (No Impairment)
7a	1	Reference Profile (No Impairment)
7b	1	Reference Profile (No Impairment)
8a	1	Reference Profile (No Impairment)
8b	1	Reference Profile (No Impairment)
8c	1	Reference Profile (No Impairment)
8d	1	Reference Profile (No Impairment)
8e	1	Reference Profile (No Impairment)
9a	1	Reference Profile (No Impairment)

### 8.3.2. Profile 2 – Multiple Simultaneous Network Impairments

The DASH client is tested in the presence of a set of test patterns is defined for each test case where the bandwidth, delay and packet loss are dynamically varied at the same time.

Purpose: Stress the rate adaption algorithm, TCP stack, ability of DASH client to deal with changes in network conditions.

Each pattern has the follow properties:

1. The pattern is a sequence of bandwidth, delay and packet loss that are changed every 30 seconds in general. This can be adjusted however based on content and (sub)-segment duration.
2. Each pattern is looped for the duration of the video.

The methodology and rational for calculating the pattern based on MPD and additional teat pattern are documented in Annex A. The test patterns defined here are based on G.1050/TIA-921B Partially Managed Network with latency of less than 400ms and packet loss less than 2%.

### 8.3.2.1. Network Profiles for DASH-264/AVC and DASH-264/AVC SD test cases

Network Profiles defined in Table 1 through Table 6 are applicable to the test vectors 1a (3), 1a (4), 1b (4), 1b (5), 1c (1), 1c (2), 1c (3), 2a (1), 2a (2), 2b (2), 2b (3), 2b (4), 2c (1), and 2c (2) (the vector index is indicated in the parenthesis).

Table 1 provides a network profile with bandwidth variation of 5 Mbps to 1.5Mbps, RTT 75 ms to 200 ms, Loss 0.15% to 1.5%. The pattern is High-Low-High (HLH).

Bandwidth (kbps)	Delay=RTT/2 (ms)	Packet Loss (%)
5000	38	0.09
4000	50	0.08
3000	75	0.06
2000	88	0.09
1500	100	0.12
2000	88	0.09
3000	75	0.06
4000	50	0.08

**Table 1: Network Profile 2a (NP2a)**

Table 2 provides a network profile based on same conditions as Table 1, but the pattern is Low-High-Low (LHL).

Bandwidth (kbps)	Delay=RTT/2 (ms)	Packet Loss (%)
1500	100	0.12
2000	88	0.09
3000	75	0.06



4000	50	0.08
5000	38	0.09
4000	50	0.08
3000	75	0.06
2000	88	0.09

**Table 2: Network Profile 2b (NP2b)**

Table 3 provides a network profile with bandwidth variation of 5 Mbps to 1.5Mbps, RTT 25 ms to 400 ms, Loss 0.03% to 0.81%. The pattern is HLH.

Bandwidth (kbps)	Delay=RTT/2 (ms)	Packet Loss (%)
5000	13	0.81
4000	18	0.63
3000	28	0.44
2000	58	0.21
1500	200	0.03
2000	58	0.21
3000	28	0.44
4000	18	0.63

**Table 3: Network Profile 2c (NP2c)**

Table 4 provides a network profile based on same conditions as Table 3, but the pattern is LHL.

Bandwidth (kbps)	Delay=RTT/2 (ms)	Packet Loss (%)
1500	200	0.03
2000	58	0.21
3000	28	0.44
4000	18	0.63
5000	13	0.81
4000	18	0.63
3000	28	0.44
2000	58	0.21

**Table 4: Network Profile 2d (NP2d)**

Table 5 provides a network profile with bandwidth variation of 5 Mbps to 1.5Mbps, RTT 22 ms to 50 ms, Loss 1% to 2%. The pattern is HLH.

Bandwidth (kbps)	Delay=RTT/2 (ms)	Packet Loss (%)
5000	11	1.00
4000	13	1.25
3000	15	1.50
2000	20	1.75
1500	25	2.00
2000	20	1.75
3000	15	1.50
4000	13	1.25

**Table 5: Network Profile 2e (NP2e)**

Table 6 provides a network profile based on same conditions as Table 5, but the pattern is LHL.

Bandwidth (kbps)	Delay=RTT/2 (ms)	Packet Loss (%)
1500	25	2.00
2000	20	1.75
3000	15	1.50
4000	13	1.25
5000	11	1.00
4000	13	1.25
3000	15	1.50
2000	20	1.75

**Table 6: Network Profile 2f (NP2f)**

#### 8.3.2.2. Network Profiles for DASH-264/AVC HD test cases

Network Profiles defined in Table 7 through Table 12 are applicable to the HD test vectors 1a (1), 1a (2), 1b (1), 1c (1), 1b (2), 2a (2), 2a (3), 2b (2), 2c (1), and 2b (3) (the vector index is indicated in the parenthesis).

Table 7 provides a network profile with bandwidth variation of 9 Mbps to 1 Mbps, RTT 50 ms to 200 ms, Loss 0.06% to 0.16%. The pattern is High-Low-High (HLH).

Bandwidth (kbps)	Delay=RTT/2 (ms)	Packet Loss (%)
9000	25	0.06
4000	50	0.07

2000	75	0.10
1000	100	0.16
2000	75	0.10
4000	50	0.07
9000	25	0.06
4000	50	0.07

**Table 7: Network Profile 2g (NP2g)**

Table 8 provides a network profile based on same conditions as Table 7, but the pattern is Low-High-Low (LHL).

Bandwidth (kbps)	Delay=RTT/2 (ms)	Packet Loss (%)
1000	100	0.16
2000	75	0.10
4000	50	0.07
9000	25	0.06
4000	50	0.07
2000	75	0.10
1000	100	0.16
2000	75	0.10

**Table 8: Network Profile 2h (NP2h)**

Table 9 provides a network profile with bandwidth variation of 9 Mbps to 1 Mbps, RTT 20 ms to 400 ms, Loss 0.03% to 0.4%. The pattern is HLH.

Bandwidth (kbps)	Delay=RTT/2 (ms)	Packet Loss (%)
9000	10	0.40
4000	50	0.08
2000	150	0.03
1000	200	0.07
2000	150	0.03
4000	50	0.08
9000	10	0.40
4000	50	0.08

**Table 9: Network Profile 2i (NP2i)**

Table 10 provides a network profile based on same conditions as Table 9, but the pattern is LHL.

Bandwidth (kbps)	Delay=RTT/2 (ms)	Packet Loss (%)
1000	200	0.07
2000	150	0.03
4000	50	0.08
9000	10	0.40
4000	50	0.08
2000	150	0.03
1000	200	0.07
2000	150	0.03

1 **Table 10: Network Profile 2j (NP2j)**

2 Table 11 provides a network profile with bandwidth variation of 9 Mbps to 1 Mbps, RTT 12 ms  
3 to 50 ms, Loss 1% to 2%. The pattern is HLH.

4

Bandwidth (kbps)	Delay=RTT/2 (ms)	Packet Loss (%)
9000	6	1.00
4000	13	1.25
2000	20	1.50
1000	25	2.00
2000	20	1.50
4000	13	1.25
9000	6	1.00
4000	13	1.25

5 **Table 11: Network Profile 2k (NP2k)**

6 Table 12 provides a network profile based on same conditions as Table 11, but the pattern is LHL.

7

Bandwidth (kbps)	Delay=RTT/2 (ms)	Packet Loss (%)
1000	25	2.00
2000	20	1.50
4000	13	1.25
9000	6	1.00
4000	13	1.25

2000	20	1.50
1000	25	2.00
2000	20	1.50

**Table 12: Network Profile 2I (NP2I)**

### 8.3.3. Profile 3 – Multiple Dash Clients Competing for Bandwidth at the Same Time

The setup shall consist of a multiple clients accessing multiple video streams from one or more servers over a link where the bandwidth is shared.

Purpose: Observe client / server behaviour in presence the of real-world scenario where multiple videos are being watched over the same access network. The video streams are competing with each other for the limited network bandwidth. This test stresses the TCP stack and buffers.

Test Case	Vector index	Network Emulator Profile	Network Emulation	
			Delay	Band-width
2a	2	3	25ms Delay	7000k
2a	2	3	25ms Delay	6000k
2a	2	3	25ms Delay	3000k
2a	2	3	25ms Delay	1000k

## 8.4. Network Emulation Tools

Testing can be performed using any network emulation tool that is capable of accurately producing the network characteristics between two network endpoints. Key to this is that transitions between impairment levels do not produce any incorrect values of impairment or introduce any unexpected characteristics such as reordered packets, duplicate packets packet loss, latency or bandwidth limitation.

## 8.5. Guidelines for Recording Results

### 8.5.1. Client indicators

It is recommended that each client provide a visual indicator that may be used to verify that adaptive switching is working correctly. This indicator should show which representation is active, what the nominal bitrate of the representation is, and what the actual bitrate of the content is as it is received.

1 For clients that do not have a visual indicator available the network behaviour may be verified  
2 using a network monitoring tool such as Wireshark. In addition, the test vector used for adaptive  
3 testing will have the nominal video bitrate overlaid on the test content in order to facilitate client  
4 verification.

#### 5 **8.5.2. Playback Observations**

6 It is recommended at a minimum the following be recorded concerning the client playback: Good  
7 Playback, No Audio, No Video, No Video and Audio, Stay at low bit rate, Minor Rebuffer, Re-  
8 peated Rebuffer, Play Halted and a graph of the raw download rate.

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## Annex A – Example Network Emulation Patterns and Rational for Patterns used in Multiple Simultaneous Network Impairments

5

### 8.1. Example Patterns for Bandwidth (Throttle)

6

Example Network Emulation Patterns for Bandwidth (Throttle) Stepped Low-to-High was used in the recommended test cases.

7

8

Purpose: Stress the rate adaption algorithm of DASH client.

9

Pattern	Bandwidth (kbps)
Stepped Low-to-High	612
	1052
	1712
	3362
Stepped High-to-Low	3362
	1712
	1052
	612
Immediate Low-to-High	3362
	612
Immediate High-to-Low	3400
	600
Stepped Low-High-Low	612
	1052
	1712
	3362
	1712
	1052
	612
Immediate Low-Mid-Low	612
	1712
Immediate High-Mid-High	3362
	1712
	3362

10

**Table 13: Example Bandwidth (Throttle) Variation for Test Case 2a1**

1 **8.2. Example Patterns for Delay (Latency) Variation**

2 Example Network Emulation Pattern for delay only are tabulated in Table 14.

3 Purpose: This pattern stresses TCP stack and buffers

Title	Key	Delay (msec)
Typical	Delay_L_H_L	200
		150
		100
		75
		50
		25
		10
		10
		25
		50
		75
		100
		150
		200
Large de- lays	Delay_S_H_S	400
		600
		800
		1300
		800
		600
		400
		200
		200
		200

4 **Table 14: Example Delay (Latency) Variation for Test Case 2a1**

5 **8.3. Example Patterns for Packet Loss Variation**

6 Example Network Emulation Pattern for delay only are tabulated in Table 3.

7 Purpose: This pattern stresses TCP stack and buffers

Title	Key	Delay (msec)
Typical	Loss_L_H_L	0.1
		0.1
		0.01
		0.01
		0.001
		0.001



Large Packet Loss Val- ues	Loss_L_H_L	0.01
		0.01
		0.1
		0.1
		0.1
		1
		2
		5
		10
		5
		2
		1
		0.1

**Table 15: Example Packet Loss Variation for Test Case 2a1**

### 8.3.1. Rational for Patterns used in Multiple Simultaneous Network Impairments – Section 6.3.2. Profile 2

#### 8.3.1.1. General

The determination for bandwidth (BW) is made as [5]

$$BW \leq \frac{MSS}{RTT} \frac{C}{\sqrt{p}},$$

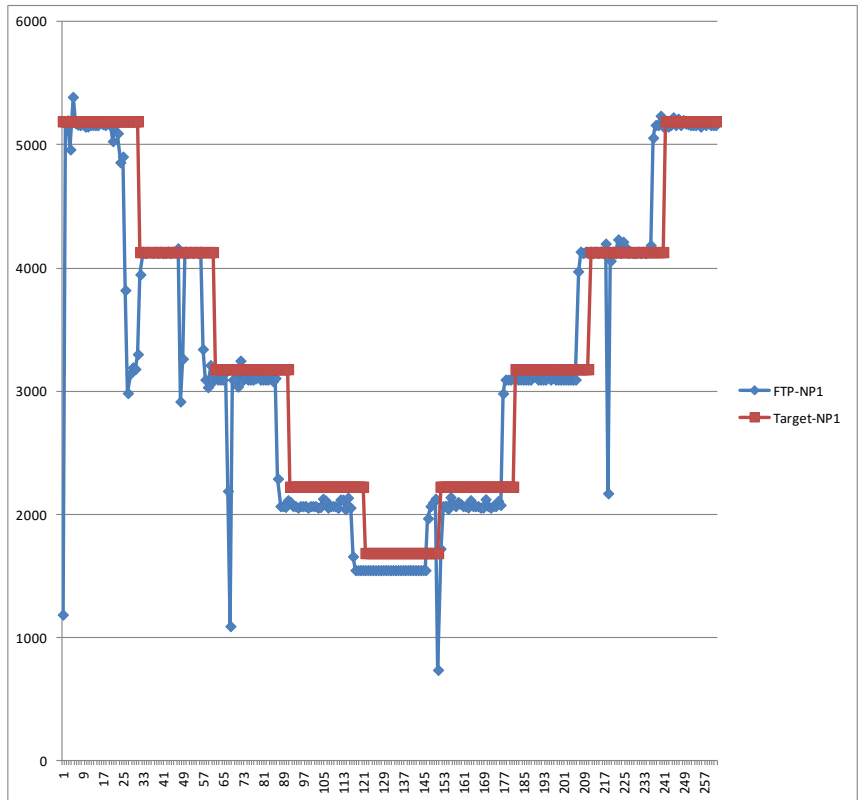
for a maximum segment size (MSS) bytes, round trip time (RTT) and loss rate ( $p$ ). The resulting calculation for NP2a is tabulated in the following as an example:

BW(kbps)	RTT	Loss	BW < (1460*8/RTT)* (1/sqrt(LOSS))	Delta BW (kbps)	BW (kbps)	Delay=RTT/2 (ms)	Packet Loss (%)
5000	75	0.09	5191	191	5000	38	0.09
4000	100	0.08	4130	130	4000	50	0.08
3000	150	0.06	3179	179	3000	75	0.06
2000	175	0.09	2225	225	2000	88	0.09
1500	200	0.12	1686	186	1500	100	0.12
2000	175	0.09	2225	225	2000	88	0.09
3000	150	0.06	3179	179	3000	75	0.06
4000	100	0.08	4130	130	4000	50	0.08

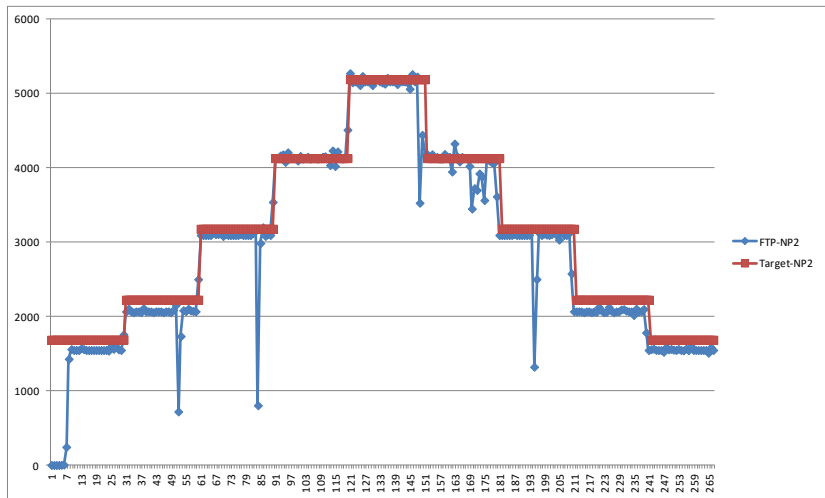
**Table : Example calculation for NP2a**

**8.3.1.2. Verification of Network Profile Calculation**

The target / calculated network profiles have been verified on a simulation setup. The red curve in Figure below is the target / calculated bandwidth for NP2a, while the blue curve is the measured FTP bandwidth by DASH-264/AVC test vector 2b (2) using the profile. A similar result is seen for NP2b.



**Figure 4: Validation of NP2a for DASH-264/AVC test vector 2b (2)**



**Figure 5: Validation of NP2b for DASH-264/AVC SD test vector 2b (2)**

## Annex B: Test Content Generation

Content generation for DASH-264/AVC compliant content involves the steps in Figure 6. Content is generated in multiple rates and encapsulated in MP4 compliant fragmented movie files. Encryption may be added. A process is applied to convert the multi-bitrate content to DASH content by generating the MPD and segments. Conformance checking is applied. The content is made available on an HTTP server. The content may also be made available as dynamic content. The content offering is verified with a reference client using some bandwidth variation profiles (see section.

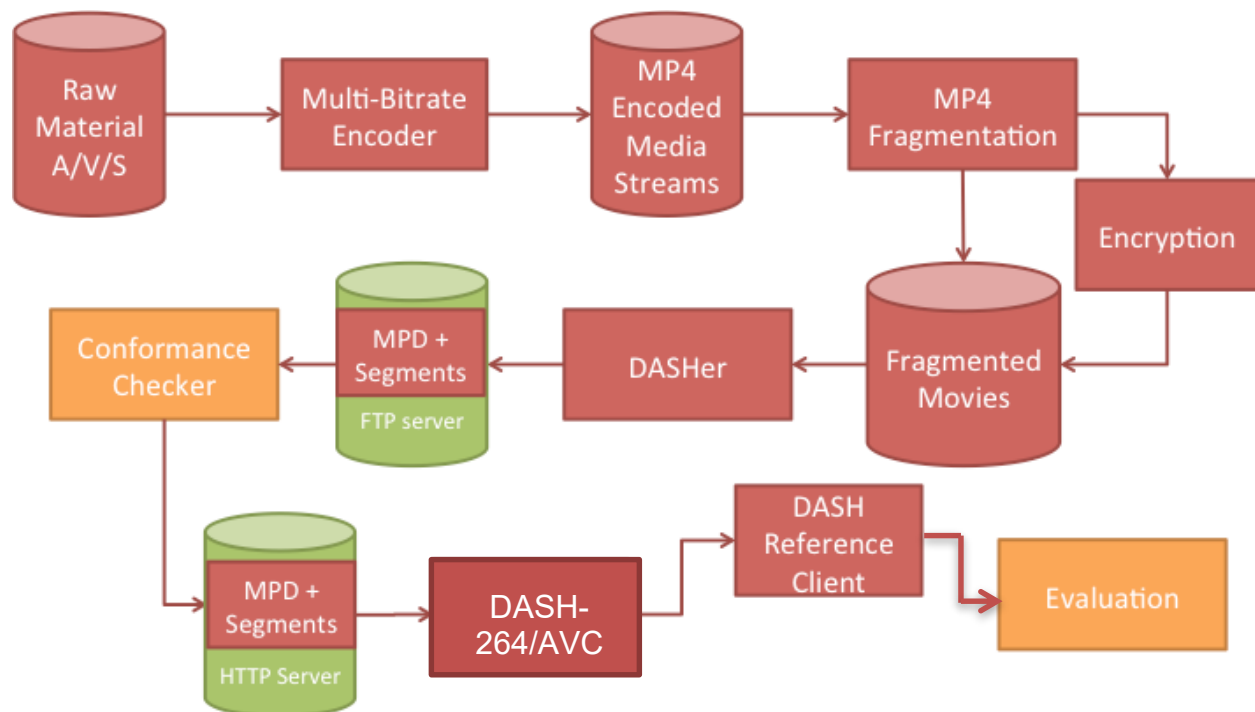


Figure 6 DASH content generation and conformance checking

### 8.4. Source Material for Content Generation

For the generation of content the following raw material is available:

#### 8.4.1. Elephant's Dream

This source material is available in various formats at [7], and in raw format at [8].

#### 8.4.2. Big Buck Bunny

This source material is available in various formats at [9], and in raw format at [10].

#### 8.4.3. Sintel

This source material is available in various formats at [11].

#### 8.4.4. Tears of Steel

This source material is available in various formats at [12].

1   **8.4.5.     The Last Time I Saw Paris**

2   This source material is available in various formats at [13].

3

## 9. References

- [1] DASH Industry Forum, "Guidelines for Implementation: DASH-264/AVC Interoperability Points v2.0, August 2013, accessible at <http://www.dashif.org>.
- [2] DASH Industry Forum, "Guidelines for Implementation: DASH-264/AVC Conformance Software", under development.
- [3] Application Bulletin "Fraunhofer Surround Codecs", <http://www.iis.fraunhofer.de/content/dam/iis/de/dokumente/amm/wp/FraunhoferSurroundCodecsv19.pdf>
- [4] ISO/IEC 23009-2:2012 Information technology -- Dynamic adaptive streaming over HTTP (DASH) -- Part 2: Conformance and Reference Software (Study of DIS).
- [5] Hacker, Thomas J., Brian D. Athey, and Brian Noble. "The end-to-end performance effects of parallel TCP sockets on a lossy wide-area network." Parallel and Distributed Processing Symposium., Proceedings International, IPDPS 2002, Abstracts and CD-ROM. IEEE, 2002.
- [6] DASH-IF test vectors, [Online]: <http://dashif.org/testvectors/>
- [7] Elephant's Dream, [Online]: <http://www.w6rz.net/>
- [8] Elephant's Dream (Raw format), [Online]: <http://media.xiph.org/ED/>
- [9] Big Buck Bunny, [Online]: <http://www.bigbuckbunny.org/index.php/download/>
- [10] Big Buck Bunny (Raw Format), [Online]: <http://media.xiph.org/BBB/>
- [11] Sintel, [Online]: <http://www.sintel.org/download/>
- [12] Tears of Steel [Online]: <http://mango.blender.org/>
- [13] The Last Time I Saw Paris [Online]: [http://archive.org/download/last\\_time\\_i\\_saw\\_paris/last\\_time\\_i\\_saw\\_paris.mpeg](http://archive.org/download/last_time_i_saw_paris/last_time_i_saw_paris.mpeg)