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Third edition
2020-09

Information technology — Dynamic adaptive streaming over HTTP (DASH) —

Part 2: Conformance and reference software

Technologies de l'information — Diffusion en flux adaptatif dynamique sur HTTP (DASH) —

Partie 2: Conformité et logiciel de référence

Reference number
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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see: www.iso.org/iso/foreword.html.

This document was prepared by Joint Techncial Committee ISO/IEC JTC 1, *Information technology*, SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

This third edition cancels and replaces the second edition (ISO/IEC 23009-2:2017), which has been technically revised.

The main changes compared to the previous edition are as follows:

a) Test vectors, conformance and reference software to cover all the features of ISO/IEC 23009-5, including:

   — SAND HTTP conformance client;

   — SAND HTTP conformance server;

   — SAND WebSocket conformance server.

b) Test vecors, conformance and reference software to cover all the features of ISO/IEC 23009-6, including:

   — Command line tool to validate of ABNF grammars.

A list of all parts in the ISO/IEC 23009 series can be found on the ISO website.

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Introduction

The conformance and reference software of the ISO/IEC 23009 series serves three main purposes:

— validation of the written specification of the Parts of the ISO/IEC 23009 series;

— clarification of the written specification of the Parts of the ISO/IEC 23009 series;

— conformance testing for checking interoperability for the various applications against the reference software which aims to be compliant with the ISO/IEC 23009 series.

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Information technology — Dynamic adaptive streaming over HTTP (DASH) —

Part 2: Conformance and reference software

1 Scope

This document specifies the conformance and reference software implementing the test vectors comprising media presentation descriptions, segments and combinations thereof in ISO/IEC 23009-1, and the corresponding software modules.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 19757-3, *Information technology — Document Schema Definition Languages (DSDL) — Part 3: Rule-based validation — Schematron*

ISO/IEC 23009-1:2019, *Information technology — Dynamic adaptive streaming over HTTP (DASH) — Part 1: Media presentation description and segment formats*

ISO 8601-1, *Date and time — Representations for information interchange — Part 1: Basic rules*

ISO/IEC 23009-5:2017, *Information technology — Dynamic adaptive streaming over HTTP (DASH) — Part 5: Server and network assisted DASH (SAND)*

IETF RFC 7233:2014, *Hypertext Transfer Protocol (HTTP/1.1): Range Requests*

3 Terms, definitions, symbols and abbreviated terms

For the purpose of this document, the terms, definitions, symbols and abbreviated terms given in ISO/IEC 23009-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

4 Media presentation conformance

4.1 Overview

A media presentation conforming to ISO/IEC 23009-1 obeys the rules for the media presentation description (MPD) and the segments referenced within the MPD. To verify the conformance of a media presentation, the following steps need to be completed:

— the conformance of the MPD according to Clause 5.

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— the conformance of the segments, which includes the conformance of individual segments and representations, as well as the conformance of representations that are jointly provided in adaptation sets and periods. For details, refer to Clause 6.

The process of MPD and segment conformance checking is shown in Figure 1.

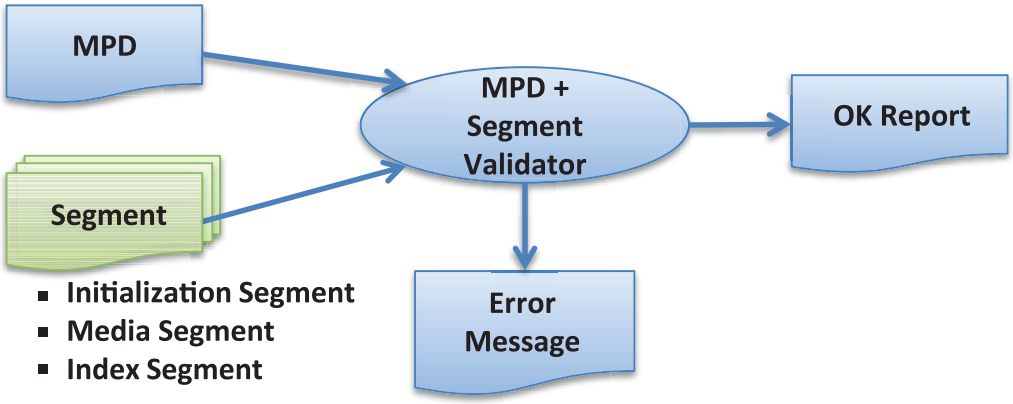

Figure 1 — MPD and segment validation

MPD + segment validator: gets as an input the MPD and segments referenced from within the MPD and performs the MPD and segment validation according to the rules defined in Annex A. On success, the output is an OK report; otherwise, an error message is provided.

4.2 Software tools

The following software tools are included:

— MPD conformance software;

— ISO BMFF segment validator;

— MPEG-2 TS segment validator;

— Conformance software for dynamic services;

— Dynamic media presentation emulator in Annex D.

All software tools are available at https://standards.iso.org/iso-iec/23009/-2/ed-3/en.

Additional supplemental software packages which may be used as sample DASH clients, sample segmentor and web-based conformance service are listed in Annex C.

Coverage of DASH features is discussed in Annex E.

5 MPD conformance

5.1 General

This clause specifies the MPD conformance checking and corresponding software modules which comprise the three steps depicted in Figure 2. Detailed means to perform MPD conformance checking are as specified in Annex A.

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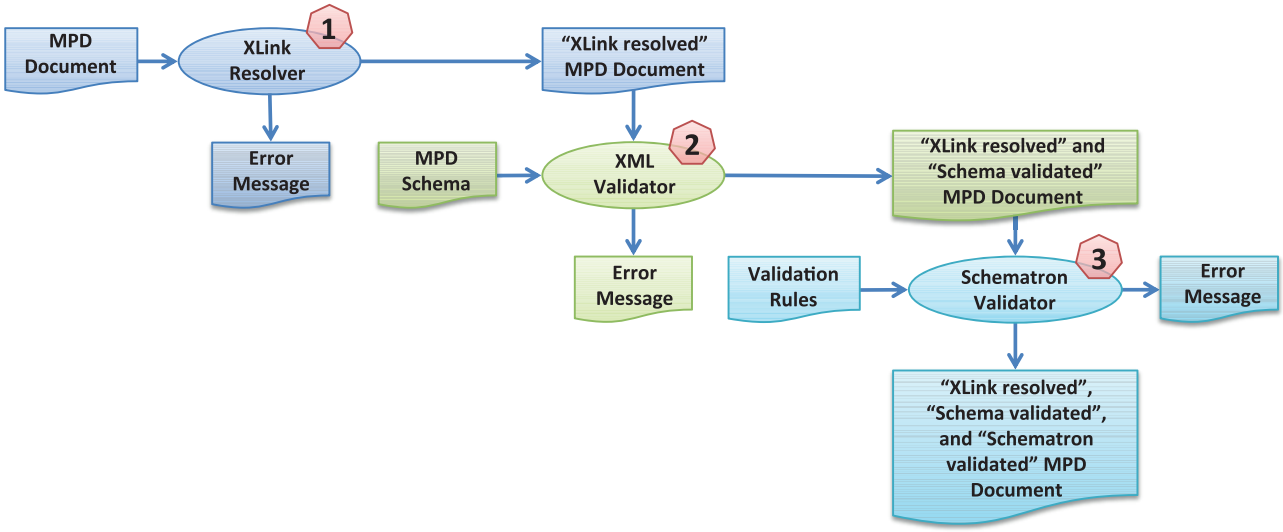

Figure 2 — MPD conformance checking

Step 1 (XLink resolver): gets as an input an MPD document and resolves all W3C XLINK[10] attributes as defined in ISO/IEC 23009-1. If an error occurs, the corresponding error message shall be provided; otherwise, the XLink resolved MPD document is provided. The details for this step of the MPD conformance checking are defined in A.2.

Step 2 (XML validator): gets as an input an XLink-resolved MPD document and performs XML validation (i.e. well-formed and valid) against the MPD schema defined in W3C XML[11] and W3C XML SCHEMA[12]. If an error occurs, the corresponding error message shall be provided; otherwise, the XLink-resolved and schema-validated MPD document is provided. The details for this step of the MPD conformance checking are defined in A.3.

Step 3 (schematron validator): gets as an input an XLink-resolved and schema-validated MPD document and performs schematron validation as defined in ISO/IEC 19757-3 according to the rules defined in A.4.2. If an error occurs, the corresponding error message shall be provided; otherwise, the XLink-resolved, schema-validated, and Schematron-validated MPD document is provided. The details for this step of the MPD conformance checking are defined in A.4.

The following command may be used to validate an MPD document with the chain depicted in Figure 2. This requires Apache Ant™1)[3].

```
ant run -Dinput="filetovalidate.mpd"
```

The program outputs a message for each step. If an error occurs during one step, the following steps are not executed.

All conformance tools are available at https://standards.iso.org/iso-iec/23009/-2/ed-3/en.

5.2 Static MPD conformance

An MPD with **MPD**`@type="static"` shall comply with the rules in 5.1.

In addition, the availability of all resources in the MPD during the **MPD**`@availabilityStartTime` and the **MPD**`@availabilityEndTime` shall be checked. A function `remoteFileExists($url)` may be executed for each segment that is documented in the MPD. This function shall return true for all Segments in the MPD during the time interval defined by the **MPD**`@availabilityStartTime` and the **MPD**`@availabilityEndTime`. The following snippet shows an example for the `remoteFileExists` function written in PHP.

1) Apache Ant is the trade name of a product supplied by The Apache Software Foundation. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC of the product named.

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```
function remoteFileExists($url) {
    $curl = curl_init($url);

     //don't fetch the actual page, you only want to check the
    connection is ok curl_setopt($curl, CURLOPT_NOBODY, true);

     //do request
     $result = curl_exec($curl);

     $ret = false;

     //if request did not fail
     if ($result !== false) {
         //if request was ok, check response code
         $statusCode = curl_getinfo($curl, CURLINFO_HTTP_CODE);

         if ($statusCode == 200) {
         $ret = true;
         }
     }

         curl_close($curl);

         return $ret;
    }
```

5.3 Dynamic MPD conformance

5.3.1 General

To ensure that servers offering a dynamic DASH media presentation adhere to the timing requirements and that clients are able to properly consume the dynamic presentation without observing unavailable segments, the DASH conformance software is extended to include and address media presentations with **MPD**`@type='dynamic'`. In 5.3, the requirements which go beyond those for static DASH conformance are listed and a functional description of the conformance software implementation is provided.

The document is aligned with the guidelines for live services as documented in ISO/IEC TR 23009-3[1].

5.3.2 Background and requirements

5.3.2.1 MPD-specific checks

Clients make use of the information in an MPD. Based on an MPD that is fetched at a certain fetch time FT the client can determine the following information:

a) At any time, WT where WT ≥ FT, a client can determine:

   1) the latest available period on the server, denoted by its Period start time PS*;

   2) the segment availability start time of any segment at position *k* within the Period, denoted as SAST(*k*);

   3) the position of the latest segment that is available on server in the Period, referred to as *k**;

   4) the URL of the latest segment that is available within this Period;

   5) the time when to fetch a new MPD based on the current presentation time, or more specifically, the greatest segment position *k'* within this Period that can be constructed by this MPD;

   6) the media presentation time within the Representation that synchronizes closest to the live edge, MPTL;

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7) the media presentation time within the Representation that synchronizes to other clients, MPTS.

b) At any time, WT, all segments with availability start time at or before WT and availability end time at or before WT are accessible.

c) An updated MPD is made available on time, taking into account the minimum update period (MUP) of the MPD. Note that by not updating the MPD, the existing MPD is validated for another MUP time.

Detailed equations to derive segment availability times are provided in ISO/IEC 23009-1 and ISO/IEC TR 23009-3[1]. When providing an MPD, the content author ensures that the segment availability times can be derived.

5.3.2.2 MPD times

In order to use the same concepts with different timing and addressing schemes, the following values are introduced according to ISO/IEC 23009-1:

— the position of the segment in the Period denoted as k with k=1,2,...;

— the MPD start time of the segment at position k, referred to as MST(k);

— the MPD duration of a segment at position k, referred to as MD(k).

Assuming that the wall-clock time at the client is denoted as WT, the client can derive the following information.

5.3.2.3 General derivation

Using these times, the values from above can be derived as follows.

— The latest Period is the Period for which AST + PS + MD(1) ≤ WT where AST is the value of the **MPD**`@availabilityStartTime` and PS is the *PeriodStart* as defined in ISO/IEC 23009-1.

— The segment availability start time is obtained as

$$SAST(k) = AST + PS + MST(k) + MD(k)$$

— Within this Period, the latest segment available on the server is the segment at the position k^* which results in the greatest value for SAST(k^*) and at the same time is smaller than WT.

— The address of the latest segment can be derived using the position information k^*. The exact value depends on the addressing method.

— Within this Period, the greatest segment position k' that can be constructed by this MPD is the one that results in the greatest value for SAST(k') and at the same time is smaller than FT + MUP.

The media presentation time in a Period is determined for each Representation as the presentation time value of the media segments minus the value of the `@presentationTimeOffset`, if present, for each Representation.

It is further assumed that a segment at position k has an assigned earliest media presentation time EPT(k).

5.3.2.4 Requirements

When receiving an MPD, the DASH client is guaranteed that:

— Each segment at position k in this Period is available prior to the sum of its earliest presentation time and its duration; SAST(k) ≤ EPT(k) + MD(k).

— If each segment with segment number k is delivered starting at SAST(k) over a constant bitrate channel with bitrate equal to the value of the `@bandwidth` attribute, then each sample with presentation time *PT* shall be available at the client by the time given by PT + (AST + PS) + MBT + MD(k).

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— Each segment in this Period shall be available at least until SAST(k) + TSB + MD(k).

— The MPD can be used to construct and request segments until media time FT + MUP. The greatest segment position k' that can be constructed by this MPD shall be the one that results in the greatest value for SAST(k') and at the same time is smaller than FT + MUP. Note that the latest segment may be significantly shorter in duration than MD(k).

In addition, updates of the MPD shall be consistent according to ISO/IEC 23009-1:2019, 5.4.

5.3.3 Dynamic conformance software design

5.3.3.1 Overview

The implementation of the conformance software for dynamic services requires the implementation of the requirements in 5.3.2.4. The process is split into two parts:

— the creation of a data set by recording/monitoring a dynamic service;

— the actual conformance checks implementing the checks of the requirements.

5.3.3.2 Data set creation

Two different cases are considered depending on the access bandwidth to the server.

In case 1, it is assumed that the conformance checker is operating with a very high (infinite) access bandwidth and minimal delay. Then the initial part is as follows.

a) Download and store the MPD and record the fetch time, FT, of the MPD.

b) Determine the following information.

   1) The smallest segment availability start time greater than FT of any Segment in any Representation referred to as $SAST_{min}$.

   2) The URLs of all segments available at $SAST_{min}$. If multiple segments are available at the same time, determine all of them.

c) For all segments with segment availability, end time greater than FT and smaller than $SAST_{min}$, generate the URL, issue an HTTP HEAD request, and record the HTTP header.

d) At time $SAST_{min}$ issue HTTP GET requests for all segments that become available at this time, record the HTTP headers and store the segments.

e) Go to a) and download the next MPD at FT = $SAST_{min}$.

f) Continue the process until manually stopped or the media presentation is ended.

In case 2, if the bandwidth connection is restricted, apply the following.

a) Download and store the MPD and record the fetch time, FT, of the MPD.

b) Determine the following information.

   1) The smallest segment availability start time greater than FT of any segment in any Representation referred to as $SAST_{min}$.

   2) The URLs of all segments available at $SAST_{min}$. If multiple segments are available at the same time, determine all of them.

c) For all segments with segment availability end time greater than FT and smaller than $SAST_{min}$, generate the URL, issue an HTTP HEAD request, and record the HTTP headers.

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d) For selected representations, issue an HTTP GET for segments that are available at this time.

e) At time $SAST_{min}$ issue HTTP HEAD for all segments that become available at this time and record the HTTP headers.

f) Go to a) and download the next MPD at FT = $SAST_{min}$.

g) Continue the process until manually stopped or the media presentation is ended.

This initial operation results in a data set as follows:

a) a sequence of MPDs, each with a FT;

b) a set of Segment URLs with associated:

   1) SAST;

   2) fetch time for segment availability start time request (typically SAST);

   3) HTTP headers for segment availability start time request;

   4) segment availability end time (SAET);

   5) fetch time for segment availability end time request (typically just slightly before the SAET);

   6) HTTP headers for segment availability end time request;

c) at least for a selected set of representations, the corresponding segments.

From the sequence of the MPDs, a single new MPD can be generated with `MPD@type=static` that includes all segments.

5.3.3.3 Conformance checks

The conformance checks operate on the stored data set and include the following checks:

— the correctness of the sequence of MPDs as documented in ISO/IEC 23009-1:2019, 5.4.

— all MPD timing aspects and segment availability times as documented in ISO/IEC 23009-1:2019, 5.3.

— the static conformance checks using the single MPD according to 5.2.

5.4 Conformance checks for spatial relationship description

The conformance rules that relate to the spatial relationship description are provided in Table 1.

An MPD shall comply with the rules in Table 1 in accordance with ISO/IEC 23009-1.

Table 1 — Spatial relationship description conformance rules

Reference in ISO/IEC 23009-1: 2019, Annex H	Rule	Conformance check implementation
H.1	When every Adaptation Set in an MPD has an SRD descriptor, at least one such descriptor shall be a SupplementalProperty.	R19.1
H.1	An EssentialProperty or SupplementalProperty descriptor with @schemeIdUri equal to “urn:mpeg:dash:srd:2014” shall be the child element of an AdaptationSet or a SubRepresentation element.	R19.2
H.2	If an EssentialProperty or SupplementalProperty descriptor with @schemeIdUri equal to “urn:mpeg:dash:srd:2014” is present, then the @value attribute shall be present.	R19.3

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Table 1 *(continued)*

Reference in ISO/IEC 23009-1: 2019, Annex H	Rule	Conformance check implementation
H.2	If an EssentialProperty or SupplementalProperty descriptor with @schemeIdUri equal to "urn:mpeg:dash:srd:2014" is present, then the @value attribute shallshall contain at least the mandatory comma separated parameters, i.e. `source_id`, `x`, `y`, `w`, `h`.	R19.4
H.2	If an EssentialProperty or SupplementalProperty descriptor with @schemeIdUri equal to "urn:mpeg:dash:srd:2014" is present, then each parameter value has to match the expected type format, i.e. non-negative integer in decimal representation.	R19.5
H.2	If an EssentialProperty or SupplementalProperty descriptor with @schemeIdUri equal to "urn:mpeg:dash:srd:2014" is present and the @value attribute contains the optional parameter `W` then the optional parameter `H` shall be present too.	R19.6
H.2	If an EssentialProperty or SupplementalProperty descriptor with @schemeIdUri equal to "urn:mpeg:dash:srd:2014" is present and the @value attribute contains the optional parameter `H` then the optional parameter `W` shall be present too.	R19.6
H.2	If an EssentialProperty or SupplementalProperty descriptor with @schemeIdUri equal to "urn:mpeg:dash:srd:2014" is present and the @value attribute contains the optional parameter `spatial_set_id` then the optional parameters `W` and `H` shall be present too.	R19.6
H.2	For a given `source_id` of the @value attribute, at least one of the EssentialProperty or SupplementalProperty in the containing Period shall specify the optional parameters `W` and `H`.	R19.7
H.2	For a given `source_id` of the @value attribute, if two SRD elements (indistinctively EssentialProperty or SupplementalProperty) explicitly specify a different pair of values for the optional parameters (`W`, `H`) then all the remaining SRD element shall explicitly specify a pair of values for (`W`, `H`) too.	R19.8
H.2	For a given `source_id` of the @value attribute, the values of x, w and `W` shall be such that, for each descriptor, the sum of `x` and `w` is smaller or equal to `W`.	R19.9a and R19.9b
H.2	For a given `source_id` of the @value attribute, the values of y, h and `H` shall be such that, for each descriptor, the sum of `y` and `h` is smaller or equal to `H`.	R19.10a and R19.10b

6 Segment conformance

6.1 Overview

Segment conformance requirements verify that the segments offered in the MPD conform to ISO/IEC 23009-1.

This includes the conformance requirements for:

— segments offered within one representation (for details, refer to 6.2);

— representations offered within one adaptation set (for details, refer to 6.3);

— segments offered in a dynamic media presentation (for details, refer to 6.4).

All conformance tools are available at https://standards.iso.org/iso-iec/23009/-2/ed-3/en.

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6.2 Representation conformance

6.2.1 ISO base media file format

The representation conformance rules, as well as the implementation status of the conformance rules for ISO base media file format segments, are provided in Table 2.

Table 2 — Representation conformance rules for ISO base media file format

	Clause in ISO/IEC 23009-1: 2019	Rule	Conformance check implementation
1	6.1	Media Segment formats shall comply with the respective container formats (ISO BMFF and MPEG-2 TS).	implemented
2	6.2.1	The Initialization Segment shall not contain any media data with an assigned presentation time	implemented
3	6.2.1	A Media Segment shall contain a number of complete access units.	implemented
4	6.2.1	If it is the first Media Segment in the Representation, it shall contain only media streams that start with a SAP of type 1 or 2.	implemented
5	6.2.1	A Media Segment shall contain sufficient information to time-accurately present each contained media component in the Representation without accessing any previous Media Segment in this Representation provided that the Media Segment contains a SAP for each media stream.	implemented
6	6.2.3.2	A Media Segment shall specify all Media Presentation times relative to the start of the Period and compensated with the value of the @presentationTimeOffset. The presentation time in Media Segments shall be accurate to ensure accurate alignment of all Representations in one Period. a) earliest_presentation_time shall be equal to the sum of all temporally preceding subsegments in the representation. b) The duration of a subsegment indexed by an 'sidx' shall be equal to the sum of the durations of all the subsegments it indices.	implemented
7	6.3.2.1	A media data box containing data referenced by a movie fragment ('moof') box shall follow that movie fragment box and precede the next movie fragment box, if any, containing information about the same track.	implemented
8	6.3.2.1	For a Media Subsegment, the value of the reference_type field in the describing Segment Index ('sidx') box shall be set to 0.	implemented
9	6.3.2.3	If the Segment Index is provided, the Segment Index ('sidx') box in ISO/IEC 14496-12 shall be used.	implemented
10	6.3.2.4	If the Subsegment Index is provided, the Subsegment Index ('ssix') box in ISO/IEC 14496-12 shall be used.	implemented
11	6.3.3	The Initialization Segment shall contain an "ftyp" box, and a "moov" box.	implemented
12	6.3.3	It shall not contain any "moof" boxes.	implemented
13	6.3.3	The tracks in the "moov" box shall contain no samples (i.e. the entry_count in the "stts", "stsc", and "stco" boxes shall be set to 0).	implemented

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Table 2 *(continued)*

	Clause in ISO/IEC 23009-1: 2019	Rule	Conformance check implementation
14	6.3.3	The “mvex” box shall be contained in the “moov” box. The “mvex” box also sets default values for the tracks and samples of the following movie fragments.	implemented
15	6.3.4.2	‘styp’ box, if present, shall carry ‘msdh’ as a compatible brand.	implemented
16	6.3.4.2	Each Media Segment shall contain one or more whole self-contained movie fragments. A whole, self-contained movie fragment is a movie fragment (‘moof’) box and a media data (‘mdat’) box that contains all the media samples that do not use external data references referenced by the track runs in the movie fragment box.	implemented
17	6.3.4.2	Each ‘moof’ box shall contain at least one track fragment.	implemented
18	6.3.4.2	The ‘moof’ boxes shall use movie-fragment relative addressing for media data that does not use external data references, the flag ‘default-base-is-moof’ shall be set, and data-offset shall be used, i.e. base-data-offset-present shall not be used.	implemented
19	6.3.4.2	Each ‘traf’ box shall contain a ‘tfdt’ box.	implemented
20	6.3.4.2	Each Media Segment may contain one or more ‘sidx’ boxes. If ‘sidx’ is present in a Media Segment, the first ‘sidx’ box shall be placed before any ‘moof’ box and the first Segment Index box shall document the entire Segment.	implemented
21	6.3.4.3	In each self-contained movie fragment, the movie fragment (‘moof’) box is immediately followed by its corresponding media data (‘mdat’).	implemented
22	6.3.4.3	Each Media Segment shall contain one or more ‘sidx’ boxes.	implemented
23	6.3.4.3	The first ‘sidx’ box shall be placed before any ‘moof’ box and shall document Subsegments that span the composition time of the entire Segment.	implemented
24	6.3.4.3	Each Media Segment shall carry ‘msix’ as a compatible brand.	implemented
25	6.3.4.4	The Subsegment Index box (‘ssix’) shall be present and shall follow immediately after the ‘sidx’ box that documents the same Subsegment. This immediately preceding ‘sidx’ shall only index Media Subsegments.	implemented
26	6.3.4.4	It shall carry ‘sims’ in the Segment Type box (‘styp’) as a compatible brand.	implemented
27	6.3.5.2	The Indexed Self-Initializing Media Segment shall carry ‘dash’ as a compatible brand.	implemented
28	5.3.5.2	If the Representation is continuously delivered at this bitrate, starting at any SAP that is indicated either by @ startWithSAP or by any Segment Index box, a client can be assured of having enough data for continuous playout providing playout begins after @minBufferTime * @bandwidth bits have been received (i.e. at time @minBufferTime after the first bit is received).	implemented

6.2.2 MPEG-2 transport stream

The representation conformance rules, as well as the implementation status of the conformance rules for MPEG-2 transport stream-based segments, are provided in Table 3.

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Table 3 — Representation conformance rules for MPEG-2 transport stream

	Clause in ISO/IEC 23009-1: 2019	Rule	Conformance check implementation
1	6.1	Media Segment formats shall comply with the respective container formats (ISO BMFF and MPEG-2 TS).	implemented
2	6.2.2	The Initialization Segment shall not contain any media data with an assigned presentation time	implemented
3	6.2.3.1	A Media Segment shall contain a number of complete access units.	implemented
4	6.2.3.1	If it is the first Media Segment in the Representation, it shall contain only media streams that start with a SAP of type 1 or 2.	implemented for AVC streams (not verifiable on container level)
5	6.2.3.1	A Media Segment shall contain sufficient information to time-accurately present each contained media component in the Representation without accessing any previous Media Segment in this Representation provided that the Media Segment contains a SAP for each media stream (not verifiable on container level).	implemented
6	6.2.3.1	A Media Segment shall specify all Media Presentation times relative to the start of the Period and compensated with the value of the @presentationTimeOffset. The presentation time in Media Segments shall be accurate to ensure accurate alignment of all Representations in one Period. a) earliest_presentation_time shall be equal to the sum of all temporally preceding subsegments in the representation. b) The duration of a subsegment indexed by an 'sidx' shall be equal to the sum of the durations of all the subsegments it indices.	implemented
7	6.4.2.1	A subsegment shall contain complete access units for the indexed media stream (i.e. stream for which reference_ID equals PID)	implemented
8	6.4.2.2	PES packet starting at I_{SAU} shall contain only an integral number of access units and shall contain a PTS.	implemented
9	6.4.2.3	If the Segment Index is provided the Segment Index ('sidx') box in ISO/IEC 14496-12 shall be used for Segment Indexing.	implemented
10	6.4.2.3	reference_ID field of `sidx` box shall be the PID value of the indexed stream.	implemented
11	6.4.2.3	All media offsets within `sidx` boxes shall be to the first (sync) byte of a TS packet	implemented
12	6.4.2.4	If the Subsegment Index is provided, the Subsegment Index ('ssix') box in ISO/IEC 14496-12 shall be used for indexing byte ranges within a subsegment	implemented
13	6.4.2.4	All media offsets within 'ssix' boxes shall be to the first (sync) byte of a TS packet	implemented
14	6.4.3.2	An Initialization Segment shall be a valid MPEG-2 TS, conforming to ISO/IEC 13818-1.	implemented
15	6.4.3.2	The concatenation of an Initialization Segment with any Media Segment shall have the same presentation duration as the original Media Segment.	implemented

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Table 3 *(continued)*

	Clause in ISO/IEC 23009-1: 2019	Rule	Conformance check implementation
16	6.4.3.2	The Initialization Segment shall contain mandatory untimed initialization information as defined in ISO/IEC 23009-1:2019, 6.4.3.1 in this order: a) PAT; b) PMT; c) If MPEG-2 conditional access is used, ECM.	implemented (w/o ECM)
17	6.4.4.2	Media Segments shall contain complete MPEG-2 TS packets	implemented
18	6.4.4.2	Media Segments shall contain exactly one program	implemented
19	6.4.4.2	All time-varying initialization information shall be present between I_{SAP} and I_{SAU} and/or in the Index Segment, if present.	implemented
20	6.4.4.2	No Media Segment shall depend on initialization information appearing in any preceding Media Segment.	implemented
21	6.4.4.3	All information necessary for decrypting, or locating information required to decrypt, the encrypted TS packets in a (Sub)Segment shall be present before the encrypted packet(s) to which they apply, either in the same (Sub)Segment, and/or in the Initialization Segment (if used).	implemented (as much as possible)
22	6.4.4.4	A Self-initializing Media Segment shall contain, at the least, all mandatory untimed and timed initialization information as defined in ISO/IEC 23009-1:2019, 6.4.3.1.	implemented
23	6.4.5	A Bitstream Switching Segment shall be a valid MPEG-2 TS, conforming to ISO/IEC 13818-1.	implemented
24	6.4.5	A Bitstream Switching Segment, when concatenated with any Media Segment, shall not alter the Media Presentation timeline for the corresponding Media Segment.	implemented
25	6.4.5	If initialization information is carried within a Bitstream Switching Segment, it shall be identical to the one in the Initialization Segment, if present, of the Representation.	implemented
26	6.4.6.2	A Single Index Segment indexes exactly one Media Segment and is defined as follows: a) Each Single Index Segment shall begin with an 'styp' box, and the brand 'sisx' shall be present in the 'styp' box. b) Each Single Index Segment shall contain one or more Segment Index boxes which index one Media Segment.	implemented
27	6.4.6.2	If present, the 'ssix' shall follow the 'sidx' box that documents the same Subsegment without any other 'sidx' preceding the 'ssix'.	implemented
28	6.4.6.2	If present, 'pcrb' shall follow the 'sidx' box that documents the same Subsegments.	implemented
29	6.4.6.3	Each Representation Index Segment shall begin with an 'styp' box, and the brand 'risx' shall be present in the 'styp' box.	implemented

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Table 3 *(continued)*

	Clause in ISO/IEC 23009-1: 2019	Rule	Conformance check implementation
30	6.4.6.3	The Segment Index for each Media Segments is concatenated in order, preceded by a single Segment Index box that indexes the Index Segment. This initial Segment Index box shall have one entry in its loop for each Media Segment, and each entry refers to the Segment Index information for a single Media Segment.	implemented
31	6.4.6.4	It shall be either a Single Index Segment or a Represention Index Segment.	implemented
32	6.4.6.4	The Subsegment Index box ('ssix') shall be present and shall follow immediately after the 'sidx' box that documents the same Subsegment.	implemented
33	6.4.6.4	The value of the reference_type field shall be equal to 0 for this Subsegment in this immediately preceding Segment Index ('sidx') box.	implemented
34	6.4.6.4	If the 'pcrb' box is present, it shall follow 'ssix'.	implemented
35	6.4.6.4	It shall carry 'ssss' in the Segment Type box ('styp') as a compatible brand.	implemented
36	7.1	The Media Presentation shall be provided such that no mismatch between the media stream and the MPD occurs.	implemented

6.3 Adaptation set conformance

6.3.1 ISO base media file format

The adaptation set conformance rules, as well as the implementation status of the conformance rules for ISO base media file format segments, are provided in Table 4.

Table 4 — Adaptation set conformance rules for ISO base media file format

	Clause in ISO/IEC 23009-1: 2019	Rule	Conformance check implementation
1	7.2.2	If a Segment Index is present in a Media Segment of one Representation within an Adaptation Set, then the following shall hold. a) The order of Segment Index boxes for multiple media streams induces an ordering on the media content components equal to the order in which a Segment Index box for a media stream for each component first appears. This ordering shall be the same for all Segments of all Representations of an Adaptation Set. As a consequence, if there is a Segment Index for a media content component in one Segment, there shall be a Segment Index for that media component in all Segments in this Adaptation Set. b) Non-indexed media streams in all Representations of an Adaptation Set shall have the same access unit duration.	implemented

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Table 4 *(continued)*

	Clause in ISO/IEC 23009-1: 2019	Rule	Conformance check implementation
2	7.3.3.2	As a consequence of @bitstreamSwitching being set to 'true', the following conditions are satisfied. a) The track IDs for the same media content component are identical for each Representation in each Adaptation Set. b) The conditions required for setting the @segmentAlignment attribute to a value other than 'false' for the Adaptation Set are fulfilled. c) The conditions required for setting the @startWithSAP attribute to 2 for the Adaptation Set, or the conditions required for all Representations within the Adaptation Set to share the same value of @mediaStreamStructureId and setting the @startWithSAP attribute to 3 for the Adaptation Set, are fulfilled.	implemented
3	7.3.4	If a SubRepresentation element is present in a Representation in the MPD and the attribute SubRepresentation@level is present, then the Media Segments in this Representation shall conform to a Sub-Indexed Media Segment as defined in ISO/IEC 23009-1:2019, 6.3.4.4. The Initialization Segment shall contain the Level Assignment ('leva') box.	implemented

6.3.2 MPEG-2 transport stream

The adaptation set conformance rules, as well as the implementation status of the conformance rules for ISO base media file format segments, are provided in Table 5.

Table 5 — Adaptation set conformance rules for MPEG-2 transport stream

	Clause in ISO/IEC 23009-1: 2019	Rule	Conformance check implementation
1	7.1	The Media Presentation shall be provided such that no mismatch between the media stream and the MPD values occurs. If it does, the value in the media stream itself takes precedence over values expressed in the MPD, especially when used in the media decoding process.	implemented

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Table 5 *(continued)*

	Clause in ISO/IEC 23009-1: 2019	Rule	Conformance check implementation
2	7.2.2	If a Segment Index is present in a Media Segment of one Representation within an Adaptation Set, then the following shall hold. a) The order of Segment Index boxes for multiple media streams induces an ordering on the media content components equal to the order in which a Segment Index box for a media stream for each component first appears. This ordering shall be the same for all Segments of all Representations of an Adaptation Set. As a consequence, if there is a Segment Index for a media content component in one Segment, there shall be a Segment Index for that media component in all Segments in this Adaptation Set. b) Non-indexed media streams in all Representations of an Adaptation Set shall have the same access unit duration.	implemented
3	7.4.3.2	If the @segmentAlignment attribute is not set to 'false': a) the Media Segment shall contain only complete PES packets; b) the first PES packet shall contain a PTS timestamp.	implemented
4	7.4.3.3	If the @subsegmentAlignment flag is not set to 'false', a Subsegment shall contain only complete PES packets for each PID.	implemented
5	7.4.3.3	If the @subsegmentAlignment flag is not set to 'false', the first PES packet from each elementary stream shall contain a PTS.	implemented
6	7.4.3.4	If the @bitstreamSwitching is set to true, then for any two Representations, X and Y, within the same Adaptation Set, concatenation of Media Segment i of X, Concatenation Segment of Representation Y, and Media Segment i+1 of Representation Y shall be a MPEG-2 TS conforming to ISO/IEC 13818-1.	implemented
7	7.4.3.4	If the @bitstreamSwitching is set to true, then the conditions required for setting the @startWithSAP attribute to 2 for the Adaptatation Set or required for all Representations within the Adaptation Set share the same value of @mediaStreamStructureId and setting the @startWithSAP attribute of the Adapaton Set 3, are fulfilled.	implemented
	7.4.3.4	If the @bitstreamSwitching is set to true, then the conditions required for setting the @segmentAlignment attribute not set to 'false' for the Adaptation Set are fulfilled.	implemented
	7.4.3.4	If the @bitstreamSwitching is set to true, then PCR shall be present in the Segment prior to the first byte of a TS packet payload containing media data, and not inferred from the 'pcrb' box.	implemented
	7.4.4	The Subsegment Index box shall contain at least one entry for the value of SubRepresentation@level and for each value provided in the SubRepresentation@dependencyLevel.	implemented

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6.4 Dynamic media presentation conformance

With the dynamic MPD conformance checks defined in 5.3, no specific segment conformance for dynamic services are necessary. The static segment conformance is sufficient to also address services with `MPD@type=dynamic`.

7 Profile specific conformance

NOTE Profile-specific conformance for MPEG-2 TS main profile, ISO base Media File Format Extended Live profile, ISO Base Media File Format Extended On Demand profile, and ISO Base Media File Format Common profile are missing.

7.1 ISO base media file format on demand profile

The profile-specific conformance rules, as well as the implementation status of the conformance rules for the ISO base media file format on-demand profile, are provided in Table 6.

Table 6 — ISO base media file format on-demand profile rules

	Clause in ISO/IEC 23009-1:2019	Rule	Conformance check implementation
1	8.3.3	All Segment Index ('sidx') and Subsegment Index ('ssix') boxes shall be placed before any Movie Fragment ('moof') boxes.	implemented
2	8.4.3	Media Segments containing multiple Media Components shall comply with the formats defined in ISO/IEC 23009-1:2019, 6.3.4.3, i.e. the brand 'msix'.	implemented
3	8.4.3	In Media Segments, all Segment Index ('sidx') and Subsegment Index ('ssix') boxes shall be placed before any Movie Fragment ('moof') boxes.	implemented

7.2 ISO base media file format live profile

The profile-specific conformance rules, as well as the implementation status of the conformance rules for the ISO base media file format live profile, are provided in Table 7.

Table 7 — ISO base media file format live profile rules

	Clause in ISO/IEC 23009-1:2019	Rule	Conformance check implementation
1	8.4.3	Media Segments containing multiple Media Components shall comply with the formats defined in ISO/IEC 23009-1:2019, 6.3.4.3, i.e. the brand 'msix'.	implemented
2	8.4.3	In Media Segments, all Segment Index ('sidx') and Sub-segment Index ('ssix') boxes shall be placed before any Movie Fragment ('moof') boxes.	implemented

7.3 ISO base media file format main profile

The profile-specific conformance rules, as well as the implementation status of the conformance rules for the ISO base media file format main profile, are provided in Table 8.

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Table 8 — ISO base media file format main profile rules

	Clause in ISO/IEC 23009-1:2019	Rule	Conformance check implementation
1	8.5.3	At least one SAP of type 1 to 3, inclusive, shall be present for each track in each subsegment	implemented
2	8.5.3	In Media Segments, all Segment Index ('sidx') and Subsegment Index ('ssix') boxes shall be placed before any Movie Fragment ('moof') boxes.	implemented
3	8.5.3	Each Media Segment of the Representations not having @startWithSAP present or having @startWithSAP value 0 or greater than 3 shall comply with the formats defined in ISO/IEC 23009-1:2019, 6.3.4.3, i.e. the brand 'msix'.	implemented

7.4 MPEG-2 transport stream simple profile

The profile-specific conformance rule, as well as the implementation status of the conformance rules for the MPEG-2 transport stream simple profile, are provided in Table 9.

Table 9 — MPEG-2 transport stream simple profile rules

	Clause in ISO/IEC 23009-1:2019	Rule	Conformance check implementation
1	8.7.3	PSI information, including versions, shall be identical within all Representations contained in an AdaptationSet	implemented
2	8.7.3	If MPEG-2 conditional access framework is used, same ECM shall be valid for the whole Subsegment, or for the whole Segment, if Index Segment is not present.	Specific to a conditional access system, cannot be tested generically.
3	8.7.3	For an Index Segment, any single Segment Index ('sidx') box may either reference media, or other 'sidx', but the same 'sidx' box may not reference both.	implemented

8 Conforming test vectors

Details on conforming test vectors are specified in Annex B.

9 DASH access engine reference software

9.1 General

This clause defines the DASH access engine reference software according to ISO/IEC 23009-1. In this clause, this reference software is referred to as libdash[8].

NOTE Reference software implements requirements of a specification and typically serves the following purposes, (1) validation of the written specification, (2) clarification of the written specification, and (3) conformance testing for checking interoperability for the various applications against the reference software.

9.2 libdash overview

ISO/IEC 23009-1 defines representation formats for the MPD and segment formats for MPEG-2 transport stream (M2TS) and ISO base media file format (ISOBMFF). The MPD is based on XML and reflects the DASH data model: providing HTTP URLs to downloadable segments. The adaptation logic

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(the component of a client which determines which segment to download based on the clients' context) is deliberately excluded from the specification and left open for industry competition.

libdash focuses on the MPD and segments identified using HTTP URLs, and provides two features:

— an object-oriented interface into the MPD;

— the download of segments via HTTP (on request).

In particular, libdash provides means to access the information within the MPD and enables scheduling the download of segments described by the MPD.

libdash implements the full profile of ISO/IEC 23009-1.

libdash does not include adaptation logic and does not provide any segment- or codec-specific features.

9.3 libdash-enabled example system

Figure 3 shows a libdash-enabled example system comprising a server (hosting the MPD and segments of various representations described within the MPD) and client (requesting segments according to the MPD). The delivery of the MPD and client components such as the DASH streaming control (including adaptation logic) and the media player are specified within ISO/IEC 23009-1.

libdash provides interfaces for the DASH streaming control (including adaptation logic) and the media player to access the MPD and downloadable media segments. The download order of such media segments is not handled by libdash as this is left open to the other components.

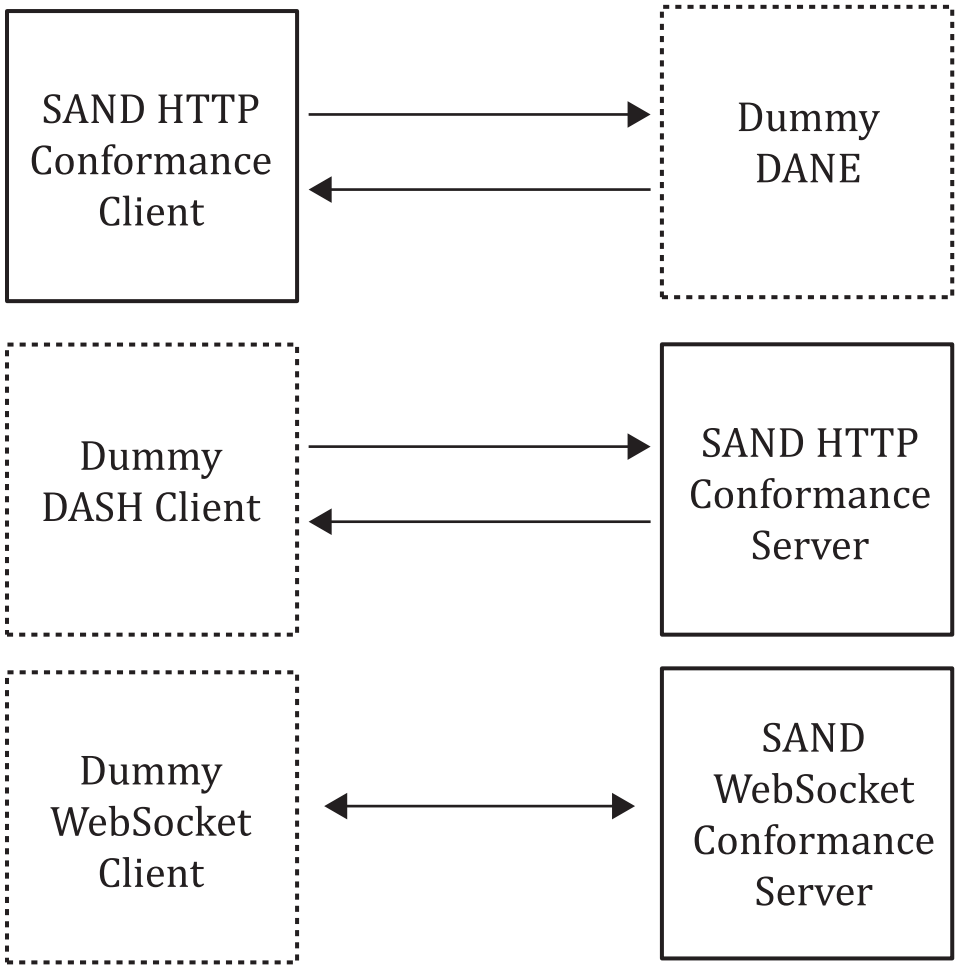

Figure 3 — libdash-enabled example system

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In an example deployment, a server may provide segments in several bitrates and resolutions. The client initially receives an MPD through libdash, which provides a convenient object orient interface to that MPD. Based on that information, the client can download individual media segments through libdash at any point in time. For example, varying bandwidth conditions can be handled by switching to the corresponding quality level at segment boundaries in order to provide a smooth streaming experience. This adaptation is not part of libdash and is left open to the application using libdash.

9.4 libdash availability

libdash is available at https://standards.iso.org/iso-iec/23009/-2/ed-3/en.

10 Conformance software for ISO/IEC 23009-4

10.1 General

In each of these cases, output media segments are saved to the local disk, and the MPD is transformed appropriately and also saved to the local disk. However, the input MPD and media segments may come from either the local disk or from URLs.

In order to compile the utility, open Eclipse and import "mpdCrypto" as an “Existing project”. Eclipse JDT will compile the needed .class files automatically.

10.2 Design limitations and assumptions

— A single MPD is processed.

— Only the first `Representation` in the first `AdaptationSet` of the first `Period` is processed.

— Segments are assumed to be listed in a single `SegmentList`.

— A single instance of `ContentProtection` descriptor of supported type is assumed in encrypted MPDs.

— Support for validating MPDs via Schematron is coming at a later date.

— All of the operations are performed serially and synchronously.

10.3 Usage

mpdEncryptionUtil [-a <authentication-scheme>] -d | -e <encryption-scheme> -i <inputfile.mpd> [--no-validate-schema] -o <output-dir>

-a,--authenticate <authentication-scheme>

Generate authenticity tags for cleartext segments, in addition to encrypting them, via one of supported authentication schemes, "sha256" and "hmac-sha1". Default value is "sha256".

-d,--decrypt

Decrypt encrypted segments, automatically validating them, if authentication information is present.

-e,--encrypt <encryption-scheme>

Encrypt cleartext segments via one of supported encryption schemes, "aes128-cbc", "aes128-gcm". Default value is "aes128-cbc".

-i,--input-file <inputfile.mpd>

MPD file path or URL.

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--no-validate-schema

Whether to skip validation of MPD via DASH schema.

-o,--output-dir <output-dir>

Directory to which encrypted/decrypted segments will be written.

11 Conformance for ISO/IEC 23009-5 server and network-assisted DASH (SAND)

11.1 Conformance rules

The conformance rules related to ISO/IEC 23009-5 as well as the implementation status of the conformance rules for SAND are provided in Table 10.

An MPD shall comply with the rules 5.G.1 to 5.H.3 in Table 10 in accordance with ISO/IEC 23009-5.

SAND messages shall comply with the rules 5.A.1 to 5.B.6 in Table 10 in accordance with ISO/IEC 23009-5.

Table 10 — Conformance rules for SAND

#	Object	Reference in ISO/IEC 23009-5:2017	Normative statements from ISO/IEC 23009-5:2017	Conformance rule	Status
5.A.1	messageType	Table 9	When using XML representation format, this field shall (messageType) be represented by the tag name of the message element.	SAND schema	covered
5.A.2	SAND message representation format	7	While SAND network elements may implement additional data representation formats, they shall at least support SAND messages in XML format.	SAND Schema	covered
5.A.4	SAND message representation format	7	While SAND network elements may implement additional data representation formats, they shall at least support SAND messages in XML format.	SAND Schema	covered
5.A.5	DCOR1 SAND schema fix			SAND Schema	covered
5.A.6	AbsoluteDeadline	6.4.4.1	AbsoluteDeadline message shall not be sent using the HTTP POST method.	SAND Schema	covered
5.A.7	MPDValidityEndTime	6.5.4.3	mpdUrl and mpd parameters are mutually exclusive and one of the two shall be present in any MPDValidityEndTime message.	SAND Schema	covered
5.A.7	ResourceStatus	Table 11	Either Representation ID or Base URL shall be used.	SAND Schema	covered
5.B.1	SharedResource Assignment	6.5.3.3	The validityTime attribute in the SAND message envelope shall be present for the SharedResourceAssignment message as it allows the DASH client to discover for how long the resource assignment is available.	SAND schematron	covered
5.B.3	QoSInformation	6.5.7.3	At least one of the above parameters (@gbr, @mbr, @delay, @pl) shall exist in the message.	SAND schematron	covered
5.B.4	bytes	Table 14	The string shall conform to the byte-range-set according to IETF RFC 7233:2014, subclause 2.1.	SAND Schematron	covered
5.B.5	AvailabilityTimeOffset	Table 21	Either Representation ID or Base URL shall be used.	SAND Schematron	covered
5.B.6	Throughput	Table 19	Either Representation ID or Base URL shall be used.	SAND Schematron	covered
5.C.1	messageType	Table 2	When using the HTTP header transport of 8.2.3, this field (messageType) shall be represented as the header name.	HTTP header syntax checker	covered
5.C.2	bytes	Table 14	The string shall conform to the byte-range-set according to IETF RFC 7233:2014, subclause 2.1.	HTTP header syntax checker	covered

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Table 10 *(continued)*

#	Object	Reference in ISO/IEC 23009-5:2017	Normative statements from ISO/IEC 23009-5:2017	Conformance rule	Status

5.C.3	Attaching a message to requests for media	8.2.3	The header value provides the message data. The header value shall conform to the following ABNF:
			`sand-message-value = sand-object`
			`sand-object = sand-attr-or-list *( "," sand-attr-or-list )`
			`sand-attr-or-list = sand-attribute / sand-list`
			`sand-list = "[" sand-object *( ";" sand-object ) "]"`
			`sand-attribute = sand-attribute-name "=" sand-value`
				HTTP header syntax checker	covered

5.C.4	Attaching a message to requests for media	8.2.3	DATETIME shall follow the ISO 8601-1 format, with a dot and not a comma for fractions of second to avoid confusion with comma separating key=value pairs.	HTTP header syntax checker	covered
5.C.5	Attaching a message to requests for media	8.2.3	If attributes defined for the envelope or attributes defined as common to all messages are included, they shall appear first in the message, and shall be provided as key=value pairs.	HTTP header syntax checker	covered
5.D.2	Transport Protocol to carry SAND Messages	8.1	This clause defines HTTP as the minimum transport protocol that shall be at least supported by SAND enabled elements.	SAND server	covered
5.D.3	Transport Protocol to carry SAND Messages	8.1	The following table summarizes which HTTP usages shall be supported (in bold in the table) by a SAND element or may be optional depending on the nature of the SAND message.	SAND server	covered
5.D.4	Sending a message directly to a DANE	8.2.2	The `Content-Type` shall be `application/sand+xml`, as defined in Annex C The message document itself is included as the body part of the HTTP request.	SAND server	covered
5.E.1	Transport Protocol to carry SAND Messages	8.1	This clause defines HTTP as the minimum transport protocol that shall be at least supported by SAND enabled elements.	SAND client	covered
5.E.2	Transport Protocol to carry SAND Messages	8.1	The following table summarizes which HTTP usages shall be supported (in bold in the table) by a SAND element or may be optional depending on the nature of the SAND message.	SAND client	covered

5.E.3	Assistance	8.3.2	Upon receiving an HTTP entity that contains the SAND header field in its entity head, the DASH client issues a GET request to the indicated element to receive the SAND message. The following ABNF syntax for the header field shall be used:
			`SAND-header-field = "MPEG-DASH-SAND" ":" element-address`
			`element-address = absolute-URI`
				SAND client	covered

5.F.1	WebSocket messages	10.2.3	Each WebSocket message shall contain a valid SAND message compliant with the SAND message XML schema.	WS SAND server and client	covered
5.G.1	`urn:mpeg:dash:sand:2015:channel:http:2016`	Table 27	In this case, the `@endpoint` of the `sand:Channel` shall be a valid HTTP-URL.	MPD schema	covered
5.H.1	`urn:mpeg:dash:sand:channel:header:2016`	Table 27	In this case, the `@endpoint` of the `sand:Channel` shall not be present.	MPD schematron	covered
5.H.2	`urn:mpeg:dash:sand:channel:websocket:2016`	10.1	In this case, the `@endpoint` of the `sand:Channel` shall be a valid WebSocket URI as specified in RFC 6455:2011, Clause 3.	MPD schematron	covered

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Table 10 *(continued)*

#	Object	Reference in ISO/IEC 23009-5:2017	Normative statements from ISO/IEC 23009-5:2017	Conformance rule	Status
5.H.3	urn:mpeg:dash:sand:channel:2016	Table 29	In this case, the Reporting@value attribute shall contain the value of a sand:Channel@id attribute present in the MPD.	MPD Schematron	covered
	messageID	Table 2	Among messages with same sender and same messageType, the message with highest messageID value shall take precedence over the others.	No rule	N/A
	messageID	Table 2	The maximum value for messageId is decided by senders and shall be high enough for receivers to easily identify which message shall take precedence even when messageID values have looped back to 0.	No rule	N/A
	bandwidth	Table 5	If playback rate is not 1, this bandwidth value shall be modified accordingly.	No rule	N/A
	AcceptedAlternatives	6.4.3.1	As such message is sent at the same time as a DASH segment request, transport protocol defined in subclause 8.2.3 (use of header extensions) shall be used.	No rule	N/A
	MaxRTT	6.4.5.1	If MaxRTT message is sent with HTTP POST method, it shall be intended for every segment request during validity time.	No rule	N/A
	clientID	Table 16	This field shall use the same value as the senderId of the SharedResourceAllocation message sent by the client.	No rule	N/A
	SAND message representation format	7	This clause defines XML as the format for SAND messages data representation format. While SAND network elements may implement additional data representation formats (such as JSON), they shall at least support SAND messages in XML format.	No rule	N/A
	Attaching a message to requests for media	8.2.3	For SAND messages defined in another namespace than the MPEG namespace (urn:mpeg:dash:schema:sandmessage:2016), the namespace shall be present in the SAND message name with colon characters replaced with hyphens. For instance: SAND-urn-my-example-com-MyMessage.	No rule	N/A
	Signalling of SAND communication channel	9.1	The sand:Channel@schemeIdUri specifies which protocol the DASH client shall use with this SAND channel. The table below lists the mandatory protocols.	No rule	N/A
	urn:mpeg:dash:sand:2015:channel:http:2016	Table 28	The identifier indicates that the DASH client shall use the protocol defined in ISO/IEC 23009-5:2017, subclause 8.1.1, that is, the SAND messages are transmitted via HTTP POST request inside the body of the request.	No rule	N/A
	urn:mpeg:dash:sand:channel:header:2016	Table 28	The identifier indicates that the DASH client shall use the protocol defined in ISO/IEC 23009-5:2017, subclause 8.1.2, that is, the SAND messages are transmitted via HTTP header extension of HTTP requests for media segments and MPD.	No rule	N/A
	Signalling of SAND communication channel	9.1	DASH clients which implement SAND shall support signalling of SAND channel via HTTP header and MPD.	No rule	N/A
	urn:mpeg:dash:sand:channel:websocket:2016	10.1	The identifier indicates that the DASH client shall use the WebSocket Protocol as specified in ISO/IEC 23009-5:2017, 10.2 WebSocket Protocol.	No rule	N/A
	Signalling via the MPD	10.2.2	The @schemaIdUri attribute of the sand:Channnel element shall be urn:mpeg:dash:sand:channel:websocket:2016 while the @endpoint attribute shall contain a valid WebSoscket URI as defined in RFC 6455:2011, Clause 3.	No rule	N/A
	urn:mpeg:dash:sand:channel:2016	Table 30	The identifier indicates that the DASH client shall use a SAND channel to report the metrics defined in ISO/IEC 23009-1.	No rule	N/A

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Table 10 *(continued)*

#	Object	Reference in ISO/IEC 23009-5:2017	Normative statements from ISO/IEC 23009-5:2017	Conformance rule	Status
	SharedResource Allocation Allocation Strategies	C.1	Implementation of these strategies shall follow the normative algorithms described in this annex. When DASH clients do not agree on the same strategy, it is up to the DANE to decide which strategy to apply.	No rule	N/A

11.2 Software

11.2.1 Design and architecture

The conformance of ISO/IEC 23009-5 comprises two modules, namely the SAND Conformance Client and the SAND Conformance Server. The SAND Client validates the SAND protocol and the SAND messages sent by the HTTP server simulating a DANE (called Dummy DANE in Figure 4). For instance, a DANE can insert a URL pointing to a SAND message in the HTTP header of a segment response. In this scenario, the SAND Client verifies that the SAND HTTP header is present. If present, it sends a HTTP request to that URL. Upon reception, it checks the received SAND messages against the SAND XML schema and schematron. Conversely, the SAND Server validates the SAND protocol and the SAND messages sent by an HTTP client simulating a DASH Client.

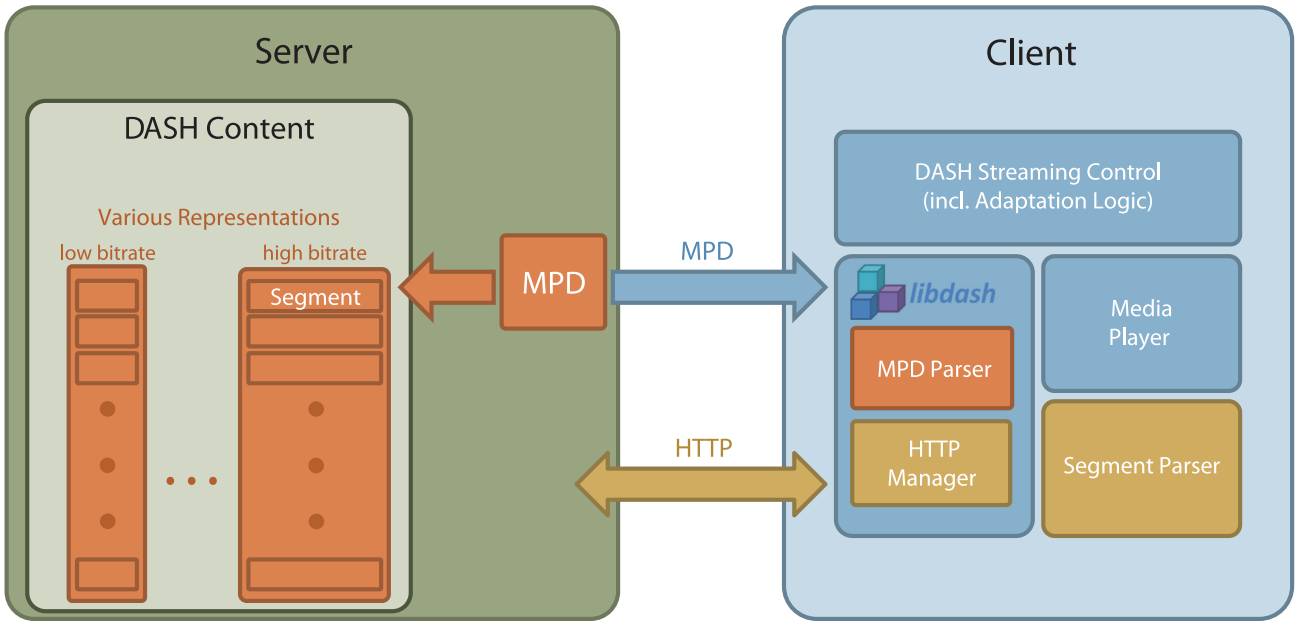

Figure 4 — Scope of conformance software for ISO/IEC 23009-5

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