The *TV-Anytime* Forum

www.tv-anytime.org

Specification Series: S-3

On:

Metadata

(Normative)

Part B: System Aspects in a Unidirectional Environment

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Series Overview

This is the third in a series of "S-series" specification documents produced by the *TV-Anytime* Forum. These documents establish the fundamental specifications for the services, systems and devices that will conform to the *TV-Anytime* standard, to a level of detail that is implementable for compliant products and services.

As is common practice in such standardization efforts, these specification documents were preceded by requirements documents ("R-series"), which define the requirements for the *TV-Anytime* services, systems, and devices.

Congruent with the structure defined in the initial *TV-Anytime* Call for Contributions (TV014r3), these specifications are parsed into three major areas: Metadata, Content Referencing and Rights Management and Protection. Within these general areas, four specifications have been developed to date: Metadata (S-3), Content Referencing (S-4), Bi-directional Metadata (S-6) and Metadata Protection (S-7). A specification for Rights Management and Protection (S-5) is still under development. See the several *TV-Anytime* Calls for Contributions for more detail on the derivation and background of these categories and their respective roles in the *TV-Anytime* standardization process.

The other two documents released to date in the *TV-Anytime* S-series are intended to define the context and system architecture in which the standards in S-3, S-4, S-6 and S-7 are to be implemented in "Phase 1" of the TV-Anytime environment. The first document in the series (S-1) provides benchmark business models against which the *TV-Anytime* system architecture is evaluated to ensure that the specification enable key business applications. The next document in the series (S-2) presents the *TV-Anytime* System Architecture. These two documents are placed ahead of the other three for their obvious introductory value. (Note that S-1 and S-2 are largely informative documents, while the remainder of the S-series is normative. Also note that a "Phase 2" of the *TV-Anytime* process is currently underway, in which additional requirements and specifications that will build on Phase 1 are being developed. Readers are encouraged to check the *TV-Anytime* Forum's website at www.tv-anytime.org for the most recent status of its specifications.)

Although each of the S-series documents is intended to stand alone, a complete and coherent sense of the *TV-Anytime* system standard can be gathered by reading all of the Phase 1 specification documents in numerical order.

Metadata Specification S-3
Document Revision History

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About the TV-Anytime Forum

The global *TV-Anytime* Forum is an association of organizations that seeks to develop specifications to enable audio-visual and other services based on mass-market high volume digital storage in consumer platforms – simply referred to as *personal media storage*.

The *TV-Anytime* Forum was formed at an inaugural meeting held in Newport Beach, California, USA, on 27-29 September 1999. It has started work to develop open specifications designed to allow Consumer Electronics Manufacturers, Content Creators, Telcos, Broadcasters and Service Providers to exploit personal media storage.

As part of its formation, the *TV-Anytime* Forum has established four fundamental objectives for the organization, which are:

- The *TV-Anytime* Forum will define specifications that will enable applications to exploit persistent personal media storage in consumer electronics platforms.
- The *TV-Anytime* Forum is network independent with regard to the means for content delivery to consumer electronics equipment, including various DTV delivery mechanisms (e.g. ATSC, DVB, DBS and others) as well as the Internet and enhanced TV systems.
- The *TV-Anytime* Forum will develop specifications for interoperable and integrated systems, from content creators/providers, through service providers, to the consumers.
- The *TV-Anytime* Forum will specify the necessary security structures to protect the interests of all parties involved.

Member organizations from Europe, the USA, and Asia, are drawn from a wide variety of industries: Traditional Broadcasters, Internet Broadcasters, Content Owners, Service Providers, Telcos, Consumer Electronics Manufacturers, IT Industries, Professional Equipment Manufacturers, Component Manufacturers and Software Vendors.

The *TV-Anytime* Forum invites *participation* from all interested organizations. Membership is open to all who sign the TVAF Membership Agreement. Meetings are held approximately every two months in Europe, the USA, and Asia.

For more information or to become involved with the work of the *TV-Anytime* Forum, visit the *TV-Anytime* Forum (www.tv-anytime.org) or contact:

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1. Scope

The following diagram depicts the combined scope of the TV-Anytime Specification on Metadata part A"*Metadata Description Definitions*", and part B "*System Aspects in a Unidirectional Environment*".

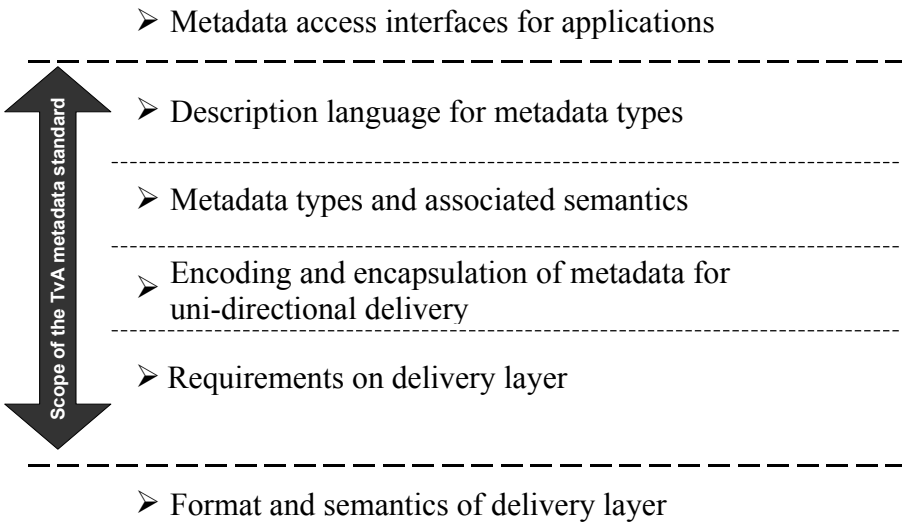


Figure 1- Overview of the scope of TVA Specification on Metadata parts A and B

Part A of SP003 addresses the description language, structure and semantics of TV-Anytime metadata descriptions. Part B introduces new technologies used to process these descriptions for the purpose of transmission in a unidirectional environment.

The actual format and semantics of the delivery layer are specific to the particular uni-directional environment in which TVAnytime is deployed. However, in order for the encoding and encapsulation mechanisms to operate as intended the delivery layer must meet certain requirements. These requirements are defined in the TV-Anytime System Specification document S-2 (SP002v1.3)

2. Normative References

The following normative documents contain provisions, which through reference in this text, constitute part of this specification.

[1] ISO/IEC 10646-1:1993. International Standard – Information technology – Universal Multiple-Octet Coded Character Set (UCS) – Part 1: Architecture and Basic Multilingual Plane.

Note (informative): *The UTF-8 encoding scheme is described in Annex R of ISO/IEC 10646-1:1993, published as Amendment 2 of ISO/IEC 10646-1:1993.*

[2] XML, Extensible Markup Language (XML) 1.0, October 2000.

[3] XML Schema, W3C Recommendation, 2 May 2001

[4] XML Schema Part 0: Primer, W3C Recommendation, 2 May 2001

[5] XML Schema Part 1: Structure, W3C Recommendation, 2 May 2001

[6] XML Schema Part 2: Datatypes, W3C Recommendation, 2 May 2001

[7] Xpath, XML Path Language, W3C Recommendation, 16 November 1999

[8] Namespaces in XML, W3C Recommendation, 14 January 1999

Note (informative): *These documents are maintained by the W3C (http://www.w3.org)*

[9] RFC 2396, Uniform Resource Identifier (URI): Generic Syntax

[10] IEEE Standard for Binary Floating-Point Arithmetic, Std 754-1985 Reaffirmed 1990, http://standards.ieee.org/reading/ieee/std_public/description/busarch/754-1985_desc.html

[11] ISO/IEC 15938-1:2001. International Standard – Information technology – Multimedia content description interface – Part 1: Systems

[12] ISO/IEC 15938-2:2001. International Standard – Information technology – Multimedia content description interface – Part 2: Description Definition Language

[13] ISO/IEC 15938-5:2001. International Standard – Information technology – Multimedia content description interface – Part 5: Multimedia Description Schemes

[14] Zlib: - The Zlib API, http://www.gzip.org/zlib, RFC 1950, RFC 1951, RFC 1952 available at http://www.cis.ohio-state.edu/cgi-bin/rfc

[15] SP002V1.3. TV-Anytime Specification – Systems http://www.tv-anytime.org

3. Definitions and abbreviated terms

3.1 Definitions

Application	A specific set of functions running on the PDR. Some applications use metadata, either automatically or under *consumer* control
Head End	Source of emission of the transport stream where metadata is inserted
Metadata	Generally, data about content, such as the title, genre and summary of a television program. In the context of *TV-Anytime*, metadata also includes consumer profile and history data.
TVA Schema	A set of rules describing the syntax and semantics of the metadata, defined by TV-Anytime in part A.
Partial Description	Reconstructed portion of the TV-Anytime metadata description in the PDR obtained after having decoded a subset of the metadata fragment stream. This document instantiates the TV-Anytime schema and must therefore be schema valid with respect to it.
Segment	A continuous portion of a piece of content, for example a single news topic in a news program.
Segmentation	The process of creating segments from a piece of content.
Transport stream	The transport stream is made up of the A/V and/or the TVAnytime data streams including the metadata
TVA access unit	Container which holds one or more TVA fragments when carried over the transport stream
TVA fragment	Self-consistent atomic portion of a metadata description sent to the decoder.
TVA metadata description	Actual document instantiating the TVA schema which is to be sent to the PDR. This document may be subject to partial updates in time using the fragmentation mechanism. In any case, it must be schema valid with respect to the TVA schema.
TVA metadata fragment stream	Set of the many TVA fragments constituting a single TVA metadata description and inserted in the transport stream received by the decoder.
TVA MPEG-7 profile	Implementation profile of the ISO/IEC 15938-1 standard, adopted by TV-Anytime for the encoding of the metadata description as specified in the current document.

3.2 Abbreviations

BiM	Binary Format of MPEG-7
CRID	Content Reference IDentifier, an identifier for content that is

	independent of its location
DDL	Description Definition Language, the language used to define description schemes in MPEG-7 [12].
DL	Delivery Layer
ECG	Electronic Content Guide: A means of presenting available content to the consumer, allowing selection of desired content
GMT	Greenwich Mean Time
IPR	Intellectual Property Rights
MPEG-7	Ongoing effort by the Motion Pictures Expert Group (working group SC29 WG11 of ISO/IEC) to specify a standard set of content-related metadata applicable to a broad range of applications. The first version of these specifications is referenced as ISO/IEC 15938.
PDR	Personal Digital Recorder
TVA	TV-Anytime
UI	User Interface
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
UTF	Universal Character Set Transformation Formats
XML	Extensible Markup Language
XPath	XML Path Language

3.3 Mnemonics

The following mnemonics are defined to describe the different data types used in the document.

Name	Definition
bslbf	Bit string, left bit first, where “left” is the order in which bit strings are written. Bit strings are generally written as a string of 1s and 0s within single quote marks, e.g. ‘1000 0001’. Blanks within a bit string are for ease of reading and have no significance.
uimsbf	Unsigned integer, most significant bit first (big-endian)
vluimsbf8	Variable length coded unsigned integer, most significant bit first. The size of vluimsbf8 is a multiple of one byte. The first bit of each byte specifies if set to ‘1’ that another byte is present for this vluimsbf8 code word. The unsigned integer is encoded by the concatenation of the seven least significant bits of each byte belonging to this vluimsbf8 code word.
vluimsbf5	Variable length code unsigned integer, most significant bit first. The first n bits which are 1 except for the n-th bit which is 0, indicates that the integer is encoded by n times 4 bits.

4. System mechanisms in a unidirectional environment

4.1 Overview

4.1.1 Main features of a unidirectional environment

Unidirectional environments deliver content and metadata from the transmitting device (head-end) to the terminal device (PDR) over a one-way link. No communication is possible from the PDR to the head-end.

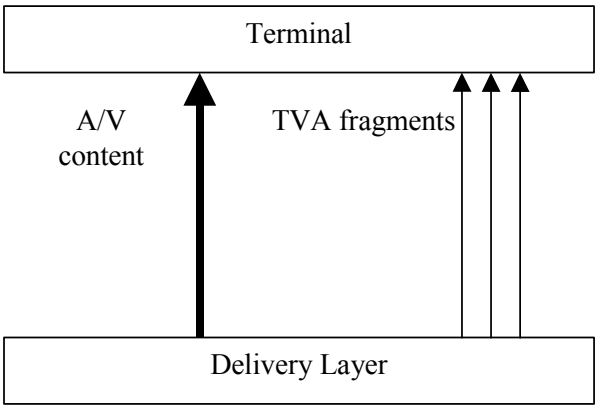


Figure 3 - Unidirectional environment

The restrictions imposed by a unidirectional environment mean that a TV-Anytime metadata delivery system needs to have the following attributes:

All the TV-Anytime metadata descriptions required by the applications running on the PDR will need to be available in the streams provided by the DL to the terminal at the time when those applications need them.

- Since the head-end is never advised that the PDR is connected and no acknowledgement is provided to indicate that the data has been correctly transmitted, the data will need to be broadcast cyclically during the time that they are potentially needed by the applications.
- Unidirectional environments are in practice limited in the amount of bandwidth that can be allocated to metadata, the size occupied by the TV-Anytime metadata description in the transport stream needs to be kept as small as possible.

4.1.2 Access Methods

Resources available to PDRs will vary, as will the nature of different unidirectional environments. Because of this it is anticipated that there are a number of ways in which a receiver may wish to acquire and navigate TV-Anytime metadata descriptions. SP003 Part B has been designed to support the following methods of acquisition.

- Acquire from the metadata stream and cache the data to disk with the receiver provides its own methods of navigation.
- Use the TVA Indexing solution to enable online navigation of the metadata stream.
- Cache both TVA indexing information and data to disk to provide an enhanced version of method 2 above.

4.1.3 Definition of a TV-Anytime metadata description

A TV-Anytime metadata *description* is the actual document, which is to be sent to the PDR. It is produced in accordance with the schema specified in the TV-Anytime metadata specification (see Part A, Section 5). TV-Anytime has selected the MPEG-7 DDL language [12], based on XML schema [3], to define its schema. MPEG-7 DDL is used to define the syntax, the types and default values that comprise the TV-Anytime specification.. A TV-Anytime description can therefore be represented as an XML document instantiating the TV-Anytime schema and containing a single root element called *TVAMain*. Within the TVAMain element any number of TV-Anytime types can be instantiated. Such a description can then be declared schema valid with respect to the TVA schema (see section4.9).

4.1.4 TV-Anytime metadata description size

In many systems a TV-Anytime description can become very large. As an example, a valid TV-Anytime document could contain all the descriptive data supplied by a single provider to

feed an ECG for the next 15 days. The data-set could consist of a set of descriptions for the whole list of programs, series, and groups of contents which are going to be played out for this period, the full schedule of all the related events, the description of the channels on which they are going to be broadcast, the classification scheme tables, the cast list tables, etc. This entire dataset is contained in the same document.

Sending this dataset as an XML document is inefficient for the following reasons:

- XML is a verbose textual format, making an XML document carrying this amount of data very large. In an environment with restricted bandwidth this will result in slow download times.
- Not all of the information carried will be relevant to the terminal at any one instance. Some part of the description may require to be accessed often whilst other parts may only be accessed occasionally.
- Some parts of the document may need to be updated without affecting other parts (e.g modification of a single schedule event if one programme is replaced by another).
- Some parts of the document may need to be accessed and updated more often and more efficiently than the rest of the data set (e.g. dynamic segmentation metadata).

In order to overcome the problems associated with delivering TV-Anytime metadata as a single, homogenous document, TV-Anytime defines *fragmentation, encoding, encapsulation* and *indexing* mechanisms to apply to the TV-Anytime metadata descriptions before being transmitted to the terminal in a unidirectional environment.

4.2 Metadata general delivery framework

The delivery of TV-Anytime metadata can be viewed as five distinct processes.

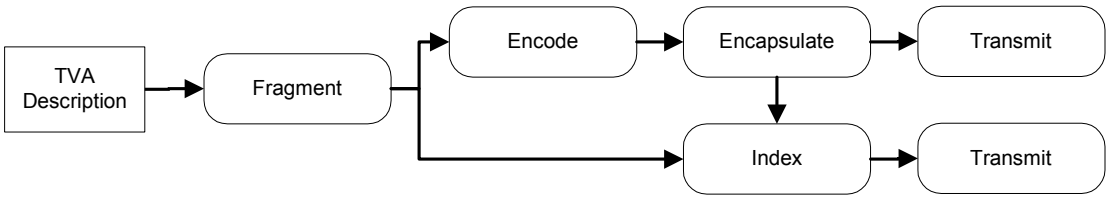


Figure 5 - Processes associated with delivery of metadata

4.2.1 Introduction to fragmentation

Fragmentation is the generic decomposition mechanism of a TVA metadata description into self-consistent units of data, called *TVA fragments*. The definition of TVA fragment types allowed by TV-Anytime can be found in section 4.3.

The *self-consistency* capability of a TVA fragment means that :

- Fragments can be obtained in a random order
- Each fragment can be transmitted and updated independently
- After a fragment has been received and decoded, the resulting *partial description* is valid with respect to the TVA schema.

The set of all TVA fragments constituting a single TVA metadata description is transmitted to the terminal within a unidirectional environment as a stream of data. This stream is termed a *TVA metadata fragment stream*.

A TVA metadata fragment stream shall always be accessed via the TVA-init message which represents the entry point, as described in section 4.4.1, followed by the TVA fragment containing the `TVAMain` root element, as described in section 4.3.1.1. Optionally, the `TVAMain` fragment may be included in the TVA-init message as indicated in section 4.4.1

The transport of TVA metadata *shall be fragmented* as defined in this specification.

4.2.2 Introduction to encoding

To enable the efficient (in terms of bandwidth, navigability and updating) delivery of data within a unidirectional environment, it is necessary to represent the TVA metadata fragments in a binary format.

TV-Anytime has chosen the MPEG-7 BiM method as defined in ISO/IEC 15937-1 (MPEG-7 Systems part) as the preferred method that would facilitate wide interoperability. However TV-Anytime appreciates that in some controlled environments, it may be desirable to enable the delivery of metadata using alternate encoding systems. To allow this, appropriate hooks are provided where necessary and the means to indicate the method of encoding used.

4.2.3 Introduction to Encapsulation

Once the fragments have been encoded they need to be *encapsulated*. The process of encapsulation provides further information to enable a receiving device to manage a set of transmitted TVA fragments. A receiver needs to be able to uniquely identify a fragment within the TVA metadata fragment stream, and also to be able to identify when the data within a fragment changes. This information is provided by the encapsulation layer.

For the transmission of fragments, the encapsulation mechanism *shall* be used.

4.2.4 Introduction to Indexing

Within a TV-Anytime metadata fragment stream there are likely to be many hundreds of fragments. Due to the volume of information necessary to provide the enhanced functionality expected of a PDR it is important that there is an efficient mechanism for locating information from within the TVA metadata fragment stream. Indexing provides this functionality by allowing multiple views on the TVA metadata description. In addition to enable a device to quickly find a fragment of interest, indices can also for example be used to provide enhanced UI functionality such as an A-Z listing for Content Titles, Genre Listing etc.

Indexing is an *optional* part of this specification, however it is seen as a powerful mechanism when TVA metadata is to be delivered to receivers that have limited processing and storage capabilities.

4.2.5 Logical decoder architecture

The components of the logical decoder architecture are shown below. Each of these components has a specific role in the process of reconstructing a TVA description or in the navigation of the TVA fragments via the indexing system.

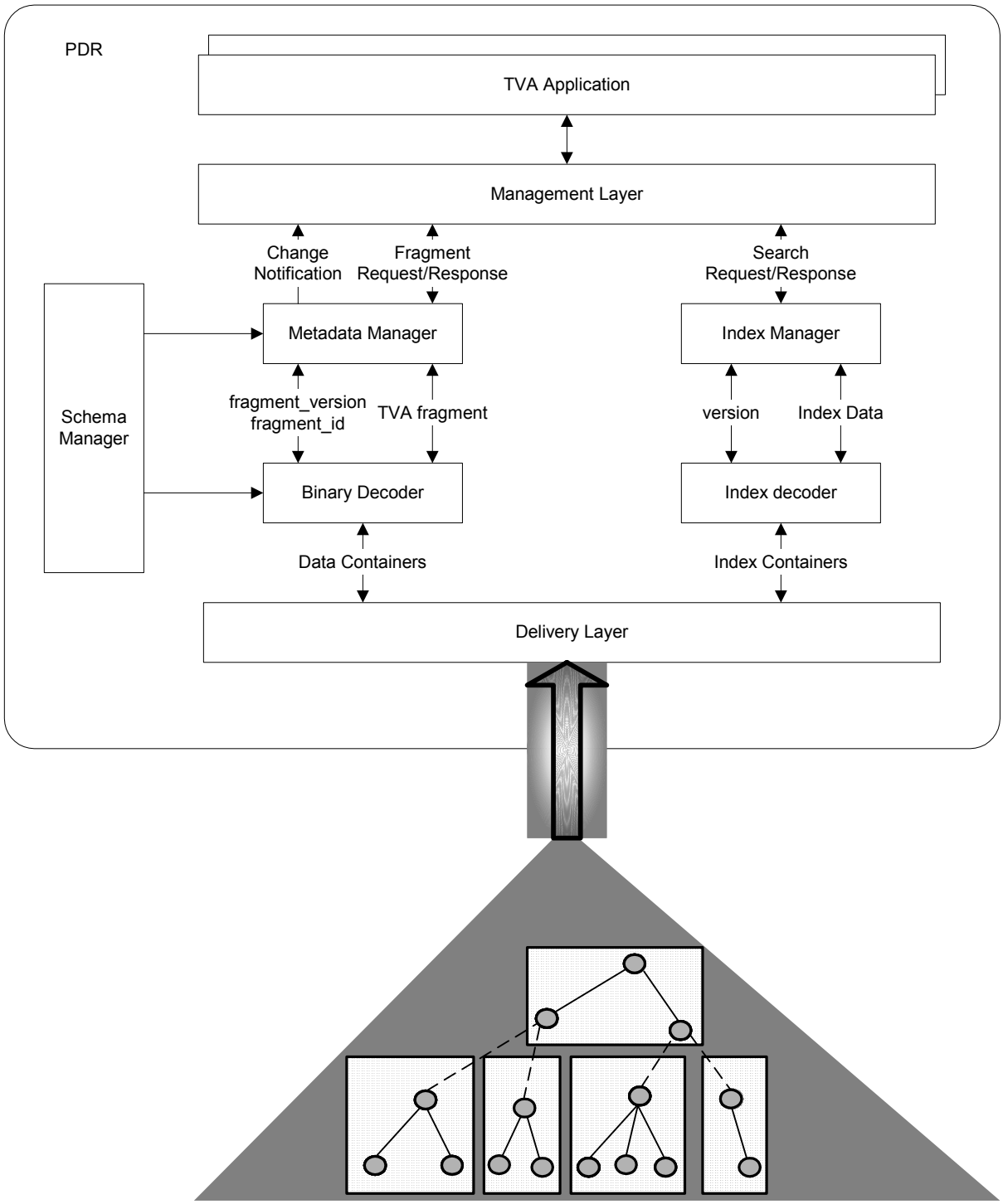


Figure 7 - Functional metadata processing architecture in a unidirectional environment

- **Delivery Layer:** The delivery layer provides the mechanism on which the TVA metadata fragment stream is transmitted. The system shall locate the TVA-init message within the delivery layer, to initialise the metadata management system. The TVA-init provides information about the encoding of the TVA fragments, and whether Indexing data is available. Once the metadata management system has been configured, the system is ready to process TVA fragments, and indexing data. TVA fragments are encapsulated within a data container. Depending on the caching model used one or more data

containers e.g. Acquire container 'N' or acquire all data containers - are requested by the management system.

- **Binary Decoder:** The binary decoder takes a data container and decodes the TVA fragment and delivers the decoded TVA fragment along with the fragments version and unique identifier to the Metadata Manager. The schema to which all fragments within the TVA metadata fragment stream shall conform is defined within the DecoderInit part of the TVA-init message.
- **The Schema Manager:** This is a black box component in the terminal which provides the Binary Decoder with details about the schemas, declared in the TVA-init message and instantiated by the related TVA metadata description. It is a requirement that the terminal knows the schema used to produce a TVA metadata description prior to processing the TVA metadata fragment stream. **However, the method in which a PDR acquires this schema is out of scope for the current version of the TV-Anytime metadata standard.**
- **Metadata Manager:** This component is responsible for managing requests from the Management Layer for TVA fragments, and also for notifying the Management layer of changes to fragments previously acquired from the TVA metadata fragment stream.
- **Management Layer**: The role of the management layer is very much dependant on the functionality of the TVA Application which is interacting with this layer. In some instances it will just notify the Application when a change as occurred to the TVA fragment stream e.g. new fragment, deleted fragment takes. In other cases it will ask for a specific fragment, which involves an index lookup. The Management Layer is then responsible for using the Index to locate a fragment and then using the Metadata manager to load the fragment from the TVA metadata fragment stream.
- **Index Decoder:** This component takes an Index container from the delivery layer, and makes the raw data available to the Index Manager, along with the index container version.
- **Index Manager:** This component takes search requests from the Management Layer and returns a set of matching references to fragments, which the Management layer then sends to the Metadata manager for loading. To perform the search the appropriate Index containers are loaded, and the search performed using the supplied parameters.

4.3 Metadata description fragmentation

To enable the efficient delivery, updating and navigation of a TV-Anytime metadata description, a number of normative TVA fragment types have been defined.

A fragment is the ultimate atomic part of a TV-Anytime metadata description that can be transmitted independently to a terminal. A fragment shall be self consistent in the sense that:

- It shall be capable of being updated independently from other fragments
- The way it is decoded, processed and accessed shall be independent from the order in which it is transmitted relative to other fragments.
- The decoding of a fragment and its addition to the partial description shall give a TV-Anytime schema valid description. Note that a partial description must have at least the fragment delivering the root element (`TVAMain`)

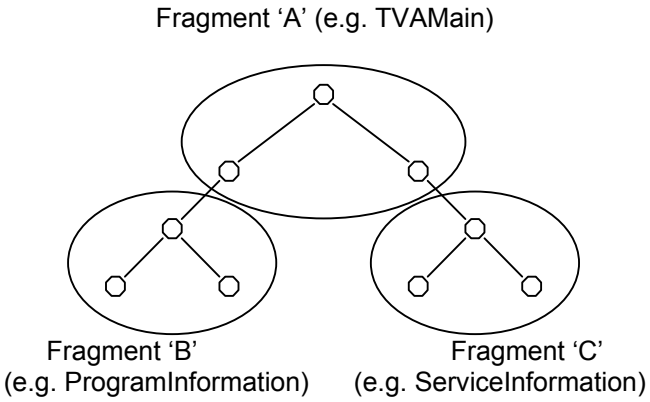


Figure 9 - Fragmentation of a TV-Anytime metadata description

When an update occurs to one or more elements or attributes within a previously transmitted fragment, the entire fragment must be transmitted again i.e. no mechanisms for sub-fragment updates are provided.

4.3.1 TVA Metadata Fragments

The TV-Anytime metadata description can be split into a number of standardised types of self contained fragments. These TV-Anytime normative fragments are defined as follows:

4.3.1.1 TVAMain fragment

The TVAMain fragment is special since every TVA fragment stream must contain one instance of this fragment type. The TVAMain fragment contains the TVAMain root element plus a limited range of child nodes.

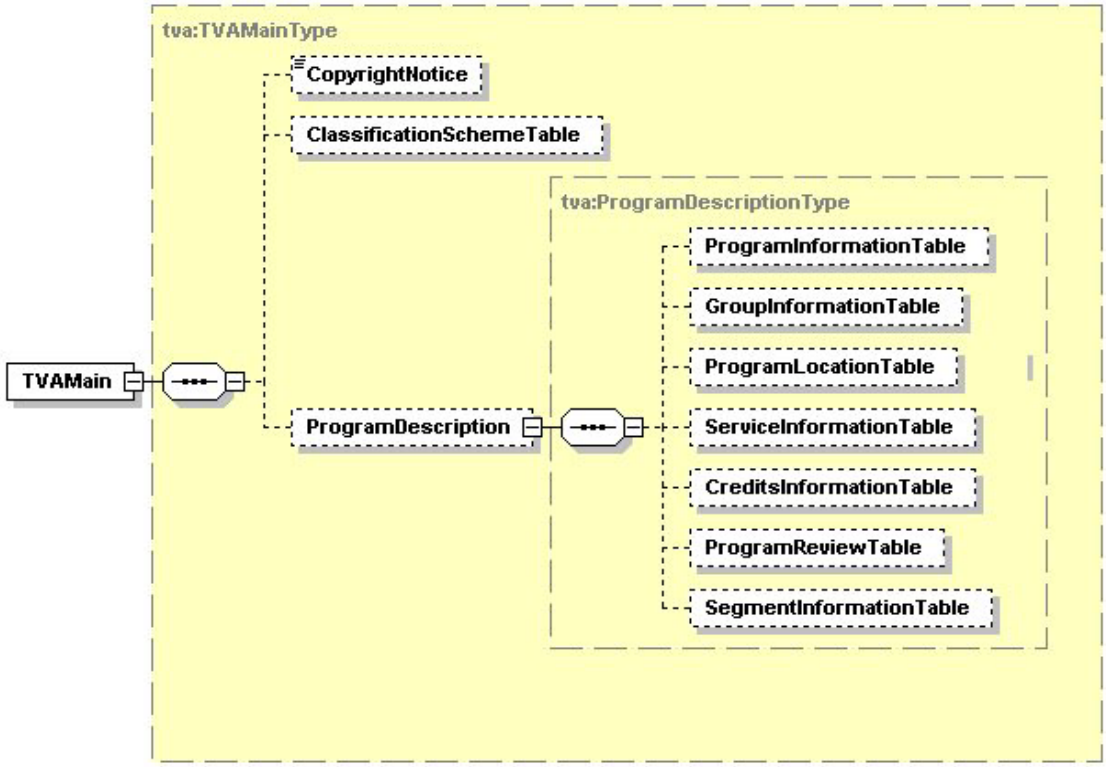


Figure 10 - UML-like representation of a TVAMain fragment

As can be seen from the representation in Figure 10 - the `TVAMain` fragment shall contain child elements down to and including the following:

- `ClassificationSchemeTable`
- `ProgramInformationTable`
- `GroupInformationTable`
- `ProgramLocationTable`
- `ServiceInformationTable`
- `CreditsInformationTable`
- `ProgramReviewTable`
- `SegmentInformationTable`
  - `SegmentList`
  - `SegmentGroupList`
  - `TimeBaseReference`

The presence of and number of each of these types shall conform to the TV-Anytime schema. Elements that are children of these element types form fragments of their own and so shall not be included within the `TVAMain` fragment.

It should be noted that updates to `TVAMain` would typically be infrequent, and an update to this fragment would cause the decoder to be re-initialised.

4.3.1.2 ProgramInformation fragment

A `ProgramInformation` fragment is one of the key attractor types of a TVA system, it carries an element of type `ProgramInformationType` and all child nodes thereof. This type contains descriptive information about a piece of content, the content being identified by a CRID.

The `ProgramInformationElement` is a child element of the `ProgramInformationTable`, which forms part of the `TVAMain` fragment.

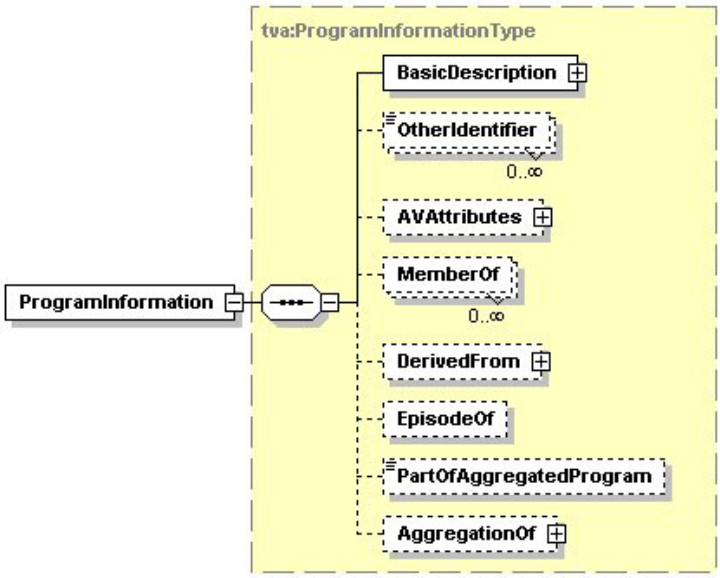


Figure 12 - UML-like Representation of a ProgramInformation Fragment

The ProgramInformation fragment is completely self-contained with one exception. Within the CreditsItem, which is a child element of the CreditList element in the BasicDescription element, the optional PersonNameIDRef and OrganizationNameIDRef elements use TVAIDRefType attributes to reference TVAIDType attributes within corresponding entries within the CreditsInformationTable. This enables optimisation in cases where a Credit Item description is common to more than one program. In such a case, a CreditsItem only needs to be defined once e.g. for all the episodes of a Soap Opera. The guidelines given for the use of TVAIDType/TVAIDRefType in section 4.3.5 should however be taken into account when assigning and using these ID values.

4.3.1.3 GroupInformation fragment

A GroupInformation fragment contains an element of type GroupInformationType and all child nodes thereof. This contains descriptive information about a conceptual content group e.g. Series, Serial, Collection etc. The GroupInformationElement is a child element of the GroupInformationTable, which forms part of the TVAMain fragment.

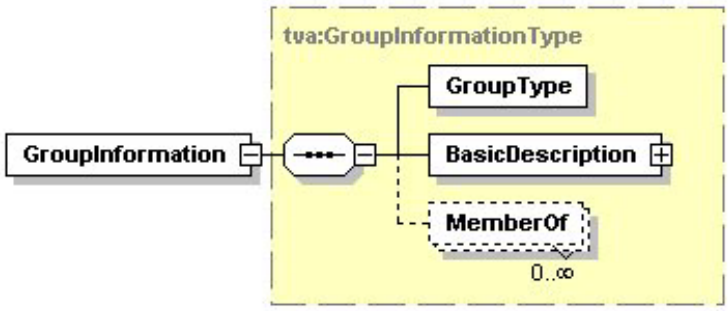


Figure 13 - UML-like Representation of a GroupInformation fragment

The GroupInformation fragment is completely self contained except for that described for the ProgramInformation fragment, namely within the CreditsItem, the optional PersonNameIDRef and OrganizationNameIDRef elements which the TVAIDRefType attribute which points to an entry within the CreditInformationTable. The guidelines given for the use of TVAIDType/TVAIDRefType in section 4.3.5 should thus be taken into account when assigning and using these ID values.

4.3.1.4 OnDemandProgram and OnDemandService fragment

Within a unidirectional environment the OnDemandProgramType and the OnDemandServiceType are seen to be of limited use.

However if a broadcaster wishes to transmit OnDemand program location information, a complete OnDemandProgram or an OnDemandService element instantiating respectively one of these types shall form a single fragment. Both the OnDemandProgram and the OnDemandService elements are child members of the ProgramLocationTable, which forms part of the TVAMain fragment.

An attribute of type TVAIDRefType is used by the serviceIDRef attribute within the OnDemandServiceType to reference the associated service information. It points to an element of type ServiceInformationType having a serviceId attribute, with a value equal to the serviceIDRef. This latter value shall be unique within the TVA metadata description. And the guideline in section 4.3.5 on the assignment and use of TVAIDType/TVAIDRefType values should be taken into account when dealing with these values.

4.3.1.5 BroadcastEvent fragment

The `BroadcastEventType` has been designed to represent dynamic events in an environment where frequent updates are required.

A `BroadcastEvent` fragment is thus an instance of the `BroadcastEventType`, a child element of the `ProgramLocationTable`, which forms part of the `TVAMain` fragment.

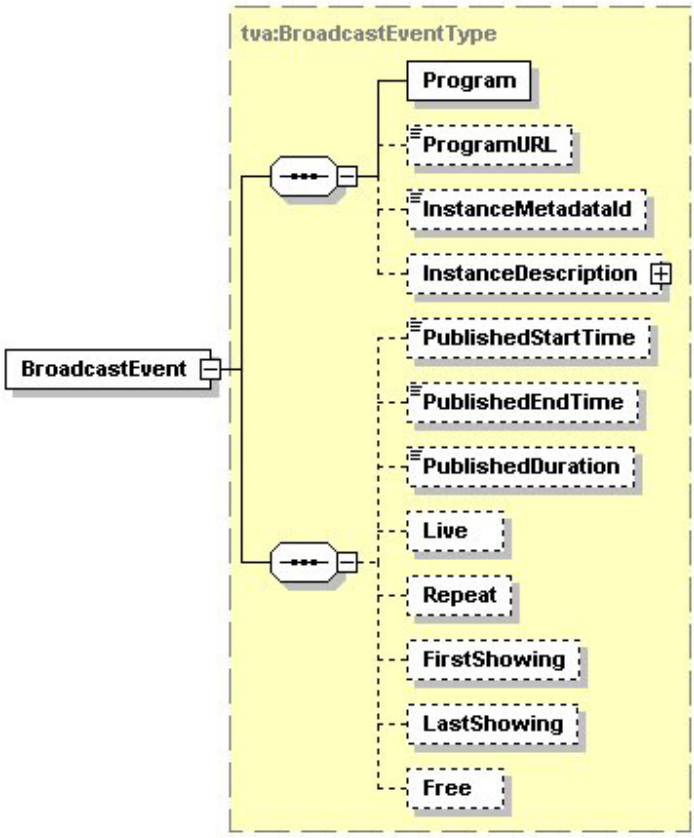


Figure 14 - UML-like Representation of a BroadcastEvent fragment

A `TVAIDRefType` value is used by the `serviceIDRef` attribute to identify the service on which the event described by this `BroadcastEvent` fragment will be broadcast. It points to the `serviceId` attribute, of a `ServiceInformation` element in the same metadata description, whose type is `TVAIDType`. This latter value shall be unique within the TVA metadata description. And the guideline in section 4.3.5 on the assignment and use of `TVAIDType/TVAIDRefType` values should be taken into account when dealing with these values.

4.3.1.6 Schedule fragment

The Schedule type provides an alternative way to that of the `BroadcastEvent` type for describing events within a broadcast system. It provides a mechanism to group a number of consecutive events together, which span a given time period on a single service.

The use of the `ScheduleType` for describing broadcast events has the following properties

- To extract a single event from a schedule, the entire schedule must be decoded to locate the event of interest.
- The schedule type has been designed to aid large and collective updates. An update to a single event, within the schedule, will cause the entire Schedule fragment to be updated. However this is often not a problem, as subsequent events are often affected by a single event change.

As a result, the Schedule fragment instantiates the `ScheduleType` and is a child element of the `ProgramLocationTable`, which forms part of the `TVAMain` fragment.

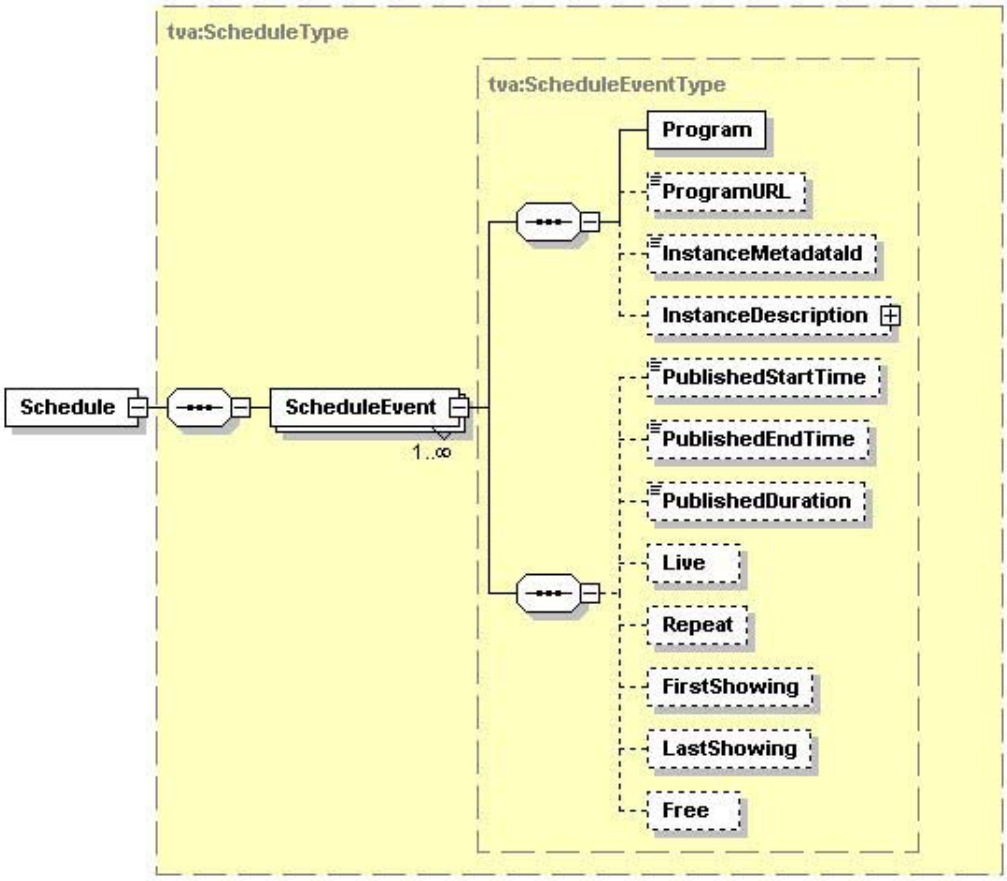


Figure 15 - UML-like Representation of a Schedule fragment

A `TVAIDRefType` value is used by the `serviceIDRef` attribute to identify the service on which the events described by the schedule will be broadcast. It should be managed the same way as described in the previous section for the `BroadcastEvent` fragment by taking into account the guidelines in section 4.3.5 on the assignment and use of `TVAIDType/TVAIDRefType` values.

4.3.1.7 ServiceInformation fragment

A `ServiceInformation` fragment contains details about a single Service within a broadcast system.

A `ServiceInformation` fragment is an instance of a `ServiceInformationType`, and a child of the `ServiceInformationTable`, which is a member of the `TVAMain` fragment.

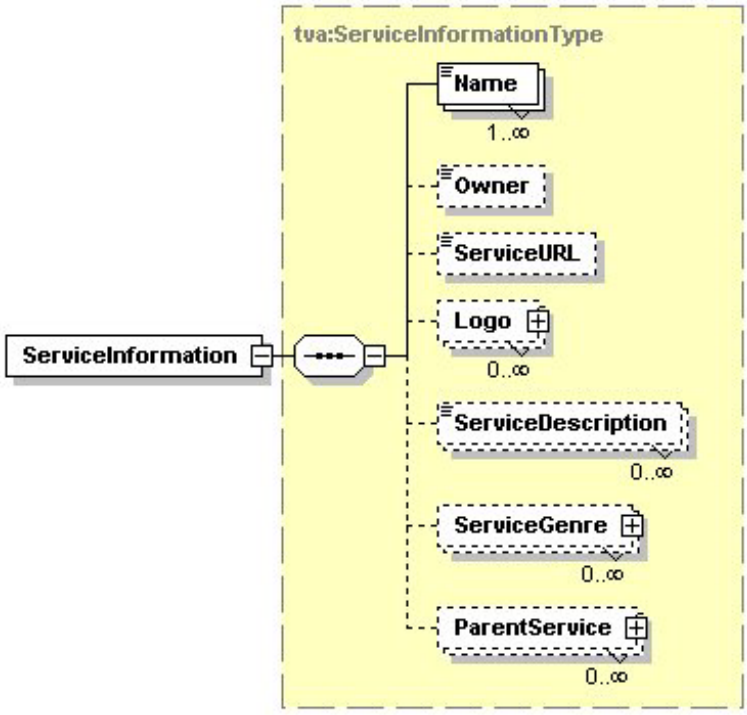


Figure 16 - UML-like Representation of a ServiceInformation Fragment

4.3.1.8 CreditInformation fragments

The `CreditsInformationTable` element instantiates the `CreditsInformationTableType`.

It gathers together details about the people and organisations involved in the production of the different content items described in the metadata description. It is used to lighten the size of the description of each content item, by allowing the use of a pointer reference to a `PersonName` or `OrganisationName` element contained within the `CreditsInformationTable`. It may be useful, for example, where several content items share the same credit information, in which case the information only need to be instantiated once.

4.3.1.8.1 PersonName fragment

A `PersonName` element instantiates a `PersonNameType` and shall form a single TVA fragment. The `PersonName` element is a child element of the `CreditsInformationTable`, where the `CreditsInformationTable` forms a member of the `TVAMain` fragment.

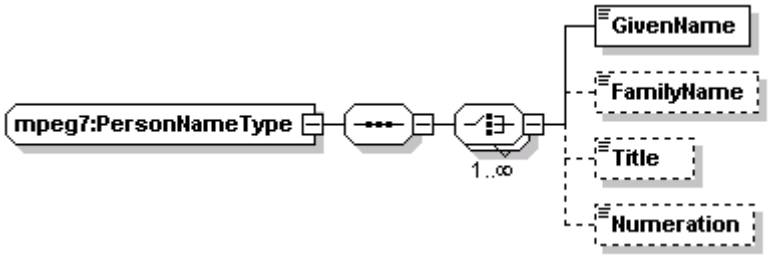


Figure 18 - UML-like representation of PersonNameType

4.3.1.8.2 OrganisationName fragment

The `OrganisationName` element shall form a single TVA fragment. The `OrganisationName` element is a child element of the `CreditsInformationTable`, where the `CreditsInformationTable` forms a member of the `TVAMain` fragment.

4.3.1.9 Review fragment

A Review element instantiates the `MediaReviewType` and contains a single review for a content item identified by a CRID.

The Review fragment is thus a child element of the `ProgramReviewTable`, which is a member of the `TVAMain` fragment.

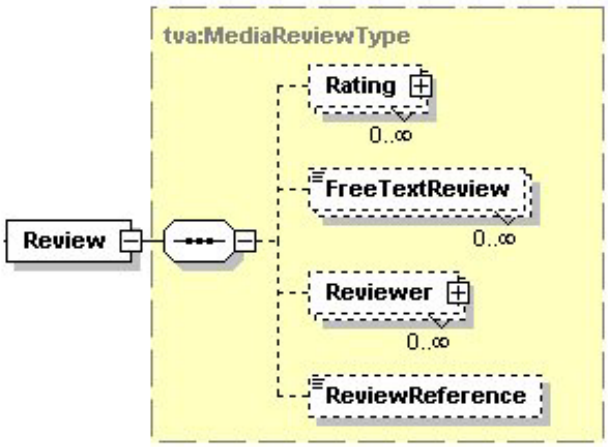


Figure 20 - UML-like Representation of a ProgramReviews fragment

4.3.1.10 User Description information

The transmission of a `UserDescription` element is not seen to be of any practical use within a unidirectional environment, and so no fragmentation structure has been defined

4.3.1.11 ClassificationScheme fragments

`ClassificationSchemes` elements are used to define a list of controlled terms used by a number of TVA data types e.g. Genre Classification, AV Coding types etc. In addition `CSAlias` elements, used as aliases to the `ClassificationSchemes`, can be provided to reduce the size of the reference required to identify the Classification scheme used.

4.3.1.11.1 CSAlias

The `CSAlias` fragment instantiates the `ClassificationSchemeAliasType` defined by MPEG-7 and is a child of the `ClassificationSchemeTable`, which is a member of the `TVAMain` fragment.

A single `CSAlias` element shall form a single `CSAlias` fragment.

4.3.1.11.2 ClassificationScheme

The `ClassificationScheme` element is an instance of the `ClassificationSchemeType`.

The `ClassificationScheme` fragment is thus a `ClassificationScheme` element, child of the `ClassificationSchemeTable`, which is a member of the `TVAMain` fragment.

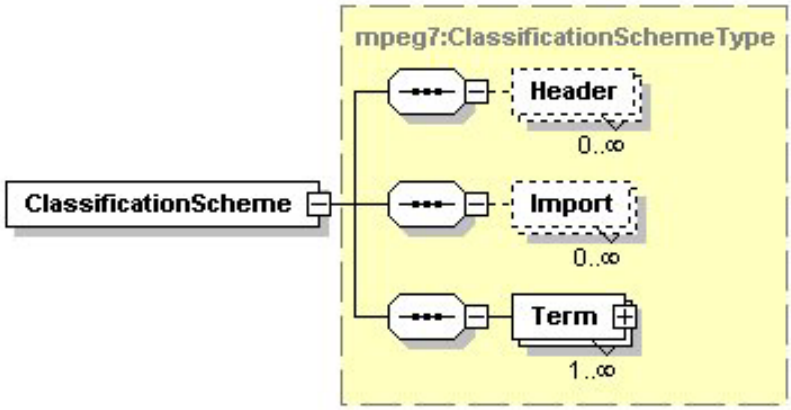


Figure 22 - UML-like Representation of a ClassificationScheme fragment

4.3.1.12 Segmentation

Segmentation Information can be used to enhance the users viewing experience by providing the ability to view content in a non-linear way. Segmentation information is split up into two groups according to the two schema types they use, namely the `SegmentInformationType` and the `SegmentGroupInformationType`.

The `SegmentInformationType` provides details about the segment e.g. start offset, duration, description etc.

The `SegmentGroupInformationType` enables the Grouping of segments so for example to define the way in which content, should be navigated.

The `SegmentGroupInformation` and `SegmentInformation` make extensive use of `TVAIDType/TVAIDRefType`, and the guideline define in section 4.3.5 should be followed.

4.3.1.12.1 SegmentInformation

A `SegmentInformation` element instantiates the `SegmentInformationType` and describes a single segment of a content item. It is seen as the smallest updateable unit and so shall form a single fragment.

A `SegmentInformation` fragment is thus a `SegmentInformation` element, which is a child of the `SegmentList` element, which forms part of the `TVAMain` fragment.

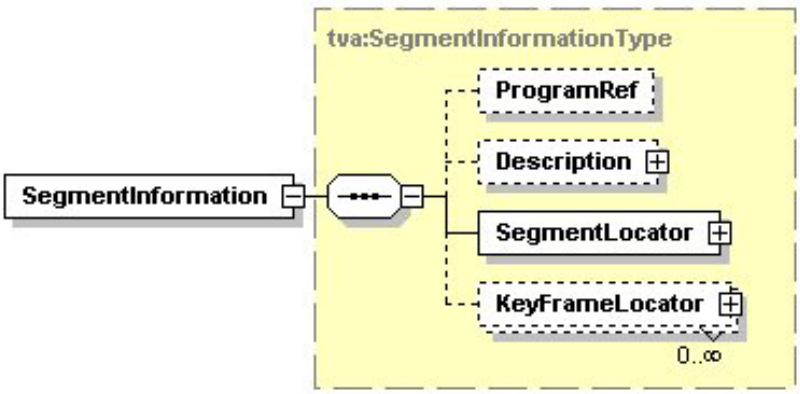


Figure 24 - UML-like Representaion of a SegmentInformation fragment

4.3.1.12.2 SegmentGroupInformation

A `SegmentGroupInformation` element instantiates the `SegmentGroupInformationType`.

It allows the definition of a segment group, namely a set of references to `SegmentInformation` elements, which can be used to define a mode of navigation or a virtual piece of content e.g. Highlights of a football match. It is also possible for a segment group to reference another segment group providing hierarchical navigation of the content similar to a table of contents.

A `SegmentGroupInformation` fragment is thus a `SegmentGroupInformation` element, which is a child of the `SegmentGroupList` element, which forms part of the `TVAMain` fragment.

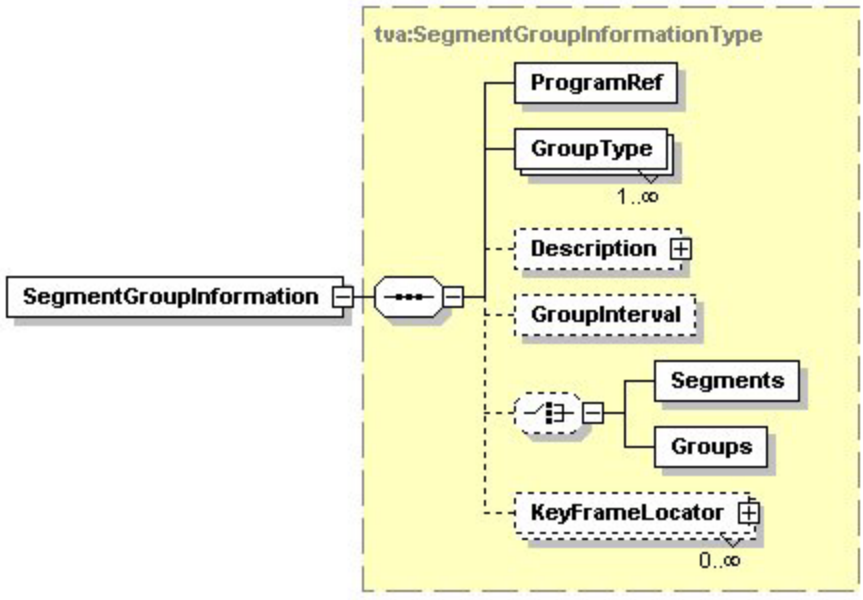


Figure 26 - UML-like Representation of a SegmentGroup fragment

4.3.2 Fragment Identification and Versioning

Many element types within the TVA schema have both a `fragmentVersion` and a `fragmentId` attributes, it is recommended not to use these attribute to identify a fragment or to indicate fragment versions in a unidirectional environment. This is because it is required to partially decode the fragment to extract the required information.

A means of assigning an identifier to a fragment and a version to a fragment at the appropriate level is described in section 4.6.

4.3.3 Element Ordering

When two or more elements of the same type occur within a metadata description, it is assumed that their order within the parent element is unimportant e.g. `ProgramInformation` elements within the `ProgramInformationTable`. Therefore, it is not a requirement to maintain the order of elements across the delivery system.

Where a parent element can contain more than one element type e.g. `PersonName` and `OrganisationName` within the `CreditsInformationTable` – it is the responsibility of the receiving terminal to ensure that the order of element types is maintained, with respect to the TVA schema.

4.3.4 TVA access unit

The TVA access unit is defined as being a container that holds one or more TVA fragments. A TVA fragment shall be wholly contained within a single container. TVA fragments within a TVA access unit can be of any type, provided that an individuals fragment type can be identified without fragment decoding.

Where BiM is used as the encoding solution a TVA access unit shall take the form of an MPEG-7 Access Unit (AU), with the TVA fragments type being identified, using the `ContextPath` within BiM.

It is the responsibility of the broadcaster to manage the number of TVA fragments within a TVA Access Unit, bearing the following in mind:

- The overhead of transmitting a container – The smaller the container the less efficient it will be in terms of bandwidth usage.
- The updating of a single TVA fragment within a container will cause the container to be updated.

4.3.5 Use of TVAIDType, TVAIDRefType and TVAIDRefsType

In a number of instances within the TVA metadata schema, elements make use of the `TVAIDType, TVAIDRefType` and `TVAIDRefsType` data types.

These replace the respective standard XML ID, IDREF and IDREFS data types. They are provided to enable elements to reference other elements within the same TVA metadata description. However as a TVA metadata description is split up into a number of TVA fragments and transmitted as a TVA metadata fragment stream, the following issues should be noted:

- The synchronization of TVAIDType, TVAIDRefType and TVAIDRefsType values between fragment versions.
- The possibility of changing references when dealing with partial metadata descriptions.

A TVA metadata fragment stream is treated as if it were a single XML instance document. The value assigned to an attribute instantiating `a TVAIDType` shall be unique within a single TVA metadata description. Also, all attributes instantiating the `TVAIDRefType` or the `TVAIDRefsType` must make references to elements containing an attribute of type `TVAIDType`, only within the same TVA metadata description. No provision is currently made for referencing elements across multiple TVA metadata descriptions.

The guideline rules for use `of TVAIDType, TVAIDRefType` and `TVAIDRefsType` are therefore:

- The value assigned to the `TVAIDType` element must be unique within a TVA metadata description.
- In case of an update to an element with an attribute of type `TVAIDType`, it may be appropriate to create a totally new element with a new `TVAIDType` value when this element changes significantly e.g. in the Credits list when an actor dies. This is to ensure that the original description can still be referenced from within the metadata description, rather than an updated one.
- Where there is a choice between an inline instantiation and the use of a reference, the broadcaster should weigh up the added complexity of using a `TVAIDType/TVAIDRefType` (additional level of indirection) against the potential bandwidth savings.
- It is important when thinking about the delivery dynamics to ensure that an element being referenced is available within the TVA metadata description, before or at the same time as the element, making the reference. The reverse is also true; when deleting elements, it is important to remove the element that makes the reference, before the element being referenced.

4.4 Fragment Encoding

4.4.1 TVA-init Message

4.4.1.1 Overview

The TVA-init message specified in this sub-clause is used to configure parameters required for the decoding of the TVA metadata fragment stream. There shall only be one TVA-init associated with a TVA metadata fragment stream.

A delivery layer suitable for conveying a TVA metadata fragment streams, shall provide a means of delivering the TVA-init message to the terminal before any fragment decoding occurs.

Syntax	No. of bits	Mnemonic
TVA-init {		
EncodingVersion	**8**	**uimsbf**
IndexingFlag	**1**	**bslbf**
reserved	**7**	
DecoderInitptr	**8**	**bslbf**
if(EncodingVersion == '0x01') {		
BufferSizeFlag	**1**	**bslbf**
PositionCodeFlag	**1**	**bslbf**
reserved	**6**	
CharacterEncoding	**8**	**uimsbf**
if (BufferSizeFlag=='1') {		
BufferSize	**24**	**uimsbf**
}		
}		
if(IndexingFlag) {		
IndexingVersion	**8**	**uimsbf**
}		
Reserved	**0 or 8+**	
DecoderInit( )		**bslbf**
}		

EncodingVersion: This field indicates the method of encoding used to represent the TVA metadata fragments. Table 1 provides the possible set of values for this field.

Value	Encoding Version
0x00	Reserved
0x01	TVA MPEG_7 profile (BiM) ISO/IEC 15938-1:2001
0x02 – 0xEF	TVA reserved
0xF0 – 0xFF	User defined

Table 1: Table of values for the EncodingVersion parameter

IndexingFlag: Indicates if one or more indexes are carried within the stream.

DecoderInitptr: This field conveys a pointer, which defines the offset in bytes from the start of the TVA-init message where the `DecoderInit` can be found.

BufferSizeFlag: Indicates if a BufferSize for the Zlib coded is defined. If not defined the decoder shall assume a maximum of 1000 bytes.

PositionCodeFlag: This flag indicates if the BiM contextPath Position Code is used in the encoded fragment. When set to '0' the Position Code within the contextPath shall be ignored. In that case, it must be noted that the canonical format of the instance description is not preserved, i.e. the order of the elements within the rebuilt description is not preserved.

CharacterEncoding: This field conveys the character encoding scheme for all textual data used within the TVA metadata fragment stream. Table 2 defines the set of possible values for this field.

Value	Description	Termination Value
0x00	7 bit ASCII (ISO 646)	0x00
0x01	UTF-8	0x00
0x02	UTF-16	0x0000
0x03	GB2312	0x00
0x04	EUC-KS	0x0000
0x05	EUC-JP	0x0000
0x06	Shift_JIS	0x0000
0x07 – 0xE0	TVA Reserved	undefined
0xE1 – 0xFF	User defined	undefined

Table 2: Character Encoding and their termination values

BufferSize: This element conveys the maximum number of bytes a Zlib buffer will decompress to.

IndexingVersion: This element indicates the method used to represent TVA indices. It provides the possible set of values for this element.

Value	Indexing Version
0x00	reserved
0x01	TVA Index Version 1
0x02 – 0xEF	TVA reserved
0xF0 – 0xFF	User defined

Table 3 : Table of values for the IndexingVersion field

Reserved: Variable data space for inserting future initialisation parameters. In this version, the length of this field shall be 0x00.

DecoderInit: This element conveys the `DecoderInit`. The format of the `DecoderInit` is dependant on the encoding method used. In the case of BiM (EncodingVersion = 0x01) it shall be as defined in section 4.4.2.1.

4.4.2 MPEG-7 system profile

Due to the characteristics of a uni-directional environment, a number of restrictions have been imposed on how the MPEG-7 BiM profile shall be used. This section details these restrictions.

4.4.2.1 DecoderInit

The `DecoderInit` is used to configure parameters required for the decoding of the binary fragments. There is only one `DecoderInit` associated with one TVAmetadata fragment stream. The `DecoderInit` shall take the form as specified in [11] with the following caveats.

4.4.2.1.1 UnitSizeCode

ISO Semantics: This is a coded representation of `UnitSize`. `UnitSize` is used for the decoding of the binary fragment update payload.

Restriction: This `UnitSizeCode` variable shall be set to the default value: '000'.

4.4.2.1.2 InitialDescription

ISO Semantics: This conveys portions of a description using the same syntax and semantics as an MPEG7 access unit. The `InitialDescription` provides an initial state for the binary description tree.

Restriction: The TVA fragment containing the `TVAMain` element and is the entry point of the TVA metadata fragment stream. The `InitialDescription` may be carried in two ways:

- Along with the `DecoderInit`.
- Independently from the `DecoderInit`

In the case where the `InitialDescription` is sent independently from the `DecoderInit`, it must be received and decoded by the receiving terminal before processing of any other TVA fragments. The delivery layer shall provide signalling to indicate where the `InitialDescription` is to be found.

4.4.2.2 FragmentUpdateCommand

ISO Semantics: The `FragmentUpdateCommand` code word specifies the command that shall be executed on the binary format description tree. It should be ignored when the `PositionCodeFlag` in the TVA-Init is set to '0'.

TVA Semantics:

In the TVA framework, the semantics of the `FragmentUpdateCommand` is refined such as :

- When a fragment is modified (i.e. updated or enriched), the replace command (`ReplaceContent`) is used.
- When a fragment is no longer valid (the program has been dropped), the delete command (`DeleteContent`) is used.
- When a fragment is obsolete, the fragment is no longer transmitted.

4.4.2.2.1 Guidelines for the use of the FragmentUpdateUnit

The `FragmentUpdateUnit` uses the `ContextPath` along with a Position Code to determine where the TVA fragment being updated should be placed relative to its parent element. The `ContextPath` provides the absolute path from the metadata description root (`TVAMain`) to the element, which this fragment is a child of. In a classical BiM implementation the Position Code is used to indicate the position of the TVA fragment among its sibling fragments, so as to maintain the original document order of sibling elements. In a TVA implementation of BiM it is not a requirement to maintain the original metadata description sibling ordering. It is not a requirement to support the use of the Position Code within a TVA

implementation. However if it is used, the Position Code provides a handle to a previously transmitted TVA fragment.

4.4.2.2.1.1 Position Code allocation

As described above, the Position Code provides a handle to a transmitted TVA fragment. This Position Code must be unique for all children of a given parent element. Due to the nature of a TVA metadata fragment stream i.e. a living description, constantly changing - over time the Position Code value will become very large. Therefore it would be advantageous to reuse previously allocated values that are no longer valid. However the following should be taken into account:

A sufficient period of time should have elapsed since the use of a specific Position Code value to ensure that receiving terminals have automatically deleted from the cache the fragment previously assigned this Position Code.

4.4.2.2.1.2 Fragment Add/Update

When a new or updated fragment is transmitted the `FragmentUpdateUnit` will have the following settings:

- `FragmentUpdateCommand` – Set to '0010' (`ReplaceContent`)
- `FragmentUpdateContext`
- `ContextModeCode` – Set to '001' (Absolute path to fragments parent element, with no multiple payload support)
- `ContextPath` Position Code – A value that identifies the fragment within a TVA metadata description and shall be unique if used.

When the receiving terminal acquires the `FragmentUpdateUnit` it will use the `ContextPath` along with the Position Code to see if there is a TVA fragment already cached with the same Position Code. If a previous TVA fragment is found the previous TVA fragment shall be deleted and replaced with the new TVA fragment. If a previous TVA fragment is not found the TVA fragment is just cached along with the rest.

4.4.2.2.1.3 Fragment Delete

When a fragment is no longer valid a Delete command can be sent to the receiving terminal, to inform the device that the fragment shall no longer be used. A delete command will have the following settings:

- `FragmentUpdateCommand` – Set to '0011' (`DeleteContent`)
- `FragmentUpdateContext`
- `ContextModeCode` – Set to '001' (Absolute path to fragments parent element, with no multiple payload support)
- `ContextPath Position Code` – The original unique value assigned to this TVA metadata description fragment.

When the receiving terminal acquires the `FragmentUpdateUnit` it will use the `ContextPath` along with the Position Code to see if the TVA fragment is within its cache. If the TVA fragment is found it shall no longer be used and removed from the terminal's cache.

It is assumed that the delete command will only be transmitted for a relatively short period of time, to enable currently listening terminals to keep their cache updated.

However due to the nature in which TVA fragments are acquired within a unidirectional environment, the Delete command should not be relied upon to remove elements from the terminals cache. The terminal should implement a timeout mechanism, where if a given fragment is not seen in the data stream for a specified period of time, the terminal shall assume that the fragment is no longer valid, and remove it from its cache.

4.4.2.2.1.4 Example decoder behaviour

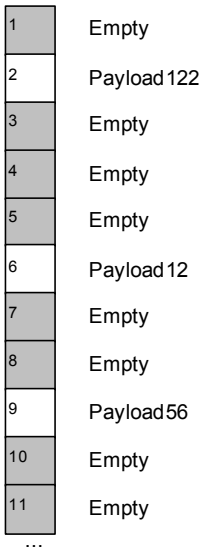
A TVA metadata fragment stream generator has an internal representation of the decoder memory. This representation can be modelled by a buffer, which contains an infinite number of slots.

A TV-Anytime decoder contains several tables (`ProgramInformationTable`, etc.). These tables correspond to the fragmentation specification of a TVA metadata description.

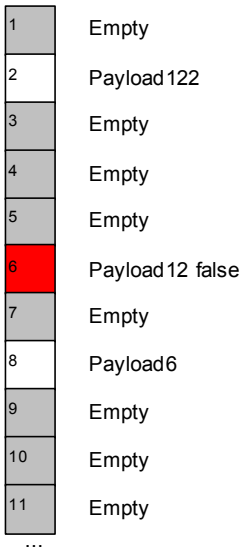
If you consider the following scenario describing the management of the `programInformation` description, a fragment unit is composed of:

- a command (`ReplaceContent, DeleteContent`)
- a path, which gives, element and type information (provides the type of the payload)
- a Position Code (gives the position of the element (child number) encoded in the payload)
- a payload (the encoded TVA fragment).

At time *t,*

Stream content (each fragment unit being carouseled)	Decoder memory
fragment unit: (`ReplaceContent`, a `ProgramInformation` / position 2, Payload122) fragment unit: (`ReplaceContent`, a `ProgramInformation` / position 6, Payload12) fragment unit: (`ReplaceContent`, a `ProgramInformation` / position 9, Payload56)	

At time *t'*

Stream content (each fragment unit being carouseled)	Decoder memory
fragment unit: (`ReplaceContent`, a `ProgramInformation` / position 2, Payload122) fragment unit: (`DeleteContent`, a `ProgramInformation` / position 6) fragment unit: (`ReplaceContent`, a `ProgramInformation` / position 8, Payload6)	

Therefore, a TVA decoder can notify an application that payload12 is not longer valid. If the application relies on payload12, it will be notified about the deletion. But if the TVA decoder has not received the first fragment unit, which sets the value of the payload 12 at position 6, the TVA decoder ignores this 'delete' fragment.

In addition payload 56 (position 9) is now obsolete and is no longer transmitted.

Therefore, a TVA metadata fragment stream generator manages the TVA metadata fragment stream in order to send these notifications to the decoder.

4.4.2.3 ContextMode

ISO Semantics: The `ContextMode` specifies the addressing mode for the context path.

Restriction: The `ContextMode` code is limited to the value '001' (Navigate in "Absolute addressing mode" from the selector node to the node specified by the `ContextPath`).

4.4.2.4 TV Anytime codec

4.4.2.4.1 Classification scheme wrapper

In the MPEG-7 framework, the use of a specific codec for a specific type is signalled using the codec configuration mechanism defined in ISO/IEC 15938-1. This mechanism associates a codec using its URI with a list of schema types. For that purpose, a URI is assigned to each codec in a `classificationScheme`, which defines the list of the specific codecs.

In this specification, this list is composed of 3 specific codecs: Zlib, `dateTime`, and `date`. The following figure gives the standard `classificationScheme` as used by the TVA MPEG-7 profile.

```
<ClassificationScheme uri=" urn:tva:metadata:cs:CodecTypeCS:2002">
  <Term termID="1">
    <Name xml:lang="en">ZlibCodec</Name>
    <Definition xml:lang="en">Encodes using Zlib</Definition>
  </Term>
  <Term termID="2">
    <Name xml:lang="en">tvadateTimeCodec</Name>
    <Definition xml:lang="en">Encodes date using Modified Julian Date
    & Time in Millisecond</Definition>
  </Term>
  <Term termID="3">
    <Name xml:lang="en">tvadateCodec</Name>
    <Definition xml:lang="en">Encodes date using Modified Julian
    Date</Definition>
  </Term>
</ClassificationScheme>
```

4.4.2.4.2 dateTime Codec

The XML Schema primitive simple type `dateTime` is used widely within the TVA metadata Schema, and so a specific codec has been designed for representing date time fields.

Times shall be based on GMT, with no provision provided for maintaining the local time offset information. Any requirement to localise time values shall be performed by the receiving terminal.

The following describes how the XML Schema primitive `dateTime` shall be encoded.

4.4.2.4.2.1 Encoding

The dateTime primitive is represented as an 8-byte unsigned integer number (Big-Endian), Days are represented using the first 4 bytes using Modified Julian Date. Time is represented using the last 4 bytes expressed as the number of elapsed milliseconds since 00:00:00 hours.

The origin for the Modified Julian Date shall be Midnight on 17th November 1858.

Example dates:

Date	**Modified Julian Date**
1st April 1980	44330
30th January 2000	51573
1st March 2001	51969

Example dateTimes:

dateTime value	**Encoded value**
1980-04-01T02:00:00Z	0x0000AD2A006DDD00
2000-01-30 T12:10:01Z	0x0000C975029C59A8
2001-03-01T00:00:00Z	0x0000CB0100000000

4.4.2.4.3 date Codec

The XML Schema primitive simple type date describes a date within the Gregorian calendar. The date takes the form of a string as defined by ISO 8601.

4.4.2.4.3.1 Encoding

The XML Schema date primitive shall be represented as a 4-byte unsigned integer (Big-Endian). It shall contain the number of days using the Modified Julian Date format, as described in section 4.4.2.4.2.1

4.4.2.4.4 Zlib optimized decoder

In the TVA MPEG-7 profile, the following *Zlib codec* is used by default for the encoding of strings instead of the UTF-8 representation. This Zlib codec is reinitialized for each TVA fragment.

4.4.2.4.4.1 Rationale

Classical lossless statistical compression algorithms (like Zip or GZip) are used in this specification to improve character strings compression. This specification uses the Zlib library [14].

In most cases, when strings are short (fewer than 100 characters), the performance of Zlib is poor. Indeed, this statistical compression algorithm requires a larger look ahead buffer to start eliminating redundancy. To achieve a good compression ratio, the proposed “Zlib optimised decoder” gathers different strings into one buffer before compressing it. The size of this buffer, noted *buffer_size,* allows the encoder to balance the compression ratio and the memory needed at the decoder. The codec has to manage an input buffer of strings as described in the following sections. The default value of the buffer size is set to 1000 bytes and can be overridden in the TVA-init Message (see 4.4.1).

4.4.2.4.4.2 Encoding

At the encoding phase, the buffer is fed with strings. When the buffer is full, it is compressed and the resulting compressed chunk of data is placed in the expected position of the first string compressed using this buffer. Figure 17 represents a BiM binary stream without the “Zlib optimised decoder”. Strings (in grey) are dispersed along the entire bitstream.

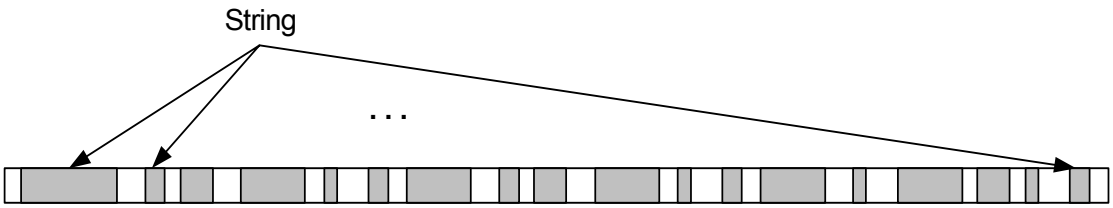


Figure 28 - BiM bitstream without Zlib optimized decoder

Figure 18 represents only the strings to be compressed and shows how they are gathered, and compressed together to create a more compact bitstream and where the resulting compressed chunks are dispersed. The location of the compressed chunk ensures that during the decoding process when a string is required either the Zlib codec gets a compressed chunk, decompress it and delivers the string from the decompressed buffer or if its decompressed buffer is not empty, it delivers the string from its decompressed buffer.

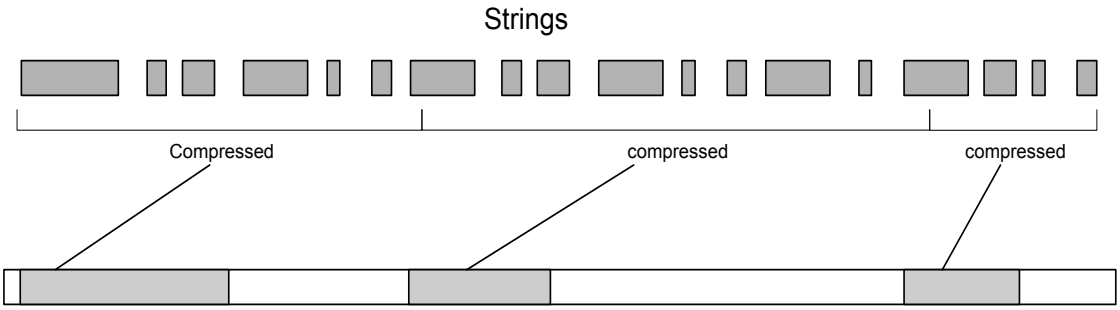


Figure 30 - BiM stream with Zlib optimized decoder

The decoding process is formally explained in section 4.4.2.4.4.3

4.4.2.4.4.3 Decoding

At the decoding level, the compressed chunk of strings is decompressed into a buffer (still limited by the *buffer_size used* at the encoder side). This buffer delivers the strings to the leaves (using the separator character). In the case where a value is encoded over two or more chunks, the value shall be the concatenation of all characters extracted from the buffers until the separator character.

4.4.2.4.4.4 Behavior

Syntax	**No. of Bits**	**Mnemonic**
ZlibDecoder() {		
ResultString=""		
TempChar = GiveNextCharInBuffer();		
While (TempChar != separatorChar) {		
ResultString = concat(ResultString, Tempchar)		
Tempchar = GiveNextCharInBuffer()		
}		
return ResultString		
}		

Syntax	**No. of Bits**	**Mnemonic**
GiveNextCharInBuffer() {		
If isEmpty (charsBuffer) {		
ZlibStringLength	**8+**	**vluimsbf8**
ZlibString	**8* ZlibStringLength**	**bslbf**
charsBuffer = ZlibDecompress(ZlibString)		
}		
return nextChar(charsBuffer)		
}		

4.4.2.4.4.5 Semantics

In order to obtain the next string, the decoder reads the `charsBuffer` until it gets a `separatorChar`. If the `charsBuffer` is totally consumed before reaching a `separatorChar`, the `charsBuffer` is refilled by decompressing the next chunk available in the bitstream.

ResultString: A local variable representing the string expected.

TempChar: A local variable representing the character read in the `charsBuffer`.

separatorChar: A constant representing the `separatorChar` as defined by the termination_value of the related character encoding format specified in TVA-Init .

ZlibStringLength: Indicates the size in bytes of the compressed ZlibString. A value of zero is forbidden.

ZlibString: A representation of a compressed sequence of characters. The compression algorithm used is Zlib [14].

ZlibDecompress(aString): This decompresses a string and returns the decompressed string.

NextChar(charsBuffer): This function returns the first character of the `charsBuffer` and removes it from the `charsBuffer`.

isEmpty (charsBuffer): This function returns true if the `charsBuffer` is empty, otherwise false.

Concat(aString, aCharacter): This function returns the concatenation of a `String` and a `Character`.

CharsBuffer: A buffer of characters. It contains a list of string separated by a `separatorChar`.

4.5 Carriage of TV-Anytime Data

TV-Anytime does not define the way in which the metadata should be carried within a specific delivery system. However TV-Anytime has defined a generic mechanism called a 'Container' for grouping a number of related data structures together for transmission.

The following sections describe the format of these containers, and additional requirements on the delivery layer, to enable the identification of containers, the type of data a container carries and the current version of a container.

4.5.1 Containers

A container forms the top-level storage unit in which all TVA data within a unidirectional environment is transmitted. A container contains one or more related structures, which can be used to convey both data fragments and indexing information.

4.5.1.1 Carriage of Containers

TV-Anytime does not define the way in which these containers should be carried, as this is specific to the delivery system. However consideration has been given, to enable the container to be easily mapped on to standard delivery methods. For example in an MPEG-2 environment, the containers may be conveyed using Sections, objects within a DSM-CC U-U Object Carousel or modules within a DSM-CC Data Carousel.

4.5.1.2 Classification of Containers

Containers are classified depending on what type of information they carry. The type of container shall be signalled with the delivery layer to enable a receiver to efficiently acquire containers carrying a specific type of data. This for example would enable a receiver to just acquire data containers, which it could use to populate a terminals local Database cache.

Containers are classified as follows:

- **Data Containers –** Containers carrying TVA metadata fragments and hold the following structures - encapsulation, `data_repository` (Binary data)

- **Index Containers –** Containers carrying Indexing information, and holding the following structures - `index_list`, `index`, `multi_field_sub_index`, `data_repository`, `fragment_locators` (optional).

It should be noted that it is possible for a single container to carry both types of data.

The use of data containers as specified in this specification for the carriage of TVA fragments is mandatory.

4.5.1.3 Container Identification

To be able to identify a container, a container must be given a unique identifier (container ID). This shall take the form of a 16 bit value, and shall be conveyed at the transport delivery layer. No provision is made to insert this identifier at the container level, since it should not be necessary to acquire the container to find out its container ID. The signalling of the container ID is out of scope for TVA, and shall be stipulated by other appropriate standards bodies e.g. DVB, ATSC and ARIB.

4.5.2 Container Versioning

Each container must have an associated version identifier. No provision is made within the container for this, as it should not be a requirement to load the container to see if the version has changed. Therefore version identification must be carried at the transport delivery layer. The definition of this version identifier is out of scope for TVA and shall be stipulated by other appropriate standards bodies e.g. DVB, ATSC and ARIB.

The container version is not used or referenced anywhere within a container or structure, and so may take any form appropriate for the delivery mechanism.

4.5.2.1 Container Syntax

Syntax	No. of Bits	Mnemonic
container () {		
container_header {		
num_structures	**8**	**uimsbf**
for (j=0; j<num_structures; j++) {		
structure_type	**8**	**uimsbf**
structure_id	**8**	**uimsbf**
structure_ptr	**24**	**uimsbf**
structure_length	**24**	**uimsbf**
}		
}		
for (j=0; j<byte_count; j++) {		
structure_body		
}		
}		

num_structures: An 8 bit field specifying the number of structures contained within this container. A value of 0x00 is invalid

structure_type: An 8 bit field identifying the type of structure being referenced, according to the following table.

Value	Description
0x00	Reserved
0x01	Encapsulation (Section 4.6.1.1)
0x02	Data Repository (Section 0)
0x03	Index List (Section 4.8.5.3)
0x04	Index (Section 4.8.5.4)
0x05	Multi Field Sub Index (Section 4.8.5.5)
0x06	Fragment Locators (Section 4.8.5.6)
0x07	moved_fragments (Section 4.6.1.2)
0x08 – 0xDF	TVA Reserved
0xE0 – 0xFF	User defined

Table 4 - structure_type assignments

structure_id: An 8 bit value which is used to distinguish between multiple occurrences of a specific `structure_type`. In some cases this is just an instance identifier (e.g. index & `multi_field_sub_index` structures) and in other cases it is used to distinguish the type of data carried within the structure (e.g. data repository)

structure_type	structure_id	Description
0x00	0x00 – 0xFF	Reserved
0x01	0x00 – 0xFF	Reserved
0x02	0x00	Data Repository of type strings, see Section 4.8.4.1
0x02	0x01	Data repository of type binary data, see Section 4.6.1.4.1
0x02	0x02 – 0xFF	Reserved
0x03	0x00 – 0xFF	Reserved
0x04	0x00 – 0xFF	Used to identify a specify instance of an index structure, within a container
0x05	0x00 – 0xFF	Used to identify a specific instance of a multi_field_sub_index structure within a container
0x06 – 0xFF	0x00 – 0xFF	Reserved

Table 5: structure_type and their matching valid structure_id

structure_ptr: A 24 bit field giving the offset in bytes from the start of this container to the first byte of the identified structure.

structure_length: A 24 bit field which indicates the length in bytes of the structure pointed to by `structure_ptr`.

Entries within the `container_header` shall be ordered in ascending `structure_type` and `structure_id`. For example all structures of type `data_repository` shall be grouped together and items within the group ordered in ascending structure_ id. This enables a device to efficiently locate a particular structure of interest.

structure_body: Data forming one or more structures within this container.

4.5.2.2 Container Map

As has been mentioned above, containers do not include information such as, container Id, version or container category. This information must be carried at the delivery layer, informing a device when containers have changed and what the appropriate download parameters are. This higher-level messaging is termed a container map.

The concept of a container map can be found in a number of Broadcast delivery mechanisms, for instance the DSM-CC Data Carousel DII. In these instances the standard mechanisms should be used, provided they support the following set of requirements.

4.5.2.2.1 Container Map Requirements

A specific container map implementation shall meet the following requirements:

- Signal the Id of each container – Containers are identified using their `container_id`. This shall be a unique number within the scope of a TVA metadata fragment stream. It is required that the id of a container is signalled at the Container map level, to enable the acquisition of a container with a given `container_id`.
- Identify the version of each container – The current version of each container shall be signalled, and this shall increment whenever the contents of a container change. It shall be possible to monitor at a single point for version changes to a container. Ideally it should be possible to monitor just data containers, or just containers forming a single index.
- Identify the type of container i.e. Index Container, Data Container. – This defines the type of data carried with a container, and can be used by a receiving device to filter for example containers carrying TVA fragments.
- The ability to download all document containers (preferably in a parallel manner)
- Enable the ability to carry multiple TVA metadata fragment streams on the same delivery channel

4.6 Fragment Encapsulation

As described above a TVA-Anytime metadata description is split into a number of fragments, where a fragment forms a self-consistent unit of data. To enable a receiver to efficiently identify a change to a TVA fragment an encapsulation format has been defined. This provides TVA fragment Version information, and an identifier specific to a TVA fragment. This enables a receiver to quickly identify fragments that have changed in relation to that cached on the receiving terminal.

4.6.1 Encapsulation format

The encapsulation data is provided by the encapsulation structure defined below. This structure is then transmitted along with the fragments using a ‘container’ as described in section 4.5.1.

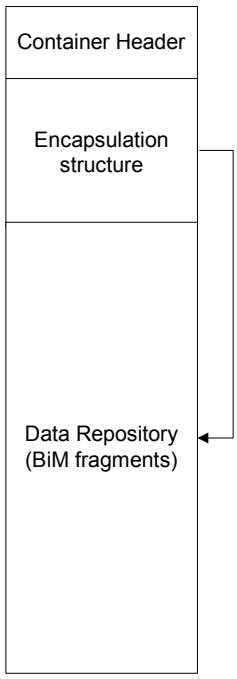


Figure 32 - Schematic representation of interrelationship between structures within a container

4.6.1.1 Encapsulation Structure

The Encapsulation structure provides the encapsulation mechanism for a set of TVA fragments, by providing the ability to assign a unique identifier (`fragment_id`) for the lifetime of a TVA fragment and indicating the current version of a TVA fragment.

Each entry references a single TVA fragment carried within a `binary_data_repository` structure carried within the same container.

There shall only ever be one encapsulation structure within a single container.

Syntax	**No. of Bits**	**Mnemonic**
encapsulation_structure () {		
encapsulation_header {		
reserved_other_use	**2**	**bslbf**
reserved	**6**	**bslbf**
fragment_reference_format	**8**	**uimsbf**
}		
for(j=0; j<fragment_count; j++) {		
encapsulation_entry {		
fragment_reference()		
fragment_version	**8**	**uimsbf**
fragment_id	**24**	**uimsbf**
}		
}		
}		

reserved_other_use: This field shall be set to '11' .

fragment_reference_format: This 8 bit value defines the format and interpretation of the `fragment_reference` field.

Value	Meaning
0x00	Reference to a BiM encoded fragment (Section 4.6.1.3.1)
0x01 – 0xE0	TVA Reserved
0xE1- 0xFF	User defined

Table 6 - Valid fragment_reference_formats

fragment_reference: A reference to a fragment, the interpretation of this field is dependant on `the fragment_reference_format`. Please refer to Table 6 to determine how this field should be interpreted.

fragment_version: An 8 bit value which identifies the version of the fragment referenced by this entry. When the data for the fragment identified by the `fragment_id` changes, the fragment_version shall increment modulo 255.

fragment_id: A 24 bit value which uniquely identifies a metadata fragment within the TVA metadata fragment stream. The value assigned to a fragment shall be persistent for the life of that fragment so long as it is transmitted in the TVA metadata fragment stream. All entries within the `encapsulation_structure` shall be ordered by ascending `fragment_id`. This enables the efficient location of a fragment by using a binary search algorithm.

4.6.1.2 Moved Fragments Structure

The `moved_fragments` structure is used to signal when a fragment has moved from one container to another. This is achieved by making an entry within the moved fragments structure carried within the fragments last container.

There shall be a maximum of one `moved_fragment` structure within a single container.

Syntax	No. of Bits	Mnemonic
moved_fragments () {		
fragment_id	**24**	**uimsbf**
new_container_id	**16**	**uimsbf**
}		

fragment_id: The id of the fragment which has moved containers. All entries within the `moved_fragment_structure` shall be ordered by ascending `fragment_id`.

new_container_id: The id of the container, where the fragment has moved to.

4.6.1.3 Fragment_Reference formats

There are a number of defined fragment locator formats to enable the referencing of fragments from within an encapsulation structure.

4.6.1.3.1 Referencing a BiM encoded fragment

Syntax	No. of Bits	Mnemonic
BiM_fragment_reference () {		
BiM_fragment_ptr	**16**	**uimsbf**
}		

BiM_fragment_ptr: Offset in bytes from the start of the Binary repository within the container where the first byte of the `FragmentUpdateUnit()` for the BiM encoded fragment can be found.

4.6.1.4 Data Repository

The Data Repository forms the base structure, used to hold string data and binary data. All references to the data repository are local i.e. from within the container. The type of data, which the data repository carries, is indicated by the structures associated `structure_id` in the `container_header`.

There may be more than one Data Repository within a container. However there shall only ever be a maximum of one data repository of a given type.

Syntax	No. of Bits	Mnemonic
data_repository () {		
if (structure_id == 0x00) {		
string_repository()		
}		
else if (structure_id == 0x01) {		
binary_repository()		
}		
else {		
user_defined_data_structure()		
}		
}		

structure_id: An 8 bit value used to specify the type of data carried within this data repository. The `structure_id` is not defined within this structure, but forms part of the structure instantiation in the container header (section 4.5.2.1).

4.6.1.4.1 Binary data repository

The encoding of data in the binary repository is defined at the point of reference. Each item of data must either have a length explicitly encoded within it, or a length implicitly understood by the decoder (i.e. fixed length). No provision is made to define the data length within the binary data repository structure.

All entries shall be byte aligned.

There shall only ever be one binary data repository within a single container.

Syntax	No. of Bits	Mnemonic
binary_repository() {		
for (i=0; i<value_count; i++) {		
for (j=0; j< length; j++) {		
value_byte	**8**	**bslbf**
}		
}		
}		

value_byte: A byte of binary value data

4.6.1.4.1.1 Carriage of BiM encoded fragments

Where the `binary_data_repository` contains BiM encoded data, a single binary data repository shall hold a single complete BiM Access Unit.

Syntax	No. of Bits	Mnemonic
binary_repository() {		
BiMAccessUnit {		
NumberOfFUU	**8+**	**vluimsbf8**
for(i=0; i< NumberOfFUU; i++) {		
FragmentUpdateUnit()		
}		
}		
}		

Table 7 - Binary Repository carrying a BiM Access Unit

4.6.1.5 Alternative Encoding formats

Where BiM is not used for the encoding of fragments, the encoding solution :

- Shall provide a mechanism for indicating the type of TVA fragment.
- Optionally provide a mechanism for indicating the action to be performed e.g. Update fragment, Delete fragment etc.

4.7 Fragment Management

In the previous section a number of structures have been specified to enable the encapsulation of TVA fragments, within a TVA metadata fragment stream. These TVA fragments are dynamic, and may change during their lifetime. In addition new TVA fragments will be added and old TVA fragments removed. The following describes how the defined encapsulation structures shall be used to enable the addition, deletion and updating of TVA fragments.

4.7.1 Fragment Id

The `fragment_id` is a 24 bit value which uniquely identifies a TVA fragment within a single TVA metadata fragment stream. This can be used by an application to track a TVA fragment during its lifetime within a TVA metadata fragment stream. It is valid to re-use a `fragment_id` value, provided that sufficient time has elapsed since the `fragment_id` value was last used.

4.7.2 Fragment Add

The addition of a new TVA fragment is straightforwardly achieved by creating an entry within the encapsulation structure having a unique `fragment_id` and an appropriate

`fragment_version` and inserting the fragment into the binary data repository. The addition of a new entry into an existing container will cause the container's version number to increment.

4.7.3 Fragment Update

An update to a previously transmitted TVA fragment will cause the TVA fragment within the binary data repository to be updated. In addition the version number of the TVA fragment shall be incremented. These changes will cause the version number of the container in which the fragment is carried to increment.

4.7.4 Fragment Move

In some situations it may be required to move fragments between containers in which they are transmitted. It is recommended for efficiency and ease of management of fragments that this is kept to a minimum. However when required to move fragments between containers, the following should occur: The fragment is inserted into the new container, along with its original `fragment_id` and current `fragment_version`. An entry is inserted into the `moved_fragments` structure of the fragments previous container to indicate in which container the fragment can now be found. These operations will cause both the previous and the current container to have their version number incremented.

4.7.5 Fragment Delete

The deletion of a fragment can mean one of two things:

- The originally transmitted fragment is valid, but has been removed from the metadata fragment stream, as the content it describes is no longer available. For example the transmission time has passed.
- The originally transmitted fragment was invalid, and so should not be used and discarded.

Both of these scenarios are supported as follows: when a fragment disappears from the metadata fragment stream it shall be treated as if the fragment has been deleted. Care should be taken when determining if a fragment is no longer in the TVA metadata fragment stream. If a fragment's `fragment_id` is not found in the expected containers encapsulation structure, the `moved_fragments` structure should be searched for an entry indicating that the fragment has moved containers. However if the metadata fragment stream is not constantly monitored for changes this mechanism should not be relied upon, as a fragment may have moved containers, but the corresponding fragment moved entry is no longer transmitted. The deletion of a fragment will cause the corresponding containers version number to be incremented.

In addition to the above methods, if BiM is used for fragment encoding and the `PositionCodeFlag` within the `TVAInit` is set to '1', the BiM `FragmentUpdateCommand`, which forms part of the `FragmentUpdateUnit` shall be used to signal the deletion of a fragment. In this case when a fragment is deleted the referenced BiM fragment will consist of a `FragmentUpdateUnit` with a `DeleteContent` command and no `FragmentUpdatePayload`. The change of fragment will cause the `fragment_version` within the encapsulation structure to be incremented.

This BiM Delete fragment command (section 4.4.2.2.1.3) if used shall be transmitted for a limited period of time, after which it should be removed. Receiver implementers should be aware that this mechanism should not be relied upon, as the receiver may be switched off or tuned away from the TVA metadata fragment stream, during the transmission of the Delete Command.

4.8 Indexing

4.8.1 Introduction

Data originally encapsulated in an XML document is not always best accessed as if it were an XML document when in the broadcast environment. In this environment, navigation of the document tree is relatively slow even when the location of the data in the tree is known. If the location is not known then the receiver must search through a set of data looking for a node with a particular value. In most cases this will be too slow to be practical. Indexing seeks to avoid these problems by avoiding the need to navigate the document tree. Indices provide direct access to a document TVA fragment by listing the values of a particular node (the index's key fields) and describing where the matching fragment(s) can be found in the carousel. Multiple indices can point to the same fragment, each using a different node as a key field.

4.8.2 Requirements

The indexing system shall be designed for metadata available in a unidirectional environment and whose TVA metadata fragments are carouseled.

The indexing system shall be compatible with any specific carousel format used to carry the TVA fragments.

The indexing system shall be designed in such a way that the data it uses may be broadcast cyclically but without being tied to a particular carousel mechanism.

The indexing system should be considered as a way to improve the navigability within the data set formed by the TVA fragments constituting a specific TVA metadata description, however this new system shall:

- be defined and used in addition and with regard to the existing solutions already standardised by TV-Anytime
- be optional in the sense that for some metadata description or some application such an improved navigability may not be necessary or helpful.

The indexing system shall allow the indexing data to be used « on-line » when searching for a specific TVA fragment, namely without needing to be necessarily cached or completely acquired.

The indexing mechanism shall be defined as a way to retrieve using a certain index key a specific TVA fragment among all the TVA fragments constituting a metadata description and carouseled over a unidirectional stream.

- the nature of the key index may differ from one type of TVA fragment to another.
- For each of these possible standard index data type, TV-Anytime will specify what the encoded format and the sorting order are.
- The value of the key used to index a TVA fragment shall always be available directly or via an indirection in this TVA fragment.

The indexing mechanism should be extensible to support the possible definition of private new indexes through the use of hooks.

4.8.3 Carriage of Indexing Information

Indexing data is carried using the generic Container format specified in section 4.4.2. This section makes use of some structures already define in section 4.6 on Fragment Encapsulation.

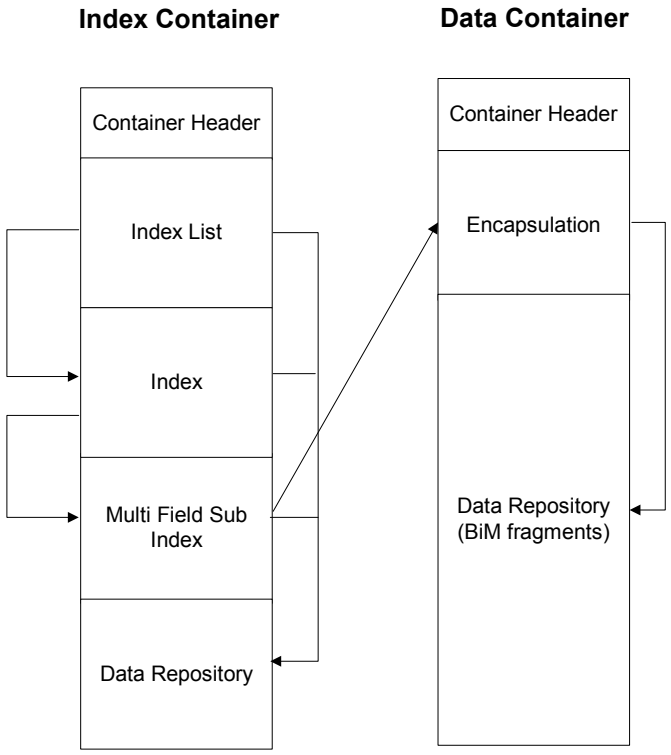


Figure 34 - Schematic representation of interrelationship between Index containers and Data containers

4.8.4 Data repository

The data repository within the context of an Index is used to carry data used in the representing of an index e.g. key field values. The syntax of a data repository is defined in section 4.6.1.4 along with how binary data is carried within a data repository. In addition to binary data the data repository is used to carry Strings, as described below.

4.8.4.1 String repository

The string repository is used to hold all strings used by structures within the same container.

There shall only ever be one string repository per container. References to this repository are always local (that is, from the same container). Support is provided for identifying the string encoding system, to enable the use of non ASCII based character sets. The use of length fields or termination values are dependent on the string encoding used.

Syntax	No. of Bits	Mnemonic
string_repository() {		
encoding_type	**8**	**uimsbf**
for (i=0; i<strings_count; i++) {		
for (j=0; j<string(i).length; j++) {		
string_character	**variable**	
}		
string_terminator	**variable**	**bslbf**
}		
}		

encoding_type: An 8 bit field used to define the character encoding system, according to Table 2.

string_character: A character of the encoded string. The number of bytes required to represent the character will be dependent on the string encoding system used.

string_terminator: One or more bytes which indicate the end of a string. The actual value will be dependent on the string encoding system used.

4.8.5 Index structures

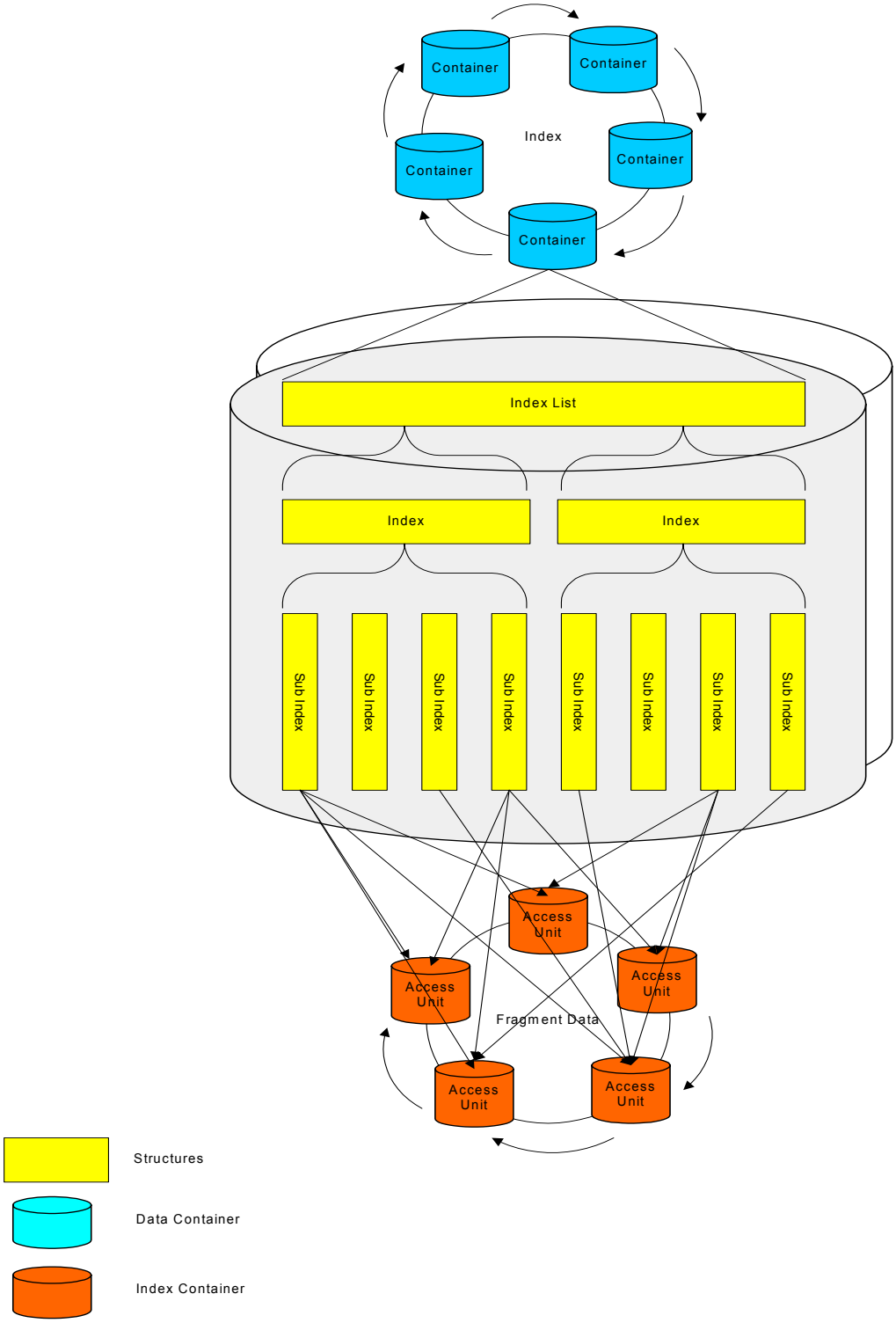


Figure 35 - Indexing Structure

4.8.5.1 Identification of Indices

Indexes are keyed on schema simple types such as dateTime, CRID. Multiple indices can reference a single TVA fragment. It is important to be able to describe what an index is keyed on.

There are two important facts that the receiver needs to know about an index:

- The first fact is where in the schema hierarchy are the document fragments that it is referencing? It is important to know this because this describes the type and context of the fragment.
- The second fact is to know "by which key fields are these fragments indexed?" The key fields are typically child members (e.g. an attribute or an element) of the fragment type being indexed.

The specification provides two mechanisms:

- Id based identification
- XPath expressions

4.8.5.1.1 Use of Ids

Ids can be used to identify both the type of TVA fragment, and the element/attribute within the fragment, which the index is keyed on. The set of normative TVA fragments have been mapped to aid interoperability, and a mechanism provided to enable metadata providers to define additional Ids to enable the support of enhanced metadata services.

4.8.5.1.2 Use of XPath

W3C has defined a standard specifically for the referencing of elements and attributes within an XML document, which is called XPath. XPath is a syntax, which can describe a path to one or more nodes in a document.

The fragment XPath is an *absolute* path (i.e. it is relative to the root of the document), whilst the key XPath is relative to the fragment XPath. In other words, the context node of the key XPath is the node referred to by the fragment XPath. Combined together they describe the absolute path to the node that forms a key field. The XPath syntax can describe the location of any type of node including elements, attributes and text nodes, enabling any of these to be a key field.

The XPath syntax is rich, and many parts are not necessary to describe an index. Therefore a restricted set of syntax, which a TVA compliant box should support has been specified:

- Absolute Location Paths only (`key_xpath` is relative, but the combined path is absolute)
- Axes types ‘attribute’ and ‘child’ only are supported
- Abbreviated Syntax only. The preceding restrictions mean that only the following two abbreviations are permitted:
  - “child::” is always omitted
  - “@” is always used to represent “attribute::”
- ‘*’ is not allowed.
- Only the following two Node tests are allowed:
  - NameTest (in which ‘*’ is not allowed)
  - text().
- Predicates, and Functions are not allowed
- The union operator “ | ”, is not allowed

All XPath expressions will be evaluated within the following context:

- The context node is the root of an XML document containing a `TVAMain` element.
- The context position and context size are both 1.
- There are no variable bindings.
- There is no function library.

In addition all elements/attributes shall be namespace qualified.

4.8.5.1.2.1 Example: Indexing by CRID and title

Considering a broadcast carousel that delivers fragments of type `ProgramInformation` the fragment XPath (in short form) would be:

```
/tva:TVAMain/tva:ProgramDescription/tva:ProgramInformationTable/tva:
ProgramInformation
```

The most likely key to use for searching this set of data is the CRID. The `field_xpath` is relative to the fragment XPath i.e.:

```
@tva:programId
```

A broadcaster may wish to index by title, as well as by CRID, to enable the receiver to search by title. The fragment XPath is:

```
/tva:TVAMain/tva:ProgramDescription/tva:ProgramInformationTable/tva:
ProgramInformation
```

and the field_xpath is:

```
tva:BasicDescription/tva:Title.text()
```

4.8.5.2 Introduction to the multi-key index

Some applications in the receiver may request matching fragments for more than one query condition. In this case, using multiple key fields is quite efficient to answer such requests. The multi-key consists of more than one key fields.

Multi-key values are ranked in order as follows. For a multi-key of n key fields ($k_1, k_2, ..., k_n$), priority of each key field is ordered according to its position from left to right, i.e., k_1 has the highest priority and k_n has the lowest priority, etc. For two multi-key values, ($a_1, a_2, ..., a_n$) and ($b_1, b_2, ..., b_n$),

- ($a_1, a_2, ..., a_n$) is larger than ($b_1, b_2, ..., b_n$) if and only if there exists an integer i ($0 \le i \le n-1$) such that for every j($0 \le j \le i-1$), $a_j = b_j$ and $a_i > b_i$.
- ($a_1, a_2, ..., a_n$) is smaller than ($b_1, b_2, ..., b_n$) if and only if there exists an integer i ($0 \le i \le n-1$) such that for every j($0 \le j \le i-1$), $a_j = b_j$ and $a_i < b_i$.
- ($a_1, a_2, ..., a_n$) is equal to ($b_1, b_2, ..., b_n$) if and only if for every i($1 \le i \le n$), $a_i = b_i$.

A typical query example that can be efficiently handled by the multi-key index is as follows:

- Search target fragment:

`/TVAMain/ProgramDescription/ProgramLocationTable/BroadcastEvent`

- Search condition:

100 **<=** ServiceId <= 110

9:00 PM <= `PublishedStartTime.text()` <= 10:00 PM

In this case, the '`BroadcastEvent`' fragments can be indexed by a multi-key index with key fields `ServiceId` and `PublishedStartTime`.

4.8.5.3 Index List

The index list structure provides a list of all indices that exist for the entire TVA metadata fragment stream. A receiver uses this structure to locate an index of interest, where an index is described using the structures `fragment_type`, and `field_identifier` fields.

It should be noted that entries within the structure are not of fixed size. The Index list must be searched sequentially. The `index_descriptor_length` field is provided to enable a receiver to efficiently skip over index entries, which it is unable to parse due to unknown `fragment_types`, `field_identifiers`, or `field_encoding`.

There shall be a maximum of one index list structure per TVA metadata fragment stream.

Syntax	No. of Bits	Mnemonic
index_list() {		
for (j=0; j<num_indexes, j++) { …		
index_descriptor_length	**8**	**uimsbf**
fragment_type	**16**	**uimsbf**
if(fragment_type == 0xffff) {		
fragment_xpath_ptr	**16**	**uimsbf**
}		
num_fields	**8**	**uimsbf**
for(k=0; k<num_fields; k++) { …		
field_identifier	**16**	**uimsbf**
if(field_identifier == 0xffff) {		
field_xpath_ptr	**16**	**uimsbf**
}		
field_encoding	**16**	**uimsbf**
}		
Index_container	**16**	**UIMSB**
index_identifier	**8**	**uimsbf**
}		
}		

index_descriptor_length: An 8 bit field which defines the number of bytes proceeding this field which are used to describe the index.

fragment_type: An id used to identify the type of TVA fragments which the index makes references to. In addition to the identifiers defined in the table below, their may be a set of unique identifier allocated on a per application basis.

Table 8 shows the set of allocated `fragment_type` values. The XPath expressions are namespace qualified and use the following namespace prefixes:

tva	http://www.tv-anytime.org/2002/metadata
mpeg7	urn:mpeg:mpeg7:schema:2001

Value	Description
0x0000	reserved
0x0001	ProgramInformation fragment (/tva:TVAMain/ tva:ProgramDescription/ tva:ProgramInformationTable/ tva:ProgramInformation)
0x0002	GroupInformation fragment (/tva:TVAMain/ tva:ProgramDescription/ tva:GroupInformationTable/ tva:GroupInformation)
0x0003	OnDemandProgram fragment (/tva:TVAMain/tva:ProgramDescription/tva:ProgramLocationTable/tva:OnDemandProgram)
0x0004	BroadcastEvent fragment (/tva:TVAMain/tva:ProgramDescription/ tva:ProgramLocationTable/ tva:BroadcastEvent)
0x0005	Schedule fragment (/tva:TVAMain/ tva:ProgramDescription/

	tva:ProgramLocationTable/ tva:Schedule)
0x0006	ServiceInformation fragment (/tva:TVAMain/ tva:ProgramDescription/ tva:ServiceInformationTable/ tva:ServiceInformation)
0x0007	PersonName fragment (/tva:TVAMain/ tva:ProgramDescription/ tva:CreditInformationTable/ tva:PersonName)
0x0008	OrganisationName fragment (/tva:TVAMain/tva:ProgramDescription/tva:CreditInformationTable/tva:OrganisationName)
0x0009	ProgramReviews fragment (/tva:TVAMain/ tva:ProgramDescription/ tva:ProgramReviewTable/ tva:Review)
0x000A	CSAlias fragment (/tva:TVAMain/ tva:ClassificationSchemeTable/tva:CSAlias)
0x000B	ClassificationScheme fragment (/tva:TVAMain/tva:ClassificationSchemeTable/tva:ClassificationScheme)
0x000C	Segment Information fragment (/tva:TVAMain/ tva:ProgramDescription/ tva:SegmentationTable/ tva:SegmentList/ tva:SegmentInformation)
0x000D	Segment Group Information fragment (/tva:TVAMain/ tva:ProgramDescription/ tva:SegmentationTable/ tva:SegmentGroupList/ tva:SegmentGroupInformation)
0x000E – 0x00EF	TVA Reserved
0x00F0 – 0xFE00	User defined
0xFFFF	W3C XPath Expression

Table 8 - fragment_type assignments

fragment_xpath_ptr: If the `fragment_type` is set to '0xffff' this provides a reference to the start of an XPath string. This reference is in the form of an offset, in bytes, from the start of the string repository in the current container. The value of this string is the XPath (in abbreviated XPath notation) to the root node of a TVA fragment.

num_fields: The number of fields which this index is based upon. The fields shall be defined in their order of importance, where the first entry is the Primary field.

field_identifier: An id used to identify the field on which the index is ordered. The specification allows the allocation of unique identifiers on a per application basis.

Value	**Description**
0x0000	reserved
0x0001 - 0xFEFF	User defined
0xFFFF	Indicates use of a W3C XPath style expression

Table 9 - field_identifier Assignments

field_xpath_ptr: Reference to the start of the fields XPath string (in abbreviated XPath notation) within the string repository belonging to the current container. This reference is in the form of an offset, in bytes, from the start of the string repository in the current container. The value of this string is an XPath expression that is relative to the `fragment_types` XPath, which identified the node that is used as one of the indexes key fields.

field_encoding: Defines the encoding used to represent a key field value. This encoding determines how the '`field_value`' within the `multi_field_sub_index`, the `low_field_value` and `high_field_value` within the index, shall be interpreted.

The `field_encoding` value has two purposes:

- It determines whether the content of the `field_value` within the `multi_field_sub_index` structure, the `low_field_value` and the `high_field_value` within the index structure, are inline or are found within a data repository structure [Table 4]

- It defines the encoding of the data held in the field-value within the `multi_field_sub_index` structure, the `low_field_value` and the `high_field_value` within the index structure [Table 10]

Encoding value	value field interpretation
0x0000 – 0x00FF	Field is an offset in bytes from the start of the string data repository structure.
0x0100 – 0x01FF	Field contains an inline 2-byte value
0x0200 – 0x04FF	Field is an offset in bytes from the start of the binary_data_repository structure
0x0500-0xFFFF	Reserved for future use

Table 10 - Encoding and interpretation of the field_value, low_field_value and high_field_value field

field_encoding	Description	Encoding	Size in bytes
0x0000	string type	Null-terminated string	variable
0x0001 - 0x00FF	Reserved for custom string types		
0x0100	signed short	twos complement – Big-Endian	2
0x0101	unsigned short	unsigned binary – Big-Endian	2
0x0102-0x01FF	Reserved for custom 2-byte types		
0x0200	signed long	twos complement – Big-Endian	4
0x0201	unsigned long	unsigned binary – Big-Endian	4
0x0202	variable length signed integer	one bit to indicate sign (0: positive, 1: negative), followed by abs(value) using vluimsbf5.	1+
0x0203	variable length unsigned integer	vluimsbf8	1+
0x0204-0x02FF	Reserved for custom integer types		
0x0300	signed float	IEEE standard 754-1985 [10] Big-Endian	4
0x0301	unsigned float	IEEE standard 754-1985 [10] Big-Endian	4
0x0302	signed double	IEEE standard 754-1985 [10] Big-Endian	8
0x0303	unsigned double	IEEE standard 754-1985 [10] Big-Endian	8
0x0304-0x03FF	Reserved for custom rational types		
0x0400	dateTime	Modified Julian Date and Milliseconds (TVA BiM codec Section 4.4.2.4.2)	8
0x0401	date	Modified Julian Date (TVA BiM codec Section 4.4.2.4.3)	4
0x0402-0x04FF	Reserved for custom binary fragments		
0x0500-0xFFFF	Reserved for future use		

Table 11 - encoding types and their respective sizes

index_container: The id of the container carrying the described index.

index_identifier: This field identifies the relevant index structure within the identified container. To locate the correct index within the container (with `id = index_container`) the `container_header` is searched for a structure of type 'index' and with a `structure_id = index_identifier`.

4.8.5.4 Index

The index structure is the top level of an index. It provides a list of all sub-indices and the ranges of field values that those sub-indices carry. When considering a classic indexing system it is normal for there not to be any overlaps in the range of field values to be found within a given set of sub indexes. This is to minimise the amount of searching required to find a particular value.

Having overlapping sub-indices can lead to sequential searching of sub index structures, introducing an associated decrease in performance. However in some circumstances it may be desirable to allow this. For example where the indexed data is carried within the same container as the index, and you wish to carousel the data out at different rates, and the set of data to be carouseled would not typically form a single sub index without overlaps.

In the case of overlapping sub indexes they shall be declared within the index structure in descending order of search priority. Where the first declared sub index, which may contain the set of required field values has the highest priority.

4.8.5.4.1 Field Value Ordering

The ordering of index entries within an index is dependent on a field's primitive XML schema simple type. In the case of strings the order may be dependent on the selected language, and not necessarily in alphanumeric order.

Simple Type	Ordering
string	All string shall be ordered in increasing Lexicographical order. Lexicographical ordering is language dependent, and may not be alphanumeric.
anyURI	Increasing alphanumeric order.
boolean	'False' precedes 'True'
NMTOKEN	Increasing binary representation order
gYear	Increasing numeric value
integer	Increasing numeric value with negative values first
date	Increasing date value
nonNegativeInteger	Increasing numeric (binary) value
positiveInteger	Increasing numeric (binary) value
dateTime	Increasing dateTime (binary) value
duration	Increasing duration (binary)
float	Increasing numeric value (negative values first)
double	Increasing numeric value (negative values first)

Table 12 - Defined index order for primitive simple types

Syntax	No. of Bits	Mnemonic
index() {		
overlapping_subindexes	**1**	**bslbf**
single_layer_sub_index	**1**	**bslbf**
reserved	**6**	**bslbf**
fragment_locator_format	**8**	**uimsbf**
for (j=0; j<num_sub_indexes, j++) { …		
for(k=0; k<num_fields; k++) { …		
if (overlapping_subindices == '1') {		

low_field_value	**16**	**uimsbf**
}		
high_field_value	**16**	**uimsb**
}		
sub_index_container	**16**	**uimsb**
sub_index_identifier	**8**	**uimsb**
}		
}		

Given high_field_values, (a_1, a_2, ..., a_n) and (b_1, b_2, ..., b_n), of two arbitrary sub-indexes among the sub-indices list, The sorting of sub-indices is determined as follows:

(a_1, a_2, ..., a_n) is larger than (b_1, b_2, ..., b_n) if and only if there exists an integer i ($0 \le i \le n-1$) such that for every j($0 \le j \le i-1$), $a_j = b_j$ and $a_i > b_i$.
(a_1, a_2, ..., a_n) is smaller than (b_1, b_2, ..., b_n) if and only if there exists an integer i ($0 \le i \le n-1$) such that for every j($0 \le j \le i-1$), $a_j = b_j$ and $a_i < b_i$.
(a_1, a_2, ..., a_n) is equal to (b_1, b_2, ..., b_n) if and only if for every i($1 \le i \le n$), $a_i = b_i$.
Specifically, within the index() structure, if there is no overlapping between subindices, for all j between 0 and num_sub_indexes-1 (high_field_value[j,0], …, high_field_value[j,k]) is smaller than (high_field_value[j+1,0], …, high_field_value[j+1,k])
"j" is the sub_index
"k" is the field

This function high_field_value[j,k] takes its value according to the loop defined in the index() table.

overlapping_subindexes: When set to '1', indicates that one or more of the sub indices which form this index, overlap with respect to the range of values found within the sub index. Where sub indices overlap, the sub indices are declared in descending order of search priority. When set to '0', indicates that the sub indices do not overlap, and the declared sub indices are ordered in ascending order.

single_layer_sub_index: This field is used to indicate the syntax used within the corresponding `multi_field_sub_index` structures to represent indexes with multiple key fields. When set to '1' it indicates that all fields for a given index entry are declared together in a single `multi_field_sub_index` structure. When set to '0' it indicates that each key field is contained within a separate `multi_field_sub_index` structure.

fragment_locator_format: Identifies the format and interpretation of the fragment locator field used within the `multi_field_sub_index` (leaf field) to reference a TVA fragment.

Value	Meaning
0x00	local_fragment_locator (Section 4.8.5.7.2)
0x01	remote_fragment_locator (Section 4.8.5.7.1)
0x02 – 0xE0	TVA Reserved
0xE1 – 0xFF	User defined

Table 13 - Fragment reference types

low_field_value: The lowest field value that can be found within the sub-index. The meaning of this field depends on the value of the `field_encoding` member of the index list structure. The lowest value of the field expressed may not be the lowest field value actually present in the given fragment, it merely indicates that the referenced sub index structure may contain entries with fields values in the given range. The type of encoding used and the interpretation

of the low_field_value are defined by the field_encoding within the index_list structure.

high_field_value: The highest field value that can be found within the sub-index. The meaning of this field depends on the value of the field_encoding member of the relevant index list structure (see section 4.8.5.3). The highest value of the field expressed may not be the highest field value actually present in the given fragment, it merely indicates that the referenced sub index structure may contain entries for key field values in the given range. The type of encoding used and the interpretation of the high_field_value are defined by field_encoding within the index_list structure.

It should be noted that the high_field_value for all but the first field may be lower than the previous high_field_value sub index entry. This is caused when there is a change in the value of the parent field.

For example if we have an index keyed on channel & event time fields, we could have a set of sub indexes with the following ranges:

Sub index 1 – channel high_field_value = '3', event time high_field_value = '12:00'

Sub index 2 – channel high_field_value = '4' event time high_field_value = '09:00'

Where the index uses multiple fields, the declaration order of the high_field_values shall match that defined for the index within the index_list structure.

When defining the range of values that a particular sub index shall cover, sufficient space should be left to enable the addition of further index entries without unduly impacting other sub indices. For example if a sub-index can hold a maximum of say 64K entries, it is recommended that the range of current entries should equal around half to two thirds the space. This leaves sufficient room for additional entries without having to changing the way in which the index is split into sub index structures.

sub_index_container: The id of the container carrying the described multi_field_sub_index.

sub_index_identifier: This field identifies the multi_field_sub_index structure instance containing the described sub index. To locate the sub index within the container (with id = sub_index_container) the container_header is searched, for a structure of type 'multi_field_sub_index' with a structure_ id equal to the sub_index_identifier.

4.8.5.5 Multi_field_sub_index

A multi field sub index provides references to TVA fragments, which contain field values within the range specified for this sub index. The structure supports indexes with both single and multiple key fields. In the case of indices with multiple key fields, the syntax provides two methods:

- Single Layer - All key fields defined together within a single multi_field_sub_index.
- Multi Layer - Each multi_field_sub_index defines a single field of a key.

4.8.5.5.1 Single Layer Structures

Single Layer Structures provide a simple mechanism for describing multiple key field indices. As each entry in the structure can be decoded one by one in a straightforward manner, this structure would be preferred in a situation where the received index data need to be reorganised in the PDR before its use. Note that the index data can be restructured inside the PDR according to its own storage method and query processing policy. For example, a PDR may want to reorganise one of the received indices in its own B-tree index.

In addition, the Single Layer Structure provides an efficient mechanism for representing multiple key field indexes, where there is typically a one to one mapping e.g. <surname, givenname>.

4.8.5.5.2 Multi Layer Structures

Multi Layer Structures provide an efficient mechanism for describing multiple field indices with common key field values. This is achieved with the use of multiple `multi_field_sub_index` structures (Figure 22), where each structure is used to describe one layer of a multi field sub index, (layer is equal to a key field of a multi field index).

Each index entry, within the `multi_field_sub_index`, points to further `multi_field_sub_index` structures (except for the leaf field), which contain index entries having the declared field value.

The `multi_field_sub_index` structure is formed of two parts:

- `multi_field_header`.
- `multi_field_index_entries`.

The `multi_field_header` defines how the `multi_field_index_entries` sub structure should be interpreted, and indirectly defines the size of each index entry.

All entries within the `multi_field_index_entries` sub structure are ordered in ascending order.

All entries are of a fixed size, which enables the sub structure to be efficiently searched using a binary search algorithm.

The number of entries within the structure is not explicitly defined, but can be inferred as follows:

```
num_entries = (structure_length  -
sizeof(multi_field_header))/sizeof(multi_field_index entry)
```

It should be noted that the syntax used within `multi_field_sub_index` structures is not always common across all sub indices. Therefore the header of each `multi_field_sub_index` should be parsed to infer the syntax used within a given instance.

Syntax	**No. of Bits**	**Identifier**
multi_field_sub_index() {		
multi_field_header {		
leaf_field	**1**	**bslbf**
multiple_locators	**1**	**bslbf**
reserved	**6**	**bslbf**
}		
if(single_layer_sub_index == '0') {		
multi_layer_sub_index_structure()		
} else {		
single_layer_sub_index_structure()		
}		
}		

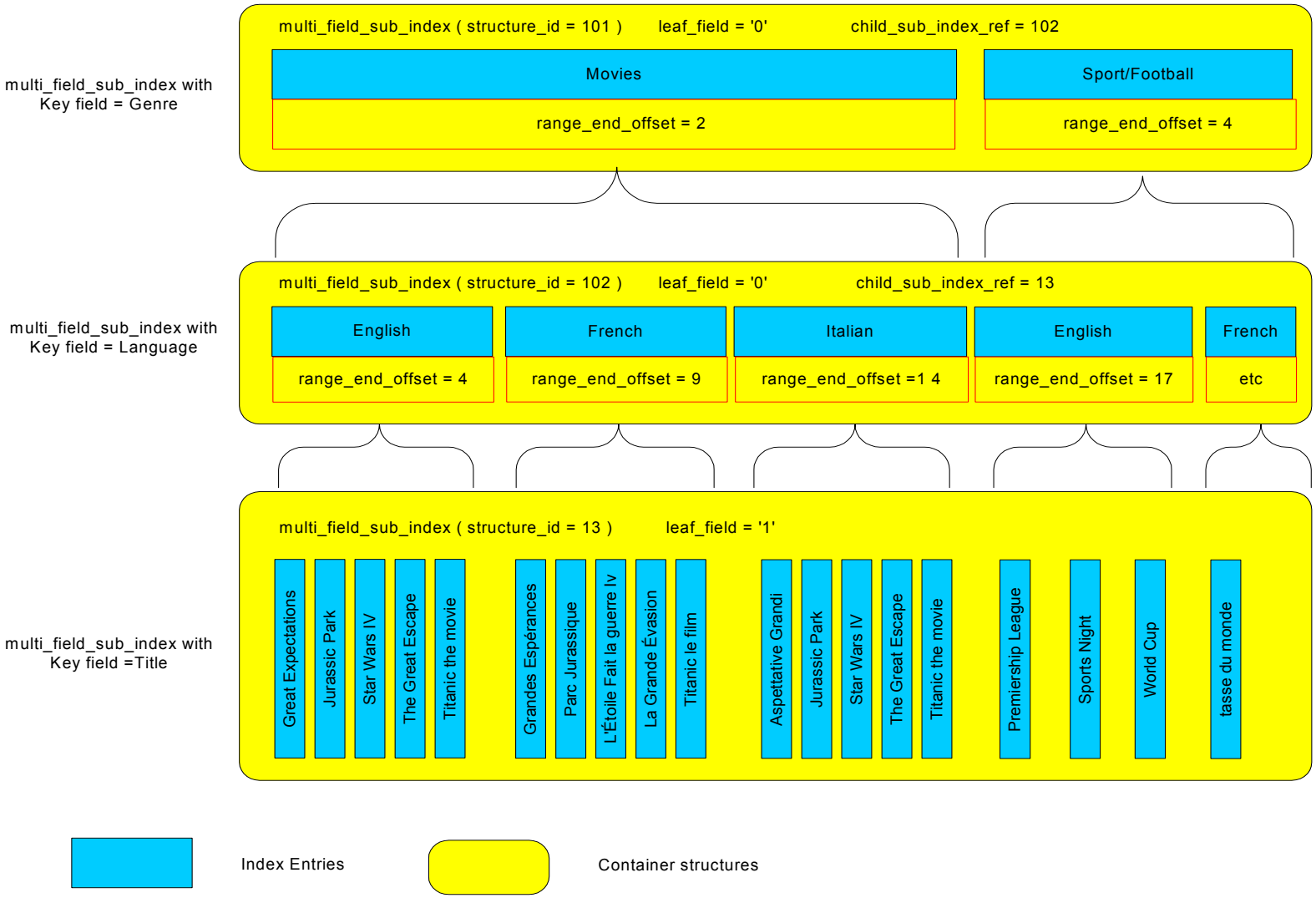


Figure 36 - Example multi_field_sub_index structure (using multi layer syntax) for an index with 3 key fields (Genre, Language, & Title)

Given `field_values`, ($a_1, a_2, ..., a_n$) and ($b_1, b_2, ..., b_n$), of two `multi_field_entries`, the order between the two entries is determined as follows:

($a_1, a_2, ..., a_n$) is larger than ($b_1, b_2, ..., b_n$) if and only if there exists an integer i ($0 \le i \le n-1$) such that for every j($0 \le j \le i-1$), $a_j = b_j$ and $a_i > b_i$.

($a_1, a_2, ..., a_n$) is smaller than ($b_1, b_2, ..., b_n$) if and only if there exists an integer i ($0 \le i \le n-1$) such that for every j($0 \le j \le i-1$), $a_j = b_j$ and $a_i < b_i$.

($a_1, a_2, ..., a_n$) is equal to ($b_1, b_2, ..., b_n$) if and only if for every i($1 \le i \le n$), $a_i = b_i$.

Specifically, within the `multi_field_sub_index()` structure, for all j between 0 and num_entries-1 (`field_value[j,0], ..., field_value[j,k]`) is smaller than (`field_value[j+1,0], ..., field_value[j+1,k]`)

leaf_field: This shall be set to '1' when the `multi_field_sub_index` carries the leaf field of an index (last indexed field). Which indicates that the structure contains references to fragments, and not to further `multi_field_sub_index` structures. This field is only used within multi layer sub indexes. When a single layer sub index is being described this flag shall be ignored.

multiple_locators: A flag which when set to '1' indicates that there are potentially multiple referenced fragments which have the same set of key field values. This provides a more bandwidth efficient mechanism, when multiple fragments have the same set of key values. The actual fragment locators are carried in a separate structure within the container, and an offset is used to reference the set of relevant locators within the structure. When the flag is set to '0' it indicates that `fragment_locators` are defined inline.

Syntax	No. of Bits	Mnemonic
single_layer_sub_index_structure () {		
multi_field_index_entries {		
for (j=0; j<num_entries; j++) { …		
for(f=0; f<num_fields; f++) {		
field_value	**16**	**uimsbf**
}		
if(multiple_locators == '1') {		
locator_end_offset	**16**	**uimsbf**
}		
else {		
fragment_locator()		
}		
}		
}		

field_value: The value of the key field of the referenced fragment. The meaning of this field depends on the value of the `field_encoding` member of the relevant index list structure (see section 4.8.5.4). Only values of the key field within the range given for this `sub_index` structure, by the relevant index structure are allowed (see section 4.8.5.4).

fragment_locator: When the `multiple_locators` flag is set to '0' in the multi_field_header this field is used to reference a fragment, having the set of specified key field values. The format of this locator is dependent on the `fragment_locator_format` defined for this index within the `index_list` stucture. For an explanation of the various defined locator formats please refer to section 4.8.5.7 .

locator_end_offset: When the `multiple_locators` flag is set to '1' in the `multi_field_header` this field is used to indicate the inclusive end offset within the `fragment_locators` structure where the set of valid locators can be found. The format of these locators is defined by the `fragment_locator_format` declared within the `index_list` structure.

The `locator_start_offset` is implicit from the previous entry within the `multi_field_sub_index`, as follows.

- If it's the first entry within the `multi_field_index_entries` then `locator_start_offset` shall equal 0.
- If it's not the first entry, the previous entries `locator_end_offset + 1` shall be used as the current entries inclusive `locator_start_offset`.

```
if (current index != 0) {
  locator_start_offset = multi_field_index_entries[current index-
1].locator end offset + 1;
 }else {
  locator_start_offset = 0;
}
```

It should be noted that these references are based on fragment locator entries and not byte offsets. The actual byte offset within the `fragment_locators` structure is calculated as follows:

```
byte_offset = locator_end_offset * sizeof(fragment_locator);
```

Syntax	No. of Bits	Mnemonic
multi_layer_sub_index_structure () {		
if (leaf_field='0') {		
child_sub_index_ref	**8**	**uimsbf**
}		
multi_field_index_entries {		
for (j=0; j<num_entries; j++) { …		
field_value	**16**	**uimsbf**
if(leaf_field == '1') { …		
if(multiple_locators == '1') {		
locator_end_offset	**16**	**uimsbf**
}		
else {		
fragment_locator()		
}		
}		
else {		
range_end_offset	**16**	**uimsbf**
}		
}		
}		
}		

For all fields not described, please refer to the semantics for the `single_layer_sub_index_structure` fields found above.

child_sub_index_ref: This value identifies a further `multi_field_sub_index` structure within the current container which holds index entries having a field value equal to that defined within this sub index. The combination of this value and the `range_end_offset` enables you to locate a set of index entries, which have a specific key field value.

range_end_offset: This field defines the set of entries within the referenced `multi_field_sub_index` (a `multi_field_sub_index` with its structure_ id equal to `child_sub_index_ref`) having a key field value equal to that defined by the `field_value`.

The value is an inclusive offset from the start of the `multi_field_index_entries` of the target `multi_field_sub_index`, where the `end_offset` for the set of entries that have

the declared value can be found. The `range_start_offset` is implicit from the previous, entry within the `multi_field_sub_index`, as follows.

- If it's the first entry within the `multi_field_index_entries` then `start_offset` shall equal 0.

- If it's not the first entry, the previous entries `range_end_offset + 1` shall be used as the current entries inclusive `range_start_offset`.

```
if (current index != 0) {
    range_start_offset = multi_field_index_entries[current index-
1].range end offset + 1;
 }else {
    range_start_offset = 0;
}
```

It should be noted that these references are based on index entries and not byte offsets. So the actual byte offset within the structure is calculated as follows:

```
byte_offset = (range_end_offset * sizeof(multi_field_index_entry))
+ sizeof(multi_field_header)
```

4.8.5.6 Fragment locators structure

The `fragment_locators` structure is used to carry `fragment_locators`, where there are multiple fragments with the same set of key field values. This structure is referenced by the `multi_field_sub_index` structure.

There shall only ever be a maximum of one `fragment_locators` structure within a single container.

Syntax	No. of Bits	Mnemonic
fragment_locators() {		
for(int i=0; i<num_locators; i++) { …		
fragment_locator()		
}		
}		

num_locators: This value is inferred from the size of the structure which is declared within the containers container_header.

I.e. `num_locators = structure_length/sizeof(fragment_locator);`

fragment_locator: This field is used to convey a reference to a TVA fragment. The format of this locator is dependent on the `fragment_locator_format` defined for this index within the `index_list` structure. For an explanation of the various defined locator formats please refer to section 4.8.5.7 .

4.8.5.7 Fragment_locator formats

There are a number of defined fragment locator formats to enable the referencing of fragments from an index entry.

4.8.5.7.1 Referencing fragments in another container

When a data structure becomes quite large, or it is a requirement to be able to carousel the index at a different rate to that of the data, it is advantageous to split the index and data across independent containers. This format provides a mechanism for an index entry to reference a TVA fragment within another container.

Syntax	No. of Bits	Mnemonic
remote_fragment_locator() {		
target_container	**16**	**uimsbf**
target_fragment	**24**	**uimsbf**
}		

target_container: The container ID of the container holding the encapsulation structure for the target fragment.

target_fragment: A 24 bit identifier which uniquely identifies a fragment within the target container. To locate the actual fragment, the appropriate container should be loaded, and the encapsulation structure searched to find a matching `fragment_id`. Once the `fragment_id` has been located the appropriate TVA fragment can be found.

4.8.5.7.2 Referencing a fragment within the same container

It is quite possible to use the above method for referencing fragments within the same container, however it is not the most efficient way. Therefore the following method is supported.

Syntax	No. of Bits	Mnemonic
local_fragment_locator() {		
fragment_offset	**16**	**uimsbf**
}		

fragment_offset: The offset within the encapsulation structure, where the fragment can be found. It should be noted that the offset is an index into the encapsulation structure and not a byte offset. The byte offset can be calculated as follows:

```
byte_offset = (sizeof(encapsulation_entry) * fragment_offset) +
encapsulation_header;
```

4.8.6 Binary representation of Simple Types

Within the Index list structure it is a requirement to define the encoding used to represent each of an index's key fields. The following is a list of XML Schema defined primitive simple types used within the TV-Anytime schema and how they should be encoded, when used within the context of an index.

SimpleType	field_encoding value	Encoding
string	0x0000	string
anyURI	0x0000	string
boolean	0x0100	signed short with false = '0x0000' and true = Non zero value e.g. 0xffff
NMTOKEN	0x0000	string
gYear	0x0000	string
date		Modified Julian Date (TVA BiM codec Section 4.4.2.4.3)
dateTime	0x0400	Modified Julian Date and Milliseconds (TVA BiM codec Section 4.4.2.4.2)
duration	0x0400	Modified Julian Date and Milliseconds (TVA BiM codec Section 4.4.2.4.2)
integer	0x0202	one bit to indicate sign (0:positive, 1: negative), followed by abs(value) using vluimsbf5.
nonNegativeInteger	0x0203	vluimsbf8

positiveInteger	0x0203	vluimsbf8
float	0x0300	signed float
double	0x0302	signed double

4.8.7 Indexes based on Classification Schemes

When creating an index based on a Classification Scheme it is recommended that the key field used is the `href` attribute within the `ControlledTermType`, and that its value is a full de-referenced URI i.e. not an Alias.

It is also recommended that all entries within the index use a single classification scheme. The indexing solution can support the use of mixed classification schemes but it may present problems to an application, which wishes to search the index. For example, there may be more than one reference value for genre 'Sport'.

4.9 Notion of Validation

TV-Anytime deals with metadata and in particular with large and highly structured metadata.

An XML Schema document is called a schema. The TVA schema is thus an XML schema document, namely the data model defining the rules to be respected to edit "valid" TVA metadata description. This includes information about default values, element types, attributes types and type hierarchies.

The validation process ensures that the descriptions transmitted to the application respect all the rules defined in the associated schema and thus that it is conformant to the standard having specified this schema. The nature (i.e. the type) of each description item (element or attributes) are also determined and controlled during this process. Validation is the way to make data more explicit to an application. It is a transformation from raw untyped well-formed (syntactically correct according to the schema definitions) information into typed useful information. The generic nature of the validation process is spelled out by W3C in the XML schema specification in [3].

Because the TV-Anytime encoding mechanism produces by nature only valid encoded metadata description and due to the design of the TV-Anytime schema and of the associated fragmentation mechanism, each partial description shall be valid according to the TVA schema, first, after the decoding of the TVAMain fragments and, afterwards, of any of its associated TVA fragments.

4.10 Extensibility of the TV-Anytime schema

4.10.1 Introduction

A TVA metadata system includes a common core set of metadata as defined in Part A of this specification to ensure a minimum level of interoperability. Scalability and extensibility are key TV-Anytime features. Backward and possibly forward compatibility shall be maintained.

The MPEG-7 Definition Description Language (DDL) that is used as the TV-Anytime representation language for metadata is the main instrument for this extensibility.

As shown in Figure 23, mechanisms need to be defined to allow the extension of the specification with new TV-Anytime definitions, or for private extensions.

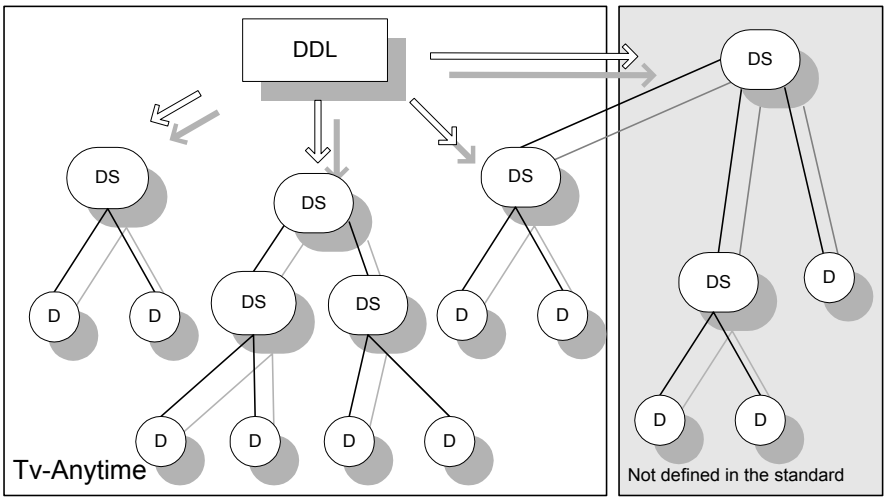


Figure 38 - Representation of a TV-Anytime extension

The associated TVA extensibility rules are presented in the following sections.

4.10.2 Extensibility rules

The following section defines rules to support specification and private extensions in a backward and forward compatible manner.

- Forward compatibility means a decoder that is only aware of a previous version of a schema is able to partially decode a description conformant to an updated version of that schema.
- Backward compatibility means a decoder that is only aware of a new version of the schema is able to partially decode a description conformant to a previous version of that schema.

With BIM, backward compatibility is provided by the unique reference of the used schema in the `DecoderInit`. Forward compatibility is ensured by a specific syntax defined in MPEG-7 Specification [1] Clause 7 and 8. Its main principle is to use the namespace of the schema. The binary format allows one to keep parts of a description related to different schemas in separate chunks of the binary description stream, so that parts related to an unknown schema may be skipped by the decoder. The Decoder Initialisation identifies schema versions with which compatibility is preserved by listing their Schema URIs. A decoder that knows at least one of the Schema URIs will be able to decode at least part of the binary description stream.

The following rules shall be applied so as to define a valid extension of the standard, in particular to allow the compatibility mechanisms described above. They constrain the extensibility of TV-Anytime schemas:

- Extension must be defined using the TVA schema representation language (i.e. MPEG-7 DDL). The way these extended schemas are transmitted is out of the scope of this version of the specification.
- The module definition must have a prose definition that describes the syntactic and semantic requirements of the elements, attributes, and/or content models that it declares.
- Existing element names should never be re-used. New elements names should be defined under their own namespace (e.g. for another version of the TVA specification or for private extensions).
- The module definition's elements and attributes must be part of an XML namespace. If the module is defined by an organization other than TVA and MPEG (for imported MPEG datatypes and description schemes), this namespace must NOT be the same as the namespace in which other TVA and MPEG standards are defined

- The namespace under which extensions are defined will need to be clearly identified.
- Any extensions to existing schema should not obscure existing functionality. Thus existing functionality should not be contained within a new element that an earlier decoder will not understand.
- Wherever possible, an extended schema should only add functionality and not replace existing functionality. This will allow a version 1 decoder to maximally understand a version 2 document.
- An application should ignore any elements or attributes they do not need, do not understand or cannot use.

Table 14 provides the list of conditions under which the extensions of TV-Anytime metadata definitions are supported or not.

Condition / Type of extension of Tv-Anytime metadata definitions	**Status**
Condition 1: A new global element of existing type	NOT PERMITTED
Condition 2: A new global attributes added to existing type	PERMITTED
new type (simple or complex – but see below for limitations on derivation etc)	PERMITTED
Polymorphism of existing type by Inheritance with restriction	PERMITTED (But see rules above)
Polymorphism of existing type by Inheritance with extension	PERMITTED (But see rules above)
Polymorphism of existing type by Redefining types during import	NOT PERMITTED
Substitution Groups	NOT PERMITTED. Instead of using substitution groups, explicit derivation can be used. This is safer for future extensions.

Table 14 - Types of extension permitted in future versions of TV Anytime