INTERNATIONAL ORGANISATION FOR STANDARDISATION
ORGANISATION INTERNATIONALE DE NORMALISATION
ISO/IEC JTC1/SC29/WG11
CODING OF MOVING PICTURES AND AUDIO

ISO/IEC JTC1/SC29/WG11
MPEG99/p547
February 1999

Title: **A Proposal for an MPEG-7 Description Definition Language (DDL)**

Submitted to: **MPEG-7 Evaluation AHG, Lancaster**

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1. Introduction

To enable resource discovery on audiovisual documents and filtering of broadcasts over the WWW, it will be necessary to define content description standards or metadata standards for complex, multi-layered, time-dependent audiovisual data streams. This is the primary goal of the developing MPEG-7 standard, the "Multimedia Content Description Interface", under development by the MPEG group.

MPEG-7 will standardize:
- A set of description schemes and descriptors
- A language to specify description schemes i.e. a Description Definition Language (DDL).
- A scheme for coding the description.

In this paper, we propose a schema which is capable of meeting the requirements of the DDL as described in the MPEG-7 Requirements Document [1]. This schema is capable of defining the envisaged description schemes as well as validating and constraining audiovisual document descriptions and their associated data models.

An earlier paper [2] compared the ability of a number of existing schema definitions, including the Resource Description Framework (RDF) Schema [3], XML Document Type Descriptors (DTD) [4], Document Content Description (DCD) [5] and Schema for Object-Oriented XML (SOX) [6], to satisfy the MPEG-7 DDL requirements. The conclusion was that none of these schemas is ideal for describing complex multimedia documents. They all satisfy some of the requirements but are lacking in other areas. None of them is designed for describing complex hierarchical structures in which there are spatial, temporal, structural and conceptual relationships between the components and where these relationships map to constraints on the relative attribute values of the related components.

The schema proposed here takes the optimum capabilities of RDF, XML DTDs, SOX, DCD and XML-Data [7] and combines and extends them, where necessary, to satisfy all of the DDL requirements. The result is a schema based on a model consisting of classes, properties and relations between classes. It extends the RDF classes and properties model with the addition of relations, temporal and spatial specifications and powerful data typing capabilities. These features enable the definition of generic (temporal, spatial, conceptual) relationships and the associated constraints on the attribute values of the related classes. In spite of the enhanced capabilities, the schema maintains its simplicity and human- and machine-readability. Because it is based on object-oriented concepts, it can easily be modified or extended.

This proposal is informed by the the RDF Schema specification [3] as well as the XML 1.0 specification [4], the DCD submission[5], SOX [6], the XML-Data submission[7] and the Synchronized Multimedia Information Language (SMIL) [8].

2. DDL Requirements

According to the MPEG-7 Requirements Document [1], the DDL requirements are:

1. **Compositional capabilities:** The DDL shall supply the ability to compose a DS from multiple DSs.
2. **Platform independence:** The DDL shall be platform and application independent. This is required to make the representation of content as reusable as possible even on grounds of changing technology.
3. **Grammar:** The DDL shall follow a grammar that is unambiguous, and allow easy parsing (interpretation) by computers.
4. **Primitive data types:** provide a set of primitive data types, e.g. text, integer, real, date, time/time index, version, etc.
5. **Composite datatypes:** The DDL must be able to succinctly describe composite datatypes that may arise from the processing of digital signals (e.g., histograms, graphs, and rgb-values).
6. **Multiple media types:** The DDL must provide a mechanism to relate Ds to data of multiple media types of inherent structure, particularly audio, video, audio-visual presentations, the interface to textual description, and any combinations of these.
7. **Partial instantiation:** The DDL shall provide the capability to allow a DS to be partially instantiated by descriptors.
8. **Mandatory instantiation:** The DDL shall provide the capability to allow the mandatory instantiation of descriptors in a DS.
9. **Unique identification:** The DDL shall provide mechanisms to uniquely identify DSs and Ds so that they can be referred to unambiguously.
10. **Distinct name spaces:** The DDL shall provide support for distinct name-spaces. Note: Different domains use the same descriptor for different features or different purposes.
11. **Transformational capabilities:** The DDL shall allow the reuse, extension and inheritance of existing Ds and DSs.
12. **Relationships within a DS and between DSs:** The DDL provides the capability to express the following relationships between DSs and among elements of a DS and express the semantics of these relations
    a) Spatial relations
    b) Temporal relations
    c) Structural relations
    d) Conceptual relations
13. **Relationship between description and data:** The DDL shall supply a rich model for links and/or references between one or several descriptions and the described data.
14. **Intellectual Property Management:** The DDL shall provide a mechanism for the expression of Intellectual Property Management and Protection (IPMP) for description schemes and descriptors.

In addition, we consider the following criteria to be important:

- Human readability (desirable but not mandatory).
- Cardinality - the ability to specify that a property, relation or attribute can have zero, one or multiple values. For example, each scene must contain between 1 and 20 shots.
- Ability to specify constraints on attribute values of related elements e.g. the start and end times of shots within a scene must lie within the start and end times of the enclosing scene. This is desirable rather than mandatory.
- Availability of supporting technologies such as parsers, databases and query languages.

3. The Chosen Description Scheme

Figure 1 shows the logical structure, the structural components and their associated Dublin Core (DC) [11] attributes for a video description scheme which we use to demonstrate our schema's capabilities.

Our description scheme extends certain Dublin Core elements to cope with video content metadata requirements. This approach provides multiple levels of descriptive information. At the top level, the 15 basic Dublin Core elements can be used to describe the bibliographic type information about the complete document (e.g. Title, Author, Contributor, Date etc.). This enables non-specialist inter-disciplinary cross-media searching for complete multimedia documents. Extensions or qualifiers on specific DC elements can be applied at the lower levels (scenes, shots, frames) to provide fine-grained discipline-specific searching (e.g. Description.Camera.Angle). The DC elements which are extended to provide complete video descriptions are: Type, Description, Format, Relation and Coverage. Details of the extensions are described in [10].

To represent the video structure and Dublin Core descriptors in Figure 1, a suitable schema must be able to support the hierarchical structure definition in which complete multimedia documents sit at the top level. These contain audio and video components. The video component contains sequences, which contain scenes, which contain shots, which contain frames, which contain objects or actors. In addition, each level (or class) within the hierarchy must be constrained to possess only specific properties or attributes. For simplification and because DC qualifiers are still unstable, we assume that each layer possesses both the 15 simple, optional and extensible DC elements plus a set of class-specific attributes unique to that layer. These represent the set of MPEG-7 descriptors for that class when they become available. These requirements are compatible with the DDL requirements listed above.

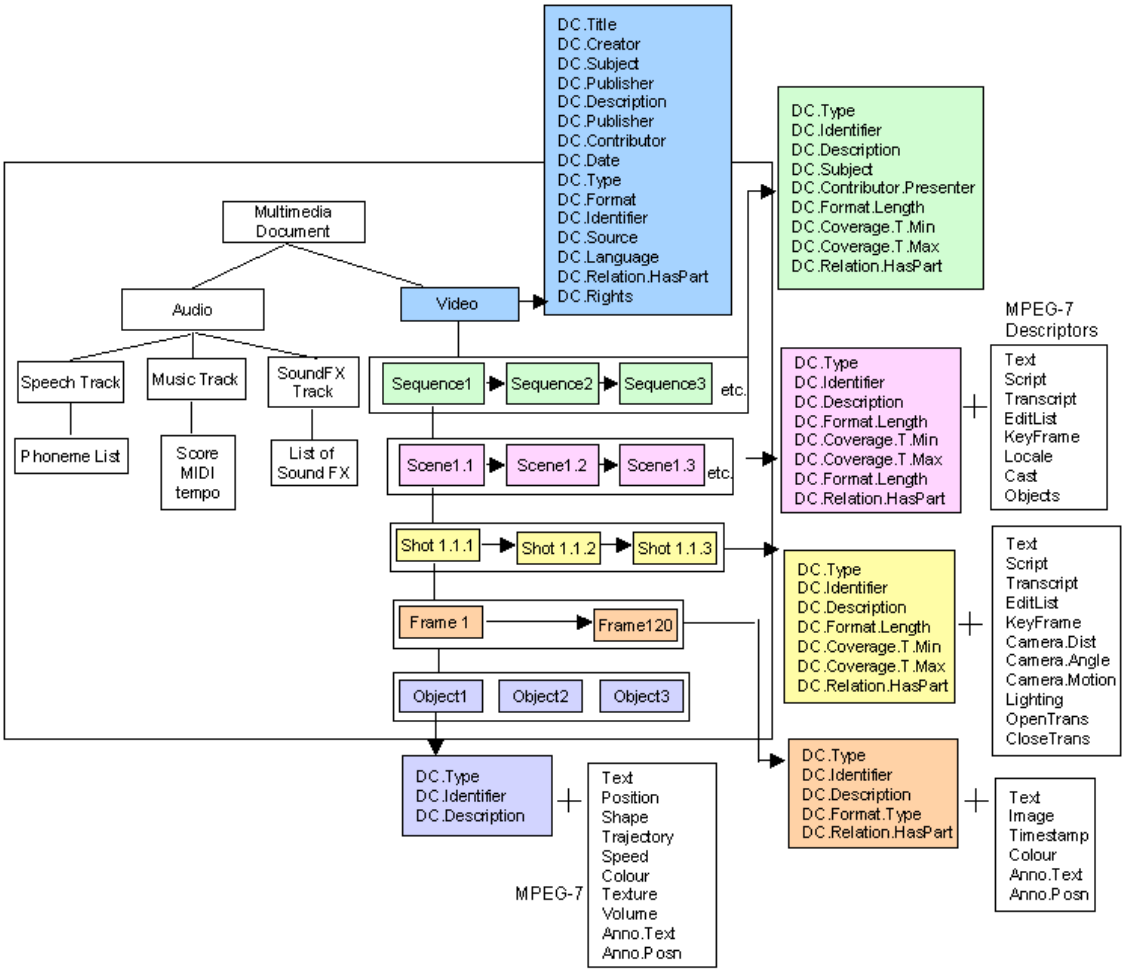


Figure 1: Multilayered Hierarchical Structure and Attributes of Video Documents

4. Proposed MPEG-7 DDL

A previous analysis of available schemas found that none of the schemas was ideal for describing multimedia content. The proposal outlined in this paper takes the optimum capabilities of each of the schemas and combines and extends them where necessary, to satisfy all of the requirements of the MPEG-7 DDL. The proposed schema is based on a model consisting of classes, properties and relations between classes. It uses the classes and properties model of RDF but adds relations, timing and spatial controls and data typing capabilities. This schema provides the ability to define generic relationships and apply them with constraints on the attribute values of the related classes. It is also capable of using these definitions to validate input descriptions.

Below is a summary of the different features included within the proposed schema.

4.1 Namespace Declarations

The XML namespace facility [12] enables the inclusion of multiple namespaces. This enables the same feature to have different descriptors which correspond to different domains or description schemes. The ability to mix classification vocabularies within one XML-based encoding allows video authors or others to deliver richer domain-specific content descriptions thus increasing the accessibility and re-usability of video content on the Web. The proposed MPEG-7 schema can also be included in other schemas or descriptions using this same facility. This is a key requirement of the MPEG-7 DDL.

```
<?xml version="1.0"?>
<mpeg7
  xmlns:rdf="http://www.w3.org/TR/WD-rdf-syntax#"
  xmlns:dc="http://purl.org/metadata/dublin_core#"
  xmlns:dcq="http://purl.org/metadata/dublin_core_qualifiers#"
  xmlns:smil ="http://www.w3c.org/TR/WD-smil#">
.
.
```

4.2 The CLASS Type Declaration and Class Hierarchies

RDF is based on a class and property data model. A collection of classes and the definition of their properties and corresponding semantics represent an RDF schema. Classes are organized in a hierarchy, and offer extensibility through subclass refinement. This way, in order to create a schema slightly different from an existing one, one can just provide incremental modifications to the base schema. In other schemas and XML DTDs, classes and properties are not really differentiated and are all considered to be "elements".

MPEG-7 classes are equivalent to RDF classes but within each class definition, the class's properties and relations are also declared. This is more in line with XML DTDs and provides much easier readability than RDF schemas which are property-centric rather than class-centric. Using this approach, it is much easier to see the properties which are associated with each class.

The subClassOf property indicates the subset/superset relation between classes. It is based on the rdfs:subClassOf property. It is transitive, so that if class A is a sub-class of some broader class B, and B is a sub-class of C, then A is also implicitly a sub-class of C. Consequently, resources that are instances of class A will also be instances of C, since A is a sub-set of both B and C. Only instances of Class can have the subClassOf property and the property value is always of type Class. A class may be a sub-class of more than one class. A class can never be declared to be a sub-class of itself, nor of any of its own sub-classes. Properties are inherited from classes to subclasses. But additional properties can be added to extend subclasses.

```
<class id="MM_Document">
   <property type="#dc_attribs"/>
</class>

<class id="Video_Document">
   <subClassOf type="#MM_Document"/>
   <property type="duration"/>
```

4.3 The Property Type Declaration

Within RDF schemas, property type definitions specify the allowable domain(s) and range. This paper proposes that a schema is easier to build, read, understand and translate to an XML DTD if the domain is defined by putting the property types in the relevant class definitions and replacing the range with data typing constraints in the property definition.

Properties are defined using *propertyType*. Properties can either be combinations of other properties or a data type. The only allowable attributes of *propertyType* are *id* and *datatype*. If a datatype is specified, then the attributes *min, max, minexclusive, maxexclusive* and *default* can also be specified, if they are relevant to the datatype. Details of allowable data types are given in Section 3.7.

Properties can also be declared to be inherited from or a specialization of other existing properties using subPropertyOf. This is the same as the RDF subPropertyOf. If some property P1 is a subPropertyOf another more general property P2, and if a resource A has a P2 property with a value B, this implies that the resource A also has a P1 property with value B.

```
<propertyType id="timeStamp">
   <Alt>
        <property type="#SMPTE"/>
        <property type="#frame_num"/>
        <property type="#secs"/>
   </Alt>
</propertyType>

<propertyType id="startTime">
   <subPropertyOf type="#timeStamp"/>
</propertyType>

<propertyType id="endTime">
   <subPropertyOf type="#timeStamp"/>
</propertyType>

<propertyType id="SMPTE" datatype="dateTime"/>
<propertyType id="frameNum" datatype="int"/>
<propertyType id="secs" datatype="float"/>

<propertyType id="dc_attribs">
   <property type="dc:title" occurs="zeroormore"/>
   <property type="dc:creator" occurs="zeroormore"/>
   <property type="dc:subject" occurs="zeroormore"/>
   <property type="dc:description" occurs="zeroormore"/>
   <property type="dc:publisher" occurs="zeroormore"/>
   <property type="dc:contributor" occurs="zeroormore"/>
   <property type="dc:date" occurs="zeroormore"/>
   <property type="dc:type" occurs="zeroormore"/>
   <property type="dc:format" occurs="zeroormore"/>
   <property type="dc:identifier" occurs="zeroormore"/>
   <property type="dc:source" occurs="zeroormore"/>
   <property type="dc:language" occurs="zeroormore"/>
   <property type="dc:relation" occurs="zeroormore"/>
```

The actual association of properties with classes or within other properties, is specified using the *property* element. Permissable attributes of *property* are : *type* (mandatory) and *occurs* (optional). The *occurs* attribute specifies the occurrence of properties and can have the values: *required* (one only), *optional* (zero or one), *zeroormore*, *oneormore*, *(n,m)*. It is also possible for properties to be combined into groups (of order Seq, Alt, Bag or Par) within a propertyType.

4.4 The Relationship Type Declaration

One of the major advantages of RDF Schema is that its additional semantics enable relations other than "contains" to be defined. The other schemas only provide the inherent "contains" relation. However, this advantage is then weakened by the need to specify a single range constraint. Since each property can only have a single range, multilayered structures can't be described using a single generic "contains" property. This requires multiple specific "contains" properties i.e. "contains_sequences", "contains_scenes", "contains_shots", "contains_frames", each with their own specific range constraint. One alternative is to implement code outside of the schema which understands specific descriptor semantics (e.g. DC.Relation.HasParts) and can perform the validation. Another alternative which has been proposed within the RDF comments mail archive [9] is to enable class-specific constraints on properties. Class-specific constraints allow the range to be specified with the property or relation inside the class definition. We propose using this approach.

Relationships between classes can be defined using the *relationType* declaration. A *relationType* declaration must contain the name of the relation, a domain (the class to which the relation is applied) and a range (the related class). In addition, it is possible to specify constraints on the properties of the related classes using the *constraint* specification. Within RDF, one cannot map relationship-type properties between classes to constraints on the property values of the classes involved. For example, if a sequence "contains" a scene, then the start and end times of the scene, must lie within the start and end times of the sequence. This is not supported by RDF Schema.

Class-specific constraints are defined by inserting *relation* elements within class definitions. The domain corresponds to the container class and the range and constraint attributes can be used to override the range and constraint values in the relation definition. The range and domain for class-specific constraints must be sub-classes of the range and domain in the relationType definition.

The presence of an order attribute with the range specification implies that the range can be a group of objects of a particular class and that the group will have the specified ordering. If the occurs attribute allows groups but no ordering is specified, then any of the ordering types are permissable. If the range consists of a group, then the particular attributes are specified using an array type syntax e.g. range[1] is the first element of the group, range[n] is the last element and range[i] represents all of the elements.

The *constraint* element is used to specify constraints on the property values of the related classes. It has two attributes: *type* and *value*. The *type* can be either *boolean* or *program*. The *value* is either a logical expression between range and domain properties or a call to a remote program e.g. CORBA IDL wrapping around some external function. The program approach would be used to perform more sophisticated content checking and validation.

In addition, the relation can be defined as either uni-directional or bi-directional via attributes. If the relation is uni-directional, then an optional inverse relation name can be specified. If the relation is bi-directional, then the inverse relation is the same as the original relation.

```
<relationType id="contains" direction="uni" inverse="#contained_by">
    <domain type="#MM_Document" />
    <range type="#MM_Document" occurs="zerormore" order="Seq"/>
    <constraint type="boolean" value=
                    "((range[1].startTime>=domain.startTime)&&
                      (range[n].endTime<=domain.endTime))"/>
</relationType>

<relationType id="overlaps" direction="bi">
    <domain type="#object"/>
    <range type="#object"  occurs="zerormore" order="Bag"/>
    <constraint type= "boolean" value=
      "((domain.X.min<=(range[i].X.min +(range[i].X.max-range[i].X.min)/2)&&
        (domain.X.max>=(range[i].X.min +(range[i].X.max-range[i].X.min)/2)&&
        (domain.Y.min<=(range[i].Y.min +(range[i].Y.max-range[i].Y.min)/2)&&
        (domain.Y.max>=(range[i].Y.min +(range[i].Y.max-range[i].Y.min)/2))"/>
</relationType>

<relationType id="neighbours" direction="bi">
    <domain type="#object" />
    <range type="#object" occurs="zerormore" order="Seq"/>
    <constraint type="program" value="checkNeighbours(domain, range)"/>
</relationType>

<class id="scene">
    <subClassOf type="#MM_Document"/>
    <property type="#dc_attribs"/>
    <relation type="contains" range="#shot"/>
</class>

<class id="object">
    <subClassOf type="#MM_Document"/>
```

4.5 Order and Occurs

We use the RDF Container syntax to specify sets or sequences of classes or properties. Alternatives or ordering among the elements is specified by the order attribute. RDF Container syntax provides Seq, Bag and Alt container types. We propose the addition of a Par container type for a collection of "parallel" elements. Hence the proposed values for the order attribute associated with groups are:

- Seq - an ordered list of elements or a collection of objects which occur in sequence;
- Bag - an unordered list of elements;
- Alt - a list of alternative choices from which one is possible;
- Par - a collection of objects which occur in parallel or concurrently.

Valid values for the *occurs* attribute are: *required* (occurs exactly once), *optional* (occurs zero or one times), *zeroormore*, *oneormore* and (*n,m*) (A minimum of *n* and a maximum of *m* occurences. *n* must be a positive integer or zero, *m* must be an integer greater than *n*, or "*" which indicates *m* is unbounded.)

The occurs attribute can be applied to *property*, *relation*, *group* and *range* elements.

4.6 Data Typing

If the property definition includes the *dataType* attribute, then it is a leaf node which includes the data type definition for this property.

<propertyType id="SMPTE" datatype="dateTime"/>
<propertyType id="frameNum" datatype="int" min="1" max="2000"/>
<propertyType id="secs" datatype="float"/>

In addition, it is possible to specify constraints on the content of particular properties using Min, Max, MinExclusive, MaxExclusive. Max and Min allow values upto and including the bound while MaxExclusive and MinExclusive allow values less than and greater than the bound, respectively, The semantics of upper and lower bounding are highly dependent on the element's Datatype; for some datatypes (e.g. uri), this property has no meaning.

<propertyType id="MonthofYear" datatype="int" min="1" max="12"/>

It is also possible to specify a default value using the default attribute on the property. For example:

<propertyType id="MonthofYear" datatype="int" min="1" max="12" default="1"/>

The data type must be selected from the following:

- the intrinsic data types;
- the library of data types which have been derived from the intrinsic data types, see Appendix B;
- a user-defined data type;

XML 1.0 defines about 10 datatypes, which may only be used to constrain attribute values, and essentially one datatype, PCDATA, that can be used for element content. Here we propose a much richer set of datatypes, applicable equally to attribute and property content. The data types available are based on the SOX data typing capabilities.

The list of primitive or intrinsic datatypes are tabulated below. They are the ten XML 1.0 datatypes plus the SOX intrinsic data types.

Name	Examples	Description
id	X	XML ID
idref	X	XML IDREF
idrefs	X Y Z	XML IDREFS
entity	Foo	XML ENTITY
entities	Foo Bar	XML ENTITIES
nmtoken	Name	XML NMTOKEN
nmtokens	Name1 Name2	XML NMTOKENS
enumeration	Red Blue Green	XML ENUMERATION Legal values must be specified
notation	GIF	XML NOTATION
string	Give me liberty or give me death!	PCDATA
binary	[01]*	A sequence of bits, represented by 0 or 1.
boolean	0, 1 (1=="true")	"1" or "0"
char	char	A single character.
number	15, 3.14, -123.456E+10	A numeric value.Used when a more specific numeric representation is not required or practical. There are no contraints on the minimum or maximum values, number of digits or number of decimal places.
date	YYYY-MM-DD	A date in a subset ISO 8601 format (no time)
time	HH:MM:SS	A time in a subset ISO 8601 format, with no date and no time zone. Fractional seconds may be as precise as nanoseconds.
uri	urn:schemas-microsoft-com:Office9 http://www.ics.uci.edu/pub/ietf/uri/	Universal Resource Identifier

The enumeration data type also requires the legal values to be specified. For example:

```
<propertyType id="cameraDistance" datatype="enumeration">
   <Values>close-up medium-shot long-shot</Values>
</propertyType>
```

4.6.1 User-defined datatypes

We propose using the same approach as the SOX W3C submission. SOX documents provide a mechanism, for defining datatypes that can be used to specify the datatype of an attribute or property content. We provide a similar mechanism through the *dataType* element. A datatype id may be referenced in the datatype attribute of the *propertyType, attributeType, enumeration, format, scalar*, and *string* elements. It is a fatal error to re-assign a datatype name or to reference a datatype that has not been defined.

User-defined datatypes may only be derived from the intrinsic datatypes. There are three types: *scalar*, *enumeration* and *format*. The valid mask values are listed in Appendix C. The MPEG-7 Schema processor must be capable of generating code to perform validation on the values of user-defined datatypes.

4.6.1.1 User-defined scalar datatypes

User-defined scalar datatypes are derived from the intrinsic number datatype. A derived datatype must specify the number of digits and decimal places, and the minimum and maximum values permitted. An optional mask describes the required format of values that conform to the datatype. The minimum and maximum permitted values may be further constrained by setting the boolean minexclusive and maxexclusive attributes to "1". A processor must be able to generate code that will validate a value against the datatype definition.

```
<dataType id="inch">
   <scalar datatype="float" digits="4" decimals="2" min="0" max="12">
     <mask>Z#.##</mask>
   </scalar>
</dataType>
```

4.6.1.2 User-defined enumeration datatypes

User-defined enumeration datatypes may be derived from any of the intrinsic datatypes. Each of the values specified in an enumerated datatype must conform to the specified type. A processor must be able to generate code that will validate the value against the datatype definition.

```
<dataType id="transition">
   <enumeration datatype="string">
      <option>cut</option>
      <option>fade</option>
      <option>wipe</option>
      <option>dissolve</option>
   </enumeration >
</dataType>
```

4.6.1.3 User-defined format datatypes

User-defined format datatypes may be derived from any of the intrinsic datatypes, but will most commonly be used to specialize string values. A required mask describes the required format of values that conform to the datatype. A processor must be able to generate code that will validate the value against the datatype definition.

```
<dataType id="part-number">
   <format datatype="string">
      <mask>AAA-###.##-aa</mask>
   </format>
</dataType>
```

4.6.2 Examples of User-defined MPEG-7 Complex Data Types

Complex data types which the DDL should be capable of supporting include : Colour histograms, 3D vectors, graphs, RGB values etc.

RGB-Values
For example, orange-red is represented by the RGB value 255;69;0 and each value must lie between 0 and 255.

```
<dataType id="rgb">
   <scalar datatype="int" min="0" max="255">
     <mask>ZZ#</mask>
   </scalar>
</dataType>

<dataType id="RGB-value">
   <format datatype="string">
      <mask>rgb;rgb;rgb</mask>
   </format>
</dataType>
```

A Colour histogram

```
<propertyType id="colourHistogram">
       <Seq>
          <propertyType id="RGB-data" datatype="#RGB-value"/>
          <propertyType id="frequency" datatype="float"/>
      </Seq>
</propertyType>
```

4.7 Attribute Definitions

Attributes are handled here similarly to attributes within the DCD Schema. Attributes can be specified for classes using attributeType. Properties which apply to attributeType are: id, datatype, occurs and default. *occurs* indicates whether the presence of this attribute is required. It can take one of two values: *required* or *optional*.

```
<attributeType id="duration" datatype=int occurs="optional" default="1" >

<attributeType id="employment" occurs="required" datatype="enumeration">
      <Values>Temporary Permanent Retired</Values>
</attributeType>
```

An example of the use of attribute and attributeType:

```
 <class id="MM_Document">
   <attributeType id="src" datatype="uri"/>
   <attribute type="begin" datatype="timestamp"/>
   <attribute type="end" datatype="timestamp"/>
   <attribute type="duration" datatype="timestamp"/>
   <attribute type="copyright" datatype="uri"/>
 </class>
```

In this example, the properties of the attribute whose name is *src* are declared within the declaration of the MM_Document class. This would make sense if MM_Document is the only class for which the *src* attribute applies.

The second attribute, *begin*, has a declaration stored separately, referenced by its id. This declaration style is suitable when such an attribute is applicable to multiple classes; it allows maintaining the declaration in one location.

4.8 Synchronisation and Temporal Specification

The proposal is to use similar timing controls to SMIL [8]. SMIL provides coarse-grain and fine-grain declarative temporal structuring. Coarse grain temporal information is provided by the following two structuring elements:

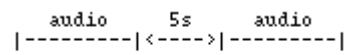
- <seq> ... </seq>: A set of objects that occur in sequence.
- <par> ... </par>: A collection of objects that occur in parallel.

Elements defined within a <seq> group have the semantics that a successor is guaranteed to start after the completion of a predecessor element. Elements within a <par> group have the semantics that, by default, they all start at the same time. Once started, all elements are active for the time determined by their encoding or for an explicitly defined duration. Elements within a <par> group can also be defined to end at the same time, either based on the length of the longest or shortest component or on the end time of an explicit master element. Note that if objects within a <par> group are of unequal length, they will either start or end at different times, depending on the attributes of the group.

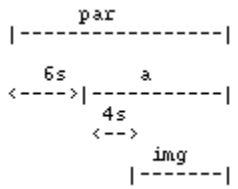
Fine-grained synchronization control is specified in each of the continuous media object references through the following values expressed as either attributes or properties:

- *duration*=" length " attribute can be used to state the presentation time of the object;
- *begin*: specifies the explicit start of an object. It can be given as an absolute offset from the start time of the enclosing structural element by using *begin*=" time " attribute e.g. begin=="5s"; Alternatively it can be given as a relative offset to the start or end time of another sibling object using *begin*="object_id +time" attribute e.g. begin="id(x)(45s)" , begin="id(x)(end)"
- *end*: this attribute specifies the explicit end of the element

```
<seq>
 <audio_track src="audio1" />
 <audio_track begin="5s" src="audio2" />
</seq>
```




```
<par>
 <audio_track id="a" begin="6s" src="audio1"/>
 <img  begin="id(a)(4s)" />
</par>
```



4.9 Spatial Specification

It is possible to break an element into spatial subparts by specifying the outline of each region. In our application we define two methods for describing outlines: rect and outline. *rect* specifies a rectangle within a visual media object. Syntax and semantics of this attribute are similar to the coords attribute in HTML image maps, when the link is associated with a rectangular shape. The rectangle is specified by four values. The first two values specify the coordinates of the upper left corner of the rectangle.The second two

values specify the coordinates of the lower right corner of the rectangle. Coordinates are relative to the top left corner of the visual media object. If a coordinate is specified as a percentage value, it is relative to the total width or height of the media object display area. Similarly non-rectangular outlines are specified by a sequential list of (x,y) pairs measured relative to the top left corner of the container visual media object. The rect and outline region properties have the following syntax:

rectangular_region = "left-x , top-y , right-x , bottom-y"
non-rectangular_region = "x1,y1,x2,y2,x3,y3,x4,y4,x5,y5,x6,y6"

e.g. region="0%, 0%, 50%, 50%"
region="10, 10, 90, 90"
region="10,25,15,85,85,110,56,96"

5. Example of an MPEG7 Schema

Below is an MPEG-7 Schema based on the specifications above, for the Description Scheme shown in Figure 1. It is not complete but illustrates most of the features. In designing the schema, there are a number of design issues to be taken into consideration. These include:

- Deciding whether descriptors should be specified as attributes or properties. In particular the spatial and temporal controls (begin, end, duration, coords) can be either attributes or properties. The advantage of putting these values within attributes means that the overall structure is more readily apparent at first glance. We have put these as properties to ensure that they are not confused with the SMIL attributes in a SMIL multimedia presentation.
- It is also possible either to nest the descriptions of subcomponents within the descriptions of higher-level super-components or alternatively, point to the descriptions using a “meta” attribute. The meta attribute can point to either a separate file or a location within the same file.

```
<?xml version="1.0"?>
  <mpeg7
    xmlns:rdf="http://www.w3.org/TR/WD-rdf-syntax#"
    xmlns:dc="http://purl.org/metadata/dublin_core#"
    xmlns:dcq="http://purl.org/metadata/dublin_core_qualifiers#"
    xmlns:smil ="http://www.w3c.org/TR/WD-smil#">

  <class id="MM_Document">
      <attributeType id="src" datatype="uri"/>
      <attributeType id="meta" datatype="uri"/>
      <property type="#dc_attribs"/>
      <property type="#sync_attribs"/>
      <relation type=”#contains”/>
  </class>

  <relationType id="contains" direction="uni" inverse="#contained_by">
      <domain="#MM_Document"/>
      <range="#MM_Document" occurs="zerormore"/>
      <constraint type="boolean"
                  value="((range[1].startTime>=domain.startTime)&&
                          (range[n].endTime<=domain.endTime))"/>
  </relationType>

  <class id="Video">
      <subclassof="#MM_Document"/>
      <relation type="contains" range="#Sequence" occurs="zerormore"
                           order="Seq"/>
  </class>

  <class id="Audio">
```

```
  <class id="Sequence">
      <subclassof="#MM_Document"/>
      <relation type="contains" range="#Scene" occurs="zerormore" order="Seq"/>
  </class>

  <class id="Scene">
      <subclassof="#MM_Document"/>
      <relation type="contains" range="#Shot" occurs="zerormore" order="Seq"/>
      <property type="#scene_attribs"/>
  </class>

  <class id="Shot">
      <subclassof="#MM_Document"/>
      <relation type="contains" range="#Frame" occurs="zerormore" order="Seq"/>
      <property type="#shot_attribs"/>
  </class>

  <class id="Frame">
      <subclassof="#MM_Document"/>
      <relation type="contains" range="#Object" occurs="zerormore" order="Bag"
                     constraint="check_contains_object(domain, range)"/>
      <property type="#frame_attribs"/>
      <property type="#visual_attribs"/>
  </class>

  <class id="Object">
       <property type="#object_attribs"/>
       <property type="#visual_attribs"/>
  </class>

<propertytype id="dc_attribs">
      <property type="dc:title" occurs="zeroormore"/>
      <property type="dc:creator" occurs="zeroormore"/>
      <property type="dc:subject" occurs="zeroormore"/>
      <property type="dc:description" occurs="zeroormore"/>
      <property type="dc:publisher" occurs="zeroormore"/>
      <property type="dc:contributor" occurs="zeroormore"/>
      <property type="dc:date" occurs="zeroormore"/>
      <property type="dc:type" occurs="zeroormore"/>
      <property type="dc:format" occurs="zeroormore"/>
      <property type="dc:identifier" occurs="zeroormore"/>
      <property type="dc:source" occurs="zeroormore"/>
      <property type="dc:language" occurs="zeroormore"/>
      <property type="dc:relation" occurs="zeroormore"/>
      <property type="dc:coverage" occurs="zeroormore"/>
      <property type="dc:rights" occurs="zeroormore"/>
  </propertytype>

<propertyType id="sync_attribs">
       <property type="begin" occurs="optional"/>
       <property type="end" occurs="optional"/>
       <property type="duration" occurs="optional"/>
</propertyType>

<propertyType id="visual_attribs">
       <property type="colourHistogram" occurs="optional"/>
       <property type="texture" occurs="optional"/>
       <property type="region" occurs="optional"/>
</propertyType>

<propertyType id="scene_attribs">
       <propertyType="transcript" occurs="optional" datatype="string"/>
       <propertyType="script" occurs="optional" datatype="string"/>
       <propertyType="edit_list" occurs="optional" datatype="string"/>
       <propertyType="locale" occurs="optional" datatype="string"/>
       <propertyType="cast" occurs="optional" datatype="string"/>
       <propertyType="object_list" occurs="optional" datatype="string"/>
</propertyType>

<propertyType id="shot_attribs">
```

```
<propertyType id="cameraDistance" datatype="enumeration">
    <Values>close-up medium-shot long-shot</Values>
</propertyType>

<propertyType id="cameraAngle" datatype="enumeration">
    <Values>low eye-level high</Values>
</propertyType>

<propertyType id="openTransition" datatype="transition">
<propertyType id="closeTransition" datatype="transition">

<propertyType id="timeStamp">
    <Alt>
         <property type="#SMPTE"/>
         <property type="#frame_num"/>
         <property type="#secs"/>
    </Alt>
</propertyType>

<propertyType id="duration">
        <subpropertyof="#timeStamp"/>
</propertyType>
<propertyType id="begin">
        <subpropertyof="#timeStamp"/>
</propertyType>
<propertyType id="end">
         <subpropertyof="#timeStamp"/>
</propertyType>

<propertyType id="SMPTE" datatype="dateTime"/>
<propertyType id="frameNum" datatype="int"/>
<propertyType id="secs" datatype="float"/>

<propertyType id="region">
    <Seq>
        <property type="#point"/>
    </Seq>
</propertyType>

<propertyType id="point" datatype="xy_pair"/>

<propertyType id="colourHistogram">
         <Seq>
              <propertyType id="colour" datatype="#rgb"/>
              <propertyType id="frequency" datatype="float"/>
        </Seq>
</propertyType>

<dataType id="xy_pair">
    <scalar datatype="string" >
      <mask>n,n</mask>
    </scalar>
</dataType>

<dataType id="rgb">
    <scalar datatype="string">
      <mask>ZZ#;ZZ#;ZZ#</mask>
    </scalar>
</dataType>

<dataType id="transition">
    <enumeration datatype="string">
        <option>cut</option>
        <option>fade</option>
        <option>wipe</option>
```

6. Instance of an MPEG-7 Video Description

Below is an example of a description of a video file, based on the MPEG-7 schema described above. In the example below, we include the Synchronized Multimedia Information Language (SMIL) namespace [11]. This allows us to refer to sequence3 by: http://www.dstc/videos/98-02-20.mpg#seq3. This is possible using SMIL temporal anchors such as:

```
<video src = "http://www.dstc/videos/98-02-20.mpg">
  <anchor id="seq3" begin="00:54:24;01" end ="00:56:32;25"/>
</video>
```

This description is unnested for easy readability but the nesting of each sub-layer's description within the description of the layer above is supported. The other alternative is to use the *meta* attribute to store the descriptions in a separate file or elsewhere within the same file.

```
<?xml version="1.0" ?>
  <MPEG7
    xmlns ="http://www.w3c.org/TR/WD-rdf-syntax#"
    xmlns:dc ="http://purl.org/metadata/dublin_core#""
    xmlns:smil ="http://www.w3c.org/TR/WD-smil#"
    xmlns:dcq="http://purl.org/metadata/dublin_core_qualifiers#"
    xmnls:mpeg7="http://www.dstc.edu.au/mpeg7#">

    <MM_Document src=http://www.dstc/videos/98-02-20.mpg>
       <DC:Title>SBS World News</DC:Title>
       <DC:Subject>News, Current Affairs</DC:Subject>
       <DC:Description>Major world news events of the day.</DC:Description>
       <DC:Publisher>Special Broadcasting Service</DC:Publisher>
       <DC:Contributor.Presenter>Indira Naidoo</DC:Contributor.Presenter>
       <DC:Format DC:Scheme="IMT">video/mpg</DC:Format>
       <DC:Type>Image.Moving.TV.News</DC:Type>
       <DC:Language>en</DC:Language>
       <DC:Date>1998-05-12</DC:Date>
       <DC:Format.Length>30 mins</DC:Format.Length>
       <contains>
          <Par>
             <Seq id=="video_sequences">
                <Sequence id="seq1" src="http://www.dstc/videos/98-02-20.mpg#seq1">
                ……
                </Sequence>
                <Sequence id="seq2" src="http://www.dstc/videos/98-02-20.mpg#seq2"/>
                <Sequence id="seq3" src="http://www.dstc/videos/98-02-20.mpg#seq3"/>
                <Sequence id="seq4" src="http://www.dstc/videos/98-02-20.mpg#seq4"/>
             </Seq>
             <Seq id="audio_tracks">
                 <Audio id="music_intro" src="vivaldi.midi"/>
                 <Audio id="speech" src="naidoo.ra"/>
                 <Audio id="music_close" src="paganini.ra"/>
             </Seq>
          <Par>
       </contains>
     </MM_Document>

    <Sequence id="seq1" src="http://www.dstc/videos/98-02-20.mpg#seq1">
      <DC:Type>Image.Moving.TV.news.sequence</DC:Type>
      <DC:Description.text>"Cambodia's democracy campaigner, Sam Rainsy,
                            criticises Australia's response to his country's
                            political crisis."</DC:Description.text>
      <DC:Subject>Cambodia -- Politics, Government, History</DC:Subject>
      <DC:Contributor.Reporter>Catherine McGrath</DC:Contributor.Reporter>
      <DC:Format.Length>90 secs</DC:Format.Length>
      <DC:Coverage.t.min DC:Scheme="SMPTE">19:31:24;1</DC:Coverage.t.min>
      <DC:Coverage.t.max DC:Scheme="SMPTE">19:32:54;1</DC:Coverage.t.max>
      <contains>
        <Seq>
         <Scene id="scene1.1" src="http://www.dstc/videos/98-02-20.mpg#scene1.1"/>
```

```
<Scene id="scene1.3" src="http://www.dstc/videos/98-02-20.mpg#scene1.3"/>
   <DC:Type>Image.Moving.TV.news.sequence.scene</DC:Type>
   <DC:Description.text>"Footage of Grenade Attack" </DC:Description.text>
   <DC:Format.Length>10 secs</DC:Format.Length>
   <DC:Coverage.t.min DC:Scheme="SMPTE">19:31:44;1</DC:Coverage.t.min>
   <DC:Coverage.t.max DC:Scheme="SMPTE">19:32:07;1</DC:Coverage.t.max>
   <Transcript>"Sam Rainsy knows the violence of political life in
Cambodia. Four months ago, 16 of his supporters were killed in a grenade
attack near Phnom Penh"</Transcript>
   <Locale>"Phnom Penh"</Locale>
   <begin>"19:31:44;1"</begin>
   <end>"19:32:07;1"</end>
   <duration>"22.0"</duration>
   <contains>
       <Seq>
          <Shot id="shot1.3.1" src="http://www.dstc/videos/98-02-20.mpg#shot1.3.1"/>
          <Shot id="shot1.3.2" src="http://www.dstc/videos/98-02-20.mpg#shot1.3.2">
             ..
          </Shot>
          <Shot id="shot1.3.3" src="http://www.dstc/videos/98-02-20.mpg#shot1.3.3"/>
       </Seq>
   </contains>
</Scene>

<Shot id="#shot1.3.2" src="http://www.dstc/videos/98-02-20.mpg#shot1.3.2"/>
     <DC:Type>Image.Moving.TV.news.sequence.scene.shot</DC:Type>
     <DC:Description.text>"Woman carrying injured child."
              </DC:Description.text>
     <keyframe>" http://www.dstc/images/frame97.jpg"</keyframe>
     <cameraDistance>"close-up"</cameraDistance>
     <cameraMotion>"pan left"</cameraMotion>
     <openTransition>"cut"</openTransition>
     <closeTransition>"fade"</closeTransition>
     <begin>"19:31:48;1"</begin>
     <end>"19:32:04;1"</end>
     <duration>"15.0"</duration>
     <contains>
       <Seq>
          <Frame id="frame97" src="http://www.dstc/images/frame97.jpg"/>
          <Frame id="frame124" src="http://www.dstc/images/frame124.jpg">
             ..
          </Frame>
          <Frame id="frame165" src="http://www.dstc/images/frame165.jpg"/>
       </Seq>
   </contains>
</Shot>

<Frame id="#frame124" src="http://www.dstc/images/frame124.jpg">
     <DC:Type>Image.Moving.TV.news.sequence.scene.shot.frame</DC:Type>
     <begin>"19:31:54;1"</begin>
     <contains>
       <Bag>
          <Object id="car"/>
          <Object id="body"/>
             ..
          </Object>
          <Object id="policeman"/>
       </Bag>
   </contains>
</Frame>

<Object id="#car" src="http://www.dstc/images/frame124.jpg#car">
    <DC:Type>Image.Moving.TV.news.sequence.scene.shot.frame.object
                                                              </DC:Type>
```

7. Conclusions

We have described a new schema which is capable of supporting all of the requirements of the MPEG-7 DDL. It is an extended RDF schema based on classes, properties and relations, which includes context-specific constraints plus data typing and cardinality.

The inheritance capabilities provided by *subClassOf* and *subPropertyOf* , the namespace capabilities and the ability to reuse property (descriptor) definitions, all contribute to the satisfaction of requirements 1, 10 and 11. XML provides the platform independence and the unambiguous, easily parsed grammar (requirements 2 and 3). The proposed data typing mechanisms provide both primitive and complex data types (requirements 4 and 5). Examples have shown the schema's ability to handle multiple media types through the application of *Seq* and *Par* containers and temporal and spatial specifications (requirement 6). The *occurs* attribute provides solutions to requirements 7 and 8. The namespace id and the *id* attribute enables unique unambiguous identification of DSs and Ds (requirement 9). The *relation* definition enables spatial, temporal, structural and conceptual relations to be defined (requirement 12). A rich model of temporal and spatial controls (based on SMIL) enable descriptions to be linked to the actual data. The ability to nest descriptions or link to descriptions within the same file or an external file all provide solutions to requirement 13. Copyright requirements can be satisfied either by adding an MPEG-7 *rights* property to each class or by using the DC.Rights property which can be a link to the copyright notice of the content contained in the class (requirement 14).

Although this schema will satisfy all of the MPEG-7 requirements, there are disadvantages associated with "yet another schema proposal". The XML Schema Working Group [13] is a working group of the W3C which is looking at a XML-based schema language which provides support for data typing and structural constraints, currently lacking in XML DTDs. Their charter includes delivering a recommendation on the best combination of DCD, XML-Data and SOX for validating document syntax. There is a need for all of these schemas to be unified. They have just begun to explore the relationship between XML and RDF schema. RDF was designed in the hope and expectation that XML schemas might want to share technology, eg. regarding cardinality constraints and data typing. Both of these were removed from the original RDF Schema design to give a chance for a common XML/RDF approach. If the XML Schema Working Group is aware of the MPEG-7 DDL requirements, then there is a possibility that the schema which they develop will attempt to meet them. However it is highly likely that there will still be a need for an application on top of the parser which can provide the extra semantics, content checking and validation required by complex hierarchical multimedia documents.

References

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Appendix A: An XML DTD for this Schema

```
<!ELEMENT class ( subclassof?|
               (property|propertyType|relation|attribute|attributeType)*)>

<!ATTLIST class id  ID  #REQUIRED>

<!ELEMENT subclassof  EMPTY>
<!ATTLIST subclassof  type CDATA #IMPLIED >

<!ENTITY %occurs_attrs
          'occurs (required|optional|oneormore|zeroormore) "required" '>
<!ENTITY %property_attrs  'datatype?
                           (min|minExclusive)?
                           (max|maxExclusive)?
                           default?'>

<!ELEMENT propertyType ( subpropertyof?|(property|Seq|Alt|Bag|Par)*)>
<!ATTLIST propertyType   id ID #REQUIRED
                         %occurs_attrs;
                         %property_attrs>

<!ELEMENT subpropertyof  EMPTY>
<!ATTLIST subpropertyof  type CDATA #IMPLIED>

<!ELEMENT property EMPTY>
<!ATTLIST property  type CDATA #IMPLIED
                    %occurs_attrs>

<!ELEMENT relationType (domain?|range?|constraint?)>
<!ATTLIST relationType id  ID #REQUIRED
                       direction (uni|bi) 'uni'
                       inverse CDATA #IMPLIED>

<!ELEMENT domain EMPTY>
<!ATTLIST domain type CDATA #IMPLIED>

<!ELEMENT range EMPTY>
<!ATTLIST range type CDATA #IMPLIED
               %occurs_attrs;
               order (Seq|Alt|Bag|Par) #IMPLIED>

<!ELEMENT constraint EMPTY>
<!ATTLIST constraint type (boolean|program) 'boolean'
                     value CDATA #IMPLIED>

<!ELEMENT relation EMPTY>
<!ATTLIST relation type  CDATA  #IMPLIED
                   range CDATA  #IMPLIED
                   constraint_type (boolean|program) 'boolean'
                   constraint CDATA #IMPLIED>

<!ELEMENT attributeType (Values?)
<!ATTLIST attributeType id ID #REQUIRED
                        %occurs_attrs;
                        %property_attrs>
```

```
<!ENTITY % container "Seq|Alt|Bag|Par"

<!ELEMENT Seq ((%container;)|property|PropertyType)>
<!ATTLIST Seq id  ID #IMPLIED
              %occurs_attrs>

<!ELEMENT Alt ((%container;)|property|PropertyType)>
<!ATTLIST Alt id  ID #IMPLIED
              %occurs_attrs>

<!ELEMENT Bag ((%container;)|property|PropertyType)>
<!ATTLIST Bag id  ID #IMPLIED
              %occurs_attrs>

<!ELEMENT Par ((%container;)|property|PropertyType)>
<!ATTLIST Par id  ID #IMPLIED
              %occurs_attrs>


<!ELEMENT datatype ((enumeration|format|scalar)+ >
<!ATTLIST datatype id     ID   #REQUIRED >

<!ELEMENT enumeration (option+) >
<!ATTLIST enumeration datatype   ID           #IMPLIED
                      multiple   (true|false) "false" >

<!ELEMENT option (#PCDATA)* >
<!ATTLIST option
               value        CDATA     #IMPLIED
               label        CDATA     #IMPLIED
               selected    (selected) #IMPLIED
               disabled    (disabled) #IMPLIED >

<!ELEMENT format (mask) >
<!ATTLIST format  datatype     NMTOKEN   "string" >

<!ELEMENT scalar (mask?) >
<!ATTLIST scalar
               datatype       NMTOKEN   "number"
               digits         CDATA     #IMPLIED
               decimals       CDATA     #IMPLIED
               minvalue       CDATA     #IMPLIED
               maxvalue       CDATA     #IMPLIED
```

Appendix B: Datatype library

Derived scalar datatypes

All derived scalar datatypes have an XML parse type of string.

byte
    Single byte. A specialization of int.
    Minimum value: -128
    Maximum value: 127
    Format: S#*
double
    A decimal value. A specialization of number.
    Minimum value: -1.17549435 * 10E308
    Maximum value: 1.17549435 * 10E308
float
    A decimal value. A specialization of number.
    Minimum value: -3.40282347 * 10E38
    Maximum value: 3.40282347 * 10E38
int
    A signed integer value. A specialization of number.
    Minimum value: -2,147,483,648
    Maximum value: 2,147,483,647
    Format: S#*
long
    A decimal value. A specialization of number.
    Minimum value: -9,223,372,036,854,775,808
    Maximum value: 9,223,372,036,854,775,807

Date and time datatypes

The following date and time datatypes are derived from ISO 8601 -- Date and Time [ISO-8601] and are informed by Date and time formats

datetime
    ISO 8601 (5.4.1.a) extended calendar date and local time format
    Format: YYYY-MM-DDThh:mm:ss
    XML parse type: string
datetime.tz
    ISO 8601 (5.4.2) extended calendar date and local time format, with time zone designator.
    Format: YYYY-MM-DDThh:mm:ssShh(:mm)?
    XML parse type: string
time.tz
    ISO 8601 (5.3.3.1) extended local time and UTC offset format.
    Format: hh:mm:ssShh(:mm)?
    XML parse type: string
time.UTC
    ISO 8601 (5.3.3) extended UTC time format.
    Format: hh:mm(:ss)?[Z]
    XML parse type: string
hour
    ISO 8601 (5.3.1.2) hour format.
    Format: hh
    Minimum: 0
    Maximum: 24
    XML parse type: string
minute
    ISO 8601 (5.3.1.4.b) minute format.

Format: -mm
Minimum: 0
Maximum: 59
XML parse type: string

second
ISO 8601 (5.3.1.4.g) second format.
Format: ss(.s)?
Minimum: 0
Maximum: 59.99
XML parse type: string

year
ISO 8601 (5.2.1.2.b) specific year format.
Format: YYYY
Minimum: 0
Maximum: unspecified
XML parse type: string

year-and-day
ISO 8601 (5.2.2.1) extended ordinal date format.
Format: YYYY-DDD
Minimum: 1
Maximum: 366
XML parse type: string

month
ISO 8601 (5.2.1.3.e) month format.
Format: --MM
Minimum: 1
Maximum: 12
XML parse type: string

day-of-a-month
ISO 8601 (5.2.1.3.d) day-of-a-month format.
Format: -MM-DD
Minimum: 1
Maximum: 31
XML parse type: string

week
ISO 8601 (5.2.3.3-Www) week format.
Format: YYYY-Www
Minimum: 1
Maximum: 53
XML parse type: string

day-of-any-week
ISO 8601 (5.2.3.3.g) day-of-any-week format.
Format: ---D
Minimum: 1 (Monday)
Maximum: 7 (Sunday)
XML parse type: string

Enumerated datatypes

countries
ISO 3166 country codes [ISO-3166]
Format: AA
XML parse type: nmtoken

currencies
ISO currency codes
Format: AAA
XML parse type: nmtoken

lang
ISO language codes [ISO-639]

Format: AA
XML parse type: nmtoken

units
ISO 31 unit identifiers [ISO-31]
Format: A+
XML parse type: nmtoken

URI datatypes

URL
Uniform Resource Locator
Format: U*
XML parse type: string

URN
Universal Resource Name
Format: [u][r][n]:U*
XML parse type: string

email
An email address
Format: [m][a][i][l][t][o]:X@X
XML parse type: string

system
XML system identifier.
Format: X*
XML parse type: string

Appendix C: Datatype masks

A mask is a datatype format constraint. A mask consists of symbols, groups of symbols, and patterns, any of which may be modified by occurrence specifiers. Each symbol is a placeholder that stands for a character or a class of characters. Date and time masks tokens are taken from those defined in [ISO-8601]

A or a	A single alphabetic character
B or b	Any one of the boolean characters (0 or 1)
D	A single digit representing the day of the week, in the range 1-7 (Monday-Sunday) (ISO8601-5.1.2)
DD	Two digits representing a day in a month in the Gregorian calendar, in the range 01-31 (ISO8601-5.1.2)
DDD	Three digits representing a day in a year in the Gregorian calendar, in the range 001-366 (ISO8601-5.1.2)
E	The character "E", used to indicate floating point numbers
hh	Two digits representing hours in a day, in the range 00-24 (ISO8601-5.1.2)
MM	Two digits representing a month in the Gregorian calendar, in the range 01-12 (January-December) (ISO8601-5.1.2)
mm	Two digits representing minutes in an hour, in the range 00-59 (ISO8601-5.1.2)
N	Any valid XML name character
n	An integer number consisting of one or more digits.
P	The character "P", used as a "period designator" to indicate the duration of a period of time. (ISO8601-5.1.2)
p	Any one of the punctuation characters (. or : or ; or ,)
Q or q	Any one of the quote characters (" or ' or `)
S	Indicates a signed number. The characters "+" or "-" must appear in this position
ss	Two digits representing seconds in an minute, in the range 00-59 (ISO8601-5.1.2)
s	One or more digits representing a decimal fraction of a second (ISO8601-5.1.2)
T	The character "T", used as a "time designator" to indicate the start of date time of day field. (ISO8601-5.1.2)
U or u	Any character that is valid in a [URI], [URL], or [URN]
W	The character "W", used as a "week designator" to indicate the start of date week field. (ISO8601-5.1.2)
ww	Two digits representing the week number in a year, in the range 1-52 (ISO8601-5.1.2)
X or x	Any character
YYYY	Four digits of a year (ISO8601-5.1.2)
Z	The leftmost leading numeric character that can be replaced by a space character when the content of the Z position is the numeral 0
space	A single blank character
#	Any numeric character
$	A currency symbol
0	The single numeric character "0"
1	The single numeric character "1"
2	The single numeric character "2"
3	The single numeric character "3"
4	The single numeric character "4"
5	The single numeric character "5"
6	The single numeric character "6"
7	The single numeric character "7"
8	The single numeric character "8"
9	The single numeric character "9"
(...)	Represents a grouping of the symbols found between the parentheses. Within parentheses the meaning of mask symbols apply.
[...]	Represents one of the characters found between the square brackets. Within square brackets any character, except for "-" represents itself. The character "-" indicates a range of characters beginning with the character to the left of the "-" and ending with the character to the right.

*	Indicates that the preceding character, or group, may occur zero or more times.
+	Indicates that the preceding character, or group, may occur one or more times.
?	Indicates that the preceding character, or group, may occur zero or one time.
{n,m}	Indicates that the preceding character, or group, must occur at least n times and no more than m times. n must be a positive integer or zero m may be an integer greater than n, or m may be the character "*", indicating that the maximum is unbounded.
!, @, #, %, _, = /, {, }, :, ;, -,. and ,	Represent themselves