XML Schema Part 2: Datatypes

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(in XML and HTML, with a schema and DTD including datatype definitions, as well as a schema for built-in datatypes only, in a separate namespace.)
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Abstract

XML Schema: Datatypes is part 2 of the specification of the XML Schema language. It defines facilities for defining datatypes to be used in XML Schemas as well as other XML specifications. The datatype language, which is itself represented in XML 1.0, provides a superset of the capabilities found in XML 1.0 document type definitions (DTDs) for specifying datatypes on elements and attributes.

Status of this document

This section describes the status of this document at the time of its publication. Other documents may supersede this document. The latest status of this document series is maintained at the W3C.

This document has been reviewed by W3C Members and other interested parties and has been endorsed by the Director as a W3C Recommendation. It is a stable document and may be used as reference material or cited as a normative reference from another document. W3C's role in making the Recommendation is to draw attention to the specification and to promote its widespread deployment. This enhances the functionality and interoperability of the Web.

This document has been produced by the W3C XML Schema Working Group as part of the W3C XML Activity. The goals of the XML Schema language are discussed in the XML Schema Requirements document. The authors of this document are the XML Schema WG members. Different parts of this specification have different editors.

This version of this document incorporates some editorial changes from earlier versions.

Please report errors in this document to www-xml-schema-comments@w3.org (archive). The list of known errors in this specification is available at http://www.w3.org/2001/05/xmlschema-errata.

The English version of this specification is the only normative version. Information about translations of this document is available at http://www.w3.org/2001/05/xmlschema-translations.

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1 Introduction

1.1 Purpose

The [XML 1.0 (Second Edition)] specification defines limited facilities for applying datatypes to document content in that documents may contain or refer to DTDs that assign types to elements and attributes. However, document authors, including authors of traditional *documents* and those transporting *data* in XML, often require a higher degree of type checking to ensure robustness in document understanding and data interchange.

The table below offers two typical examples of XML instances in which datatypes are implicit: the instance on the left represents a billing invoice, the instance on the right a memo or perhaps an email message in XML.

Data oriented

```
<invoice>
  <orderDate>1999-01-21</orderDate>
  <shipDate>1999-01-25</shipDate>
  <billingAddress>
   <name>Ashok Malhotra</name>
   <street>123 Microsoft Ave.</street>
   <city>Hawthorne</city>
   <state>NY</state>
   <zip>10532-0000</zip>
  </billingAddress>
```

Document oriented

```
<memo importance='high'
      date='1999-03-23'>
  <from>Paul V. Biron</from>
  <to>Ashok Malhotra</to>
  <subject>Latest draft</subject>
  <body>
    We need to discuss the latest
    draft <emph>immediately</emph>.
    Either email me at <email>
    mailto:paul.v.biron@kp.org</email>
```

```
  <voice>555-1234</voice>
  <fax>555-4321</fax>
</invoice>
```

```
    or call <phone>555-9876</phone>
  </body>
</memo>
```

The invoice contains several dates and telephone numbers, the postal abbreviation for a state (which comes from an enumerated list of sanctioned values), and a ZIP code (which takes a definable regular form). The memo contains many of the same types of information: a date, telephone number, email address and an "importance" value (from an enumerated list, such as "low", "medium" or "high"). Applications which process invoices and memos need to raise exceptions if something that was supposed to be a date or telephone number does not conform to the rules for valid dates or telephone numbers.

In both cases, validity constraints exist on the content of the instances that are not expressible in XML DTDs. The limited datatyping facilities in XML have prevented validating XML processors from supplying the rigorous type checking required in these situations. The result has been that individual applications writers have had to implement type checking in an ad hoc manner. This specification addresses the need of both document authors and applications writers for a robust, extensible datatype system for XML which could be incorporated into XML processors. As discussed below, these datatypes could be used in other XML-related standards as well.

1.2 Requirements

The [XML Schema Requirements] document spells out concrete requirements to be fulfilled by this specification, which state that the XML Schema Language must:

1. provide for primitive data typing, including byte, date, integer, sequence, SQL and Java primitive datatypes, etc.;
2. define a type system that is adequate for import/export from database systems (e.g., relational, object, OLAP);
3. distinguish requirements relating to lexical data representation vs. those governing an underlying information set;
4. allow creation of user-defined datatypes, such as datatypes that are derived from existing datatypes and which may constrain certain of its properties (e.g., range, precision, length, format).

1.3 Scope

This portion of the XML Schema Language discusses datatypes that can be used in an XML Schema. These datatypes can be specified for element content that would be specified as #PCDATA and attribute values of various types in a DTD. It is the intention of this specification that it be usable outside of the context of XML Schemas for a wide range of other XML-related activities such as [XSL] and [RDF Schema].

1.4 Terminology

The terminology used to describe XML Schema Datatypes is defined in the body of this specification. The terms defined in the following list are used in building those definitions and in describing the actions of a datatype processor:

[Definition:] for compatibility
A feature of this specification included solely to ensure that schemas which use this feature remain compatible with [XML 1.0 (Second Edition)]

[Definition:] may
Conforming documents and processors are permitted to but need not behave as described.

[Definition:] match
(Of strings or names:) Two strings or names being compared must be identical. Characters with multiple possible representations in ISO/IEC 10646 (e.g. characters with both precomposed and base+diacritic forms) match only if they have the same representation in both strings. No case folding is performed. (Of strings and rules in the grammar:) A string matches a grammatical production if it belongs to the language generated by that production.

[Definition:] must
Conforming documents and processors are required to behave as described; otherwise they are in error .

[Definition:] error
A violation of the rules of this specification; results are undefined. Conforming software may detect and report an **error** and may recover from it.

1.5 Constraints and Contributions

This specification provides three different kinds of normative statements about schema components, their representations in XML and their contribution to the schema-validation of information items:

[Definition:] Constraint on Schemas
Constraints on the schema components themselves, i.e. conditions components must satisfy to be components at all. Largely to be found in Datatype components (§4).

[Definition:] Schema Representation Constraint
Constraints on the representation of schema components in XML. Some but not all of these are expressed in Schema for Datatype Definitions (normative) (§A) and DTD for Datatype Definitions (non-normative) (§B).

[Definition:] Validation Rule
Constraints expressed by schema components which information items must satisfy to be schema-valid. Largely to be found in Datatype components (§4).

2 Type System

This section describes the conceptual framework behind the type system defined in this specification. The framework has been influenced by the [ISO 11404] standard on language-independent datatypes as well as the datatypes for [SQL] and for programming languages such as Java.

The datatypes discussed in this specification are computer representations of well known abstract concepts such as *integer* and *date*. It is not the place of this specification to define these abstract concepts; many other publications provide excellent definitions.

2.1 Datatype

[Definition:] In this specification, a **datatype** is a 3-tuple, consisting of a) a set of distinct values, called its value space , b) a set of lexical representations, called its lexical space , and c) a set of facet s that characterize properties of the value space , individual values or lexical items.

2.2 Value space

[Definition:] A **value space** is the set of values for a given datatype. Each value in the **value space** of a datatype is denoted by one or more literals in its lexical space .

The value space of a given datatype can be defined in one of the following ways:

- defined axiomatically from fundamental notions (intensional definition) [see primitive]
- enumerated outright (extensional definition) [see enumeration]
- defined by restricting the value space of an already defined datatype to a particular subset with a given set of properties [see derived]
- defined as a combination of values from one or more already defined value space (s) by a specific construction procedure [see list and union]

value space s have certain properties. For example, they always have the property of cardinality , some definition of *equality* and might be ordered , by which individual values within the value space can be compared to one another. The properties of value space s that are recognized by this specification are defined in Fundamental facets (§2.4.1).

2.3 Lexical space

In addition to its value space , each datatype also has a lexical space.

[Definition:] A **lexical space** is the set of valid *literals* for a datatype.

For example, "100" and "1.0E2" are two different literals from the lexical space of float which both denote the same value. The type system defined in this specification provides a mechanism for schema designers to control the set of values and the corresponding set of acceptable literals of those values for a datatype.

> **NOTE:** The literals in the lexical space s defined in this specification have the following characteristics:
>
> **Interoperability:**
> The number of literals for each value has been kept small; for many datatypes there is a one-to-one mapping between literals and values. This makes it easy to exchange the values between different systems. In many cases, conversion from locale-dependent representations will be required on both the

originator and the recipient side, both for computer processing and for interaction with humans.

Basic readability:
Textual, rather than binary, literals are used. This makes hand editing, debugging, and similar activities possible.

Ease of parsing and serializing:
Where possible, literals correspond to those found in common programming languages and libraries.

2.3.1 Canonical Lexical Representation

While the datatypes defined in this specification have, for the most part, a single lexical representation i.e. each value in the datatype's value space is denoted by a single literal in its lexical space , this is not always the case. The example in the previous section showed two literals for the datatype float which denote the same value. Similarly, there may be several literals for one of the date or time datatypes that denote the same value using different timezone indicators.

[Definition:] A **canonical lexical representation** is a set of literals from among the valid set of literals for a datatype such that there is a one-to-one mapping between literals in the **canonical lexical representation** and values in the value space .

2.4 Facets

[Definition:] A **facet** is a single defining aspect of a value space . Generally speaking, each facet characterizes a value space along independent axes or dimensions.

The facets of a datatype serve to distinguish those aspects of one datatype which *differ* from other datatypes. Rather than being defined solely in terms of a prose description the datatypes in this specification are defined in terms of the *synthesis* of facet values which together determine the value space and properties of the datatype.

Facets are of two types: *fundamental* facets that define the datatype and *non-fundamental* or *constraining* facets that constrain the permitted values of a datatype.

2.4.1 Fundamental facets

[Definition:] A **fundamental facet** is an abstract property which serves to semantically characterize the values in a value space .

All **fundamental facets** are fully described in Fundamental Facets (§4.2).

2.4.2 Constraining or Non-fundamental facets

[Definition:] A **constraining facet** is an optional property that can be applied to a datatype to constrain its value space .

Constraining the value space consequently constrains the lexical space . Adding constraining facet s to a base type is described in Derivation by restriction (§4.1.2.1).

All **constraining facets** are fully described in Constraining Facets (§4.3).

2.5 Datatype dichotomies

It is useful to categorize the datatypes defined in this specification along various dimensions, forming a set of characterization dichotomies.

2.5.1 Atomic vs. list vs. union datatypes

The first distinction to be made is that between atomic , list and union datatypes.

- [Definition:] **Atomic** datatypes are those having values which are regarded by this specification as being indivisible.

- [Definition:] **List** datatypes are those having values each of which consists of a finite-length (possibly empty) sequence of values of an atomic datatype.
- [Definition:] **Union** datatypes are those whose value space s and lexical space s are the union of the value space s and lexical space s of one or more other datatypes.

For example, a single token which match es Nmtoken from [XML 1.0 (Second Edition)] could be the value of an atomic datatype (NMTOKEN); while a sequence of such tokens could be the value of a list datatype (NMTOKENS).

2.5.1.1 Atomic datatypes

atomic datatypes can be either primitive or derived . The value space of an atomic datatype is a set of "atomic" values, which for the purposes of this specification, are not further decomposable. The lexical space of an atomic datatype is a set of *literals* whose internal structure is specific to the datatype in question.

2.5.1.2 List datatypes

Several type systems (such as the one described in [ISO 11404]) treat list datatypes as special cases of the more general notions of aggregate or collection datatypes.

list datatypes are always derived . The value space of a list datatype is a set of finite-length sequences of atomic values. The lexical space of a list datatype is a set of literals whose internal structure is a white space separated sequence of literals of the atomic datatype of the items in the list (where whitespace match es S in [XML 1.0 (Second Edition)]).

[Definition:] The atomic datatype that participates in the definition of a list datatype is known as the **itemType** of that list datatype.

Example

```
<simpleType name='sizes'>
  <list itemType='decimal'/>
</simpleType>
<cerealSizes xsi:type='sizes'> 8 10.5 12 </cerealSizes>
```

A list datatype can be derived from an atomic datatype whose lexical space allows whitespace (such as string or anyURI). In such a case, regardless of the input, list items will be separated at whitespace boundaries.

Example

```
<simpleType name='listOfString'>
  <list itemType='string'/>
</simpleType>
<someElement xsi:type='listOfString'>
this is not list item 1
this is not list item 2
this is not list item 3
</someElement>
```

In the above example, the value of the *someElement* element is not a list of length 3; rather, it is a list of length 18.

When a datatype is derived from a list datatype, the following constraining facet s apply:

- length
- maxLength
- minLength
- enumeration
- pattern
- whiteSpace

For each of length , maxLength and minLength , the *unit of length* is measured in number of list items. The value of whiteSpace is fixed to the value *collapse*.

The canonical-lexical-representation for the list datatype is defined as the lexical form in which each item in the list has the canonical lexical representation of its itemType .

2.5.1.3 Union datatypes

The value space and lexical space of a union datatype are the union of the value space s and lexical space s of its memberTypes . union datatypes are always derived . Currently, there are no built-in union datatypes.

Example

A prototypical example of a union type is the maxOccurs attribute on the element element in XML Schema itself: it is a union of nonNegativeInteger and an enumeration with the single member, the string "unbounded", as shown below.

```
<attributeGroup name="occurs">
  <attribute name="minOccurs" type="nonNegativeInteger"
       default="1"/>
  <attribute name="maxOccurs">
    <simpleType>
      <union>
        <simpleType>
          <restriction base='nonNegativeInteger'/>
        </simpleType>
        <simpleType>
          <restriction base='string'>
            <enumeration value='unbounded'/>
          </restriction>
        </simpleType>
      </union>
    </simpleType>
  </attribute>
</attributeGroup>
```

Any number (greater than 1) of atomic or list datatype s can participate in a union type.

[Definition:] The datatypes that participate in the definition of a union datatype are known as the **memberTypes** of that union datatype.

The order in which the memberTypes are specified in the definition (that is, the order of the <simpleType> children of the <union> element, or the order of the QNames in the *memberTypes* attribute) is significant. During validation, an element or attribute's value is validated against the memberTypes in the order in which they appear in the definition until a match is found. The evaluation order can be overridden with the use of xsi:type.

Example

For example, given the definition below, the first instance of the <size> element validates correctly as an integer (§3.3.13), the second and third as string (§3.2.1).

```
<xsd:element name='size'>
  <xsd:simpleType>
    <xsd:union>
      <xsd:simpleType>
        <xsd:restriction base='integer'/>
      </xsd:simpleType>
      <xsd:simpleType>
        <xsd:restriction base='string'/>
      </xsd:simpleType>
    </xsd:union>
  </xsd:simpleType>
</xsd:element>
<size>1</size>
<size>large</size>
```

```
<size xsi:type='xsd:string'>1</size>
```

The canonical-lexical-representation for a union datatype is defined as the lexical form in which the values have the canonical lexical representation of the appropriate memberTypes .

> **NOTE:** A datatype which is atomic in this specification need not be an "atomic" datatype in any programming language used to implement this specification. Likewise, a datatype which is a list in this specification need not be a "list" datatype in any programming language used to implement this specification. Furthermore, a datatype which is a union in this specification need not be a "union" datatype in any programming language used to implement this specification.

2.5.2 Primitive vs. derived datatypes

Next, we distinguish between primitive and derived datatypes.

- [Definition:] **Primitive** datatypes are those that are not defined in terms of other datatypes; they exist *ab initio*.
- [Definition:] **Derived** datatypes are those that are defined in terms of other datatypes.

For example, in this specification, float is a well-defined mathematical concept that cannot be defined in terms of other datatypes, while a integer is a special case of the more general datatype decimal.

[Definition:] There exists a conceptual datatype, whose name is **anySimpleType**, that is the simple version of the ur-type definition from [XML Schema Part 1: Structures]. **anySimpleType** can be considered as the base type of all primitive types. The value space of **anySimpleType** can be considered to be the union of the value space s of all primitive datatypes.

The datatypes defined by this specification fall into both the primitive and derived categories. It is felt that a judiciously chosen set of primitive datatypes will serve the widest possible audience by providing a set of convenient datatypes that can be used as is, as well as providing a rich enough base from which the variety of datatypes needed by schema designers can be derived .

In the example above, integer is derived from decimal.

> **NOTE:** A datatype which is primitive in this specification need not be a "primitive" datatype in any programming language used to implement this specification. Likewise, a datatype which is derived in this specification need not be a "derived" datatype in any programming language used to implement this specification.

As described in more detail in XML Representation of Simple Type Definition Schema Components (§4.1.2), each user-derived datatype must be defined in terms of another datatype in one of three ways: 1) by assigning constraining facet s which serve to *restrict* the value space of the user-derived datatype to a subset of that of the base type ; 2) by creating a list datatype whose value space consists of finite-length sequences of values of its itemType ; or 3) by creating a union datatype whose value space consists of the union of the value space its memberTypes .

2.5.2.1 Derived by restriction

[Definition:] A datatype is said to be derived by **restriction** from another datatype when values for zero or more constraining facet s are specified that serve to constrain its value space and/or its lexical space to a subset of those of its base type .

[Definition:] Every datatype that is derived by **restriction** is defined in terms of an existing datatype, referred to as its **base type**. **base type**s can be either primitive or derived .

2.5.2.2 Derived by list

A list datatype can be derived from another datatype (its itemType) by creating a value space that consists of a finite-length sequence of values of its itemType .

2.5.2.3 Derived by union

One datatype can be derived from one or more datatypes by union ing their value space s and, consequently, their lexical space s.

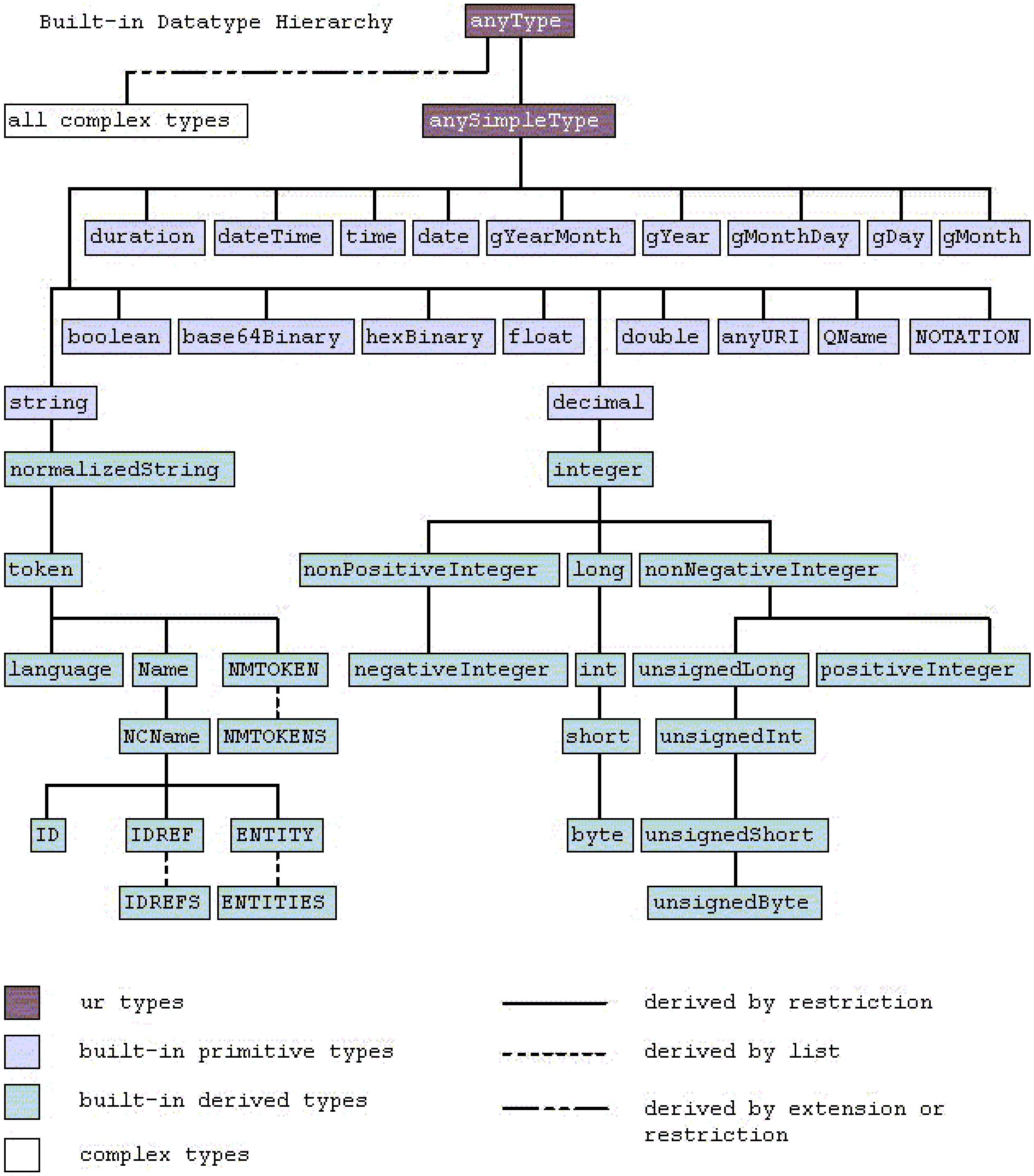
2.5.3 Built-in vs. user-derived datatypes

- [Definition:] **Built-in** datatypes are those which are defined in this specification, and can be either primitive or derived ;
- [Definition:] **User-derived** datatypes are those derived datatypes that are defined by individual schema designers.

Conceptually there is no difference between the built-in derived datatypes included in this specification and the user-derived datatypes which will be created by individual schema designers. The built-in derived datatypes are those which are believed to be so common that if they were not defined in this specification many schema designers would end up "reinventing" them. Furthermore, including these derived datatypes in this specification serves to demonstrate the mechanics and utility of the datatype generation facilities of this specification.

> **NOTE:** A datatype which is built-in in this specification need not be a "built-in" datatype in any programming language used to implement this specification. Likewise, a datatype which is user-derived in this specification need not be a "user-derived" datatype in any programming language used to implement this specification.

3 Built-in datatypes



Each built-in datatype in this specification (both primitive and derived) can be uniquely addressed via a URI Reference constructed as follows:

1. the base URI is the URI of the XML Schema namespace
2. the fragment identifier is the name of the datatype

For example, to address the int datatype, the URI is:

- `http://www.w3.org/2001/XMLSchema#int`

Additionally, each facet definition element can be uniquely addressed via a URI constructed as follows:

1. the base URI is the URI of the XML Schema namespace
2. the fragment identifier is the name of the facet

For example, to address the maxInclusive facet, the URI is:

- `http://www.w3.org/2001/XMLSchema#maxInclusive`

Additionally, each facet usage in a built-in datatype definition can be uniquely addressed via a URI constructed as follows:

1. the base URI is the URI of the XML Schema namespace
2. the fragment identifier is the name of the datatype, followed by a period (".") followed by the name of the facet

For example, to address the usage of the maxInclusive facet in the definition of int, the URI is:

- `http://www.w3.org/2001/XMLSchema#int.maxInclusive`

3.1 Namespace considerations

The built-in datatypes defined by this specification are designed to be used with the XML Schema definition language as well as other XML specifications. To facilitate usage within the XML Schema definition language, the built-in datatypes in this specification have the namespace name:

- http://www.w3.org/2001/XMLSchema

To facilitate usage in specifications other than the XML Schema definition language, such as those that do not want to know anything about aspects of the XML Schema definition language other than the datatypes, each built-in datatype is also defined in the namespace whose URI is:

- http://www.w3.org/2001/XMLSchema-datatypes

This applies to both built-in primitive and built-in derived datatypes.

Each user-derived datatype is also associated with a unique namespace. However, user-derived datatypes do not come from the namespace defined by this specification; rather, they come from the namespace of the schema in which they are defined (see XML Representation of Schemas in [XML Schema Part 1: Structures]).

3.2 Primitive datatypes

The primitive datatypes defined by this specification are described below. For each datatype, the value space and lexical space are defined, constraining facet s which apply to the datatype are listed and any datatypes derived from this datatype are specified.

primitive datatypes can only be added by revisions to this specification.

3.2.1 string

[Definition:] The **string** datatype represents character strings in XML. The value space of **string** is the set of finite-length sequences of characters (as defined in [XML 1.0 (Second Edition)]) that match the Char production from [XML 1.0 (Second Edition)]. A character is an atomic unit of communication; it is not further specified except to note that every character has a corresponding Universal Character Set code point, which is an integer.

> **NOTE:** Many human languages have writing systems that require child elements for control of aspects such as bidirectional formating or ruby annotation (see [Ruby] and Section 8.2.4 Overriding the bidirectional algorithm: the BDO element of [HTML 4.01]). Thus, **string**, as a simple type that can contain only characters but not child elements, is often not suitable for representing text. In such situations, a complex type that allows mixed content should be considered. For more information, see Section 5.5 Any Element, Any Attribute of [XML Schema Language: Part 2 Primer].

> **NOTE:** As noted in ordered, the fact that this specification does not specify an order-relation for string does not preclude other applications from treating strings as being ordered.

3.2.1.1 Constraining facets

string has the following constraining facets :

- length
- minLength
- maxLength
- pattern
- enumeration
- whiteSpace

3.2.1.2 Derived datatypes

The following built-in datatypes are derived from **string**:

- normalizedString

3.2.2 boolean

[Definition:] **boolean** has the value space required to support the mathematical concept of binary-valued logic: {true, false}.

3.2.2.1 Lexical representation

An instance of a datatype that is defined as boolean can have the following legal literals {true, false, 1, 0}.

3.2.2.2 Canonical representation

The canonical representation for **boolean** is the set of literals {true, false}.

3.2.2.3 Constraining facets

boolean has the following constraining facets :

- pattern
- whiteSpace

3.2.3 decimal

[Definition:] **decimal** represents arbitrary precision decimal numbers. The value space of **decimal** is the set of the values $i \times 10^{-n}$, where i and n are integers such that $n >= 0$. The order-relation on **decimal** is: $x < y$ iff $y - x$ is positive.

[Definition:] The value space of types derived from **decimal** with a value for totalDigits of p is the set of values $i \times 10^{-n}$, where *n* and *i* are integers such that *p >= n >= 0* and the number of significant decimal digits in *i* is less than or equal to *p*.

[Definition:] The value space of types derived from **decimal** with a value for fractionDigits of *s* is the set of values *i × 10^-n*, where *i* and *n* are integers such that *0 <= n <= s*.

> **NOTE:** All minimally conforming processors must support decimal numbers with a minimum of 18 decimal digits (i.e., with a totalDigits of 18). However, minimally conforming processors may set an application-defined limit on the maximum number of decimal digits they are prepared to support, in which case that application-defined maximum number must be clearly documented.

3.2.3.1 Lexical representation

decimal has a lexical representation consisting of a finite-length sequence of decimal digits (#x30-#x39) separated by a period as a decimal indicator. If totalDigits is specified, the number of digits must be less than or equal to totalDigits . If fractionDigits is specified, the number of digits following the decimal point must be less than or equal to the fractionDigits . An optional leading sign is allowed. If the sign is omitted, "+" is assumed. Leading and trailing zeroes are optional. If the fractional part is zero, the period and following zero(es) can be omitted. For example: `-1.23, 12678967.543233, +100000.00, 210`.

3.2.3.2 Canonical representation

The canonical representation for **decimal** is defined by prohibiting certain options from the Lexical representation (§3.2.3.1). Specifically, the preceding optional "+" sign is prohibited. The decimal point is required. Leading and trailing zeroes are prohibited subject to the following: there must be at least one digit to the right and to the left of the decimal point which may be a zero.

3.2.3.3 Constraining facets

decimal has the following constraining facets :

- totalDigits
- fractionDigits
- pattern
- whiteSpace
- enumeration
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.2.3.4 Derived datatypes

The following built-in datatypes are derived from **decimal**:

- integer

3.2.4 float

[Definition:] **float** corresponds to the IEEE single-precision 32-bit floating point type [IEEE 754-1985]. The basic value space of **float** consists of the values *m × 2^e*, where *m* is an integer whose absolute value is less than *2^24*, and *e* is an integer between -149 and 104, inclusive. In addition to the basic value space described above, the value space of **float** also contains the following *special values*: positive and negative zero, positive and negative infinity and not-a-number. The order-relation on **float** is: *x < y iff y - x* is positive. Positive zero is greater than negative zero. Not-a-number equals itself and is greater than all float values values including positive infinity.

A literal in the lexical space representing a decimal number *d* maps to the normalized value in the value space of **float** that is closest to *d* in the sense defined by [Clinger, WD (1990)]; if *d* is exactly halfway between two such values then the even value is chosen.

3.2.4.1 Lexical representation

float values have a lexical representation consisting of a mantissa followed, optionally, by the character "E" or "e", followed by an exponent. The exponent must be an integer. The mantissa must be a decimal number. The representations for exponent and mantissa must follow the lexical rules for integer and decimal. If the "E" or "e" and the following exponent are omitted, an exponent value of 0 is assumed.

The *special values* positive and negative zero, positive and negative infinity and not-a-number have lexical representations `0`, `-0`, `INF`, `-INF` and `NaN`, respectively.

For example, `-1E4, 1267.43233E12, 12.78e-2, 12 and INF` are all legal literals for **float**.

3.2.4.2 Canonical representation

The canonical representation for **float** is defined by prohibiting certain options from the Lexical representation (§3.2.4.1). Specifically, the exponent must be indicated by "E". Leading zeroes and the preceding optional "+" sign are prohibited in the exponent. For the mantissa, the preceding optional "+" sign is prohibited and the decimal point is required. For the exponent, the preceding optional "+" sign is prohibited. Leading and trailing zeroes are prohibited subject to the following: number representations must be normalized such that there is a single digit to the left of the decimal point and at least a single digit to the right of the decimal point.

3.2.4.3 Constraining facets

float has the following constraining facets :

- pattern
- enumeration
- whiteSpace
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.2.5 double

[Definition:] The **double** datatype corresponds to IEEE double-precision 64-bit floating point type [IEEE 754-1985]. The basic value space of **double** consists of the values *m* × *2^e*, where *m* is an integer whose absolute value is less than *2^53*, and *e* is an integer between -1075 and 970, inclusive. In addition to the basic value space described above, the value space of **double** also contains the following *special values*: positive and negative zero, positive and negative infinity and not-a-number. The order-relation on **double** is: *x* < *y iff y - x* is positive. Positive zero is greater than negative zero. Not-a-number equals itself and is greater greater than all double values including positive infinity.

A literal in the lexical space representing a decimal number *d* maps to the normalized value in the value space of **double** that is closest to *d*; if *d* is exactly halfway between two such values then the even value is chosen. This is the *best approximation* of *d* ([Clinger, WD (1990)], [Gay, DM (1990)]), which is more accurate than the mapping required by [IEEE 754-1985].

3.2.5.1 Lexical representation

double values have a lexical representation consisting of a mantissa followed, optionally, by the character "E" or "e", followed by an exponent. The exponent must be an integer. The mantissa must be a decimal number. The representations for exponent and mantissa must follow the lexical rules for integer and decimal. If the "E" or "e" and the following exponent are omitted, an exponent value of 0 is assumed.

The *special values* positive and negative zero, positive and negative infinity and not-a-number have lexical representations `0`, `-0`, `INF`, `-INF` and `NaN`, respectively.

For example, `-1E4, 1267.43233E12, 12.78e-2, 12 and INF` are all legal literals for **double**.

3.2.5.2 Canonical representation

The canonical representation for **double** is defined by prohibiting certain options from the Lexical representation (§3.2.5.1). Specifically, the exponent must be indicated by "E". Leading zeroes and the preceding optional "+" sign are prohibited in the exponent. For the mantissa, the preceding optional "+" sign is prohibited and the decimal point is required. For the exponent, the preceding optional "+" sign is prohibited. Leading and trailing zeroes are prohibited subject to the following: number representations must be normalized such that there is a single digit to the left of the decimal point and at least a single digit to the right of the decimal point.

3.2.5.3 Constraining facets

double has the following constraining facets :

- pattern
- enumeration
- whiteSpace
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.2.6 duration

[Definition:] **duration** represents a duration of time. The value space of **duration** is a six-dimensional space where the coordinates designate the Gregorian year, month, day, hour, minute, and second components defined in § 5.5.3.2 of [ISO 8601], respectively. These components are ordered in their significance by their order of appearance i.e. as year, month, day, hour, minute, and second.

3.2.6.1 Lexical representation

The lexical representation for **duration** is the [ISO 8601] extended format P*n*Y*n* M*n*DT*n*H *n*M*n*S, where *n*Y represents the number of years, *n*M the number of months, *n*D the number of days, 'T' is the date/time separator, *n*H the number of hours, *n*M the number of minutes and *n*S the number of seconds. The number of seconds can include decimal digits to arbitrary precision.

The values of the Year, Month, Day, Hour and Minutes components are not restricted but allow an arbitrary integer. Similarly, the value of the Seconds component allows an arbitrary decimal. Thus, the lexical representation of **duration** does not follow the alternative format of § 5.5.3.2.1 of [ISO 8601].

An optional preceding minus sign ('-') is allowed, to indicate a negative duration. If the sign is omitted a positive duration is indicated. See also ISO 8601 Date and Time Formats (§D).

For example, to indicate a duration of 1 year, 2 months, 3 days, 10 hours, and 30 minutes, one would write: `P1Y2M3DT10H30M`. One could also indicate a duration of minus 120 days as: `-P120D`.

Reduced precision and truncated representations of this format are allowed provided they conform to the following:

- If the number of years, months, days, hours, minutes, or seconds in any expression equals zero, the number and its corresponding designator may be omitted. However, at least one number and its designator must be present.
- The seconds part may have a decimal fraction.
- The designator 'T' shall be absent if all of the time items are absent. The designator 'P' must always be present.

For example, P1347Y, P1347M and P1Y2MT2H are all allowed; P0Y1347M and P0Y1347M0D are allowed. P-1347M is not allowed although -P1347M is allowed. P1Y2MT is not allowed.

3.2.6.2 Order relation on duration

In general, the order-relation on **duration** is a partial order since there is no determinate relationship between certain durations such as one month (P1M) and 30 days (P30D). The order-relation of two **duration** values *x* and *y* is *x* < *y* *iff s*+*x* < *s*+*y* for each qualified dateTime *s* in the list below. These values for *s* cause the greatest deviations in the addition of dateTimes and durations. Addition of durations to time instants is defined in Adding durations to dateTimes (§E).

- 1696-09-01T00:00:00Z
- 1697-02-01T00:00:00Z
- 1903-03-01T00:00:00Z

- 1903-07-01T00:00:00Z

The following table shows the strongest relationship that can be determined between example durations. The symbol <> means that the order relation is indeterminate. Note that because of leap-seconds, a seconds field can vary from 59 to 60. However, because of the way that addition is defined in Adding durations to dateTimes (§E), they are still totally ordered.

	Relation					
P1Y	> P364D	<> P365D			<> P366D	< P367D
P1M	> P27D	<> P28D	<> P29D	<> P30D	<> P31D	< P32D
P5M	> P149D	<> P150D	<> P151D	<> P152D	<> P153D	< P154D

Implementations are free to optimize the computation of the ordering relationship. For example, the following table can be used to compare durations of a small number of months against days.

	Months	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**...**
Days	**Minimum**	28	59	89	120	150	181	212	242	273	303	334	365	393	...
	Maximum	31	62	92	123	153	184	215	245	276	306	337	366	397	...

3.2.6.3 Facet Comparison for durations

In comparing **duration** values with minInclusive, minExclusive, maxInclusive and maxExclusive facet values indeterminate comparisons should be considered as "false".

3.2.6.4 Totally ordered durations

Certain derived datatypes of durations can be guaranteed have a total order. For this, they must have fields from only one row in the list below and the time zone must either be required or prohibited.

- year, month
- day, hour, minute, second

For example, a datatype could be defined to correspond to the [SQL] datatype Year-Month interval that required a four digit year field and a two digit month field but required all other fields to be unspecified. This datatype could be defined as below and would have a total order.

```
<simpleType name='SQL-Year-Month-Interval'>
    <restriction base='duration'>
      <pattern value='P\p{Nd}{4}Y\p{Nd}{2}M'/>
    </restriction>
</simpleType>
```

3.2.6.5 Constraining facets

duration has the following constraining facets :

- pattern
- enumeration
- whiteSpace
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.2.7 dateTime

[Definition:] **dateTime** represents a specific instant of time. The value space of **dateTime** is the space of *Combinations of date* *and time of day* values as defined in § 5.4 of [ISO 8601].

3.2.7.1 Lexical representation

A single lexical representation, which is a subset of the lexical representations allowed by [ISO 8601], is allowed for **dateTime**. This lexical representation is the [ISO 8601] extended format CCYY-MM-DDThh:mm:ss where "CC" represents the century, "YY" the year, "MM" the month and "DD" the day, preceded by an optional leading "-" sign to indicate a negative number. If the sign is omitted, "+" is assumed. The letter "T" is the date/time separator and "hh", "mm", "ss" represent hour, minute and second respectively. Additional digits can be used to increase the precision of fractional seconds if desired i.e the format ss.ss... with any number of digits after the decimal point is supported. The fractional seconds part is optional; other parts of the lexical form are not optional. To accommodate year values greater than 9999 additional digits can be added to the left of this representation. Leading zeros are required if the year value would otherwise have fewer than four digits; otherwise they are forbidden. The year 0000 is prohibited.

The CCYY field must have at least four digits, the MM, DD, SS, hh, mm and ss fields exactly two digits each (not counting fractional seconds); leading zeroes must be used if the field would otherwise have too few digits.

This representation may be immediately followed by a "Z" to indicate Coordinated Universal Time (UTC) or, to indicate the time zone, i.e. the difference between the local time and Coordinated Universal Time, immediately followed by a sign, + or -, followed by the difference from UTC represented as hh:mm (note: the minutes part is required). See ISO 8601 Date and Time Formats (§D) for details about legal values in the various fields. If the time zone is included, both hours and minutes must be present.

For example, to indicate 1:20 pm on May the 31st, 1999 for Eastern Standard Time which is 5 hours behind Coordinated Universal Time (UTC), one would write: `1999-05-31T13:20:00-05:00`.

3.2.7.2 Canonical representation

The canonical representation for **dateTime** is defined by prohibiting certain options from the Lexical representation (§3.2.7.1). Specifically, either the time zone must be omitted or, if present, the time zone must be Coordinated Universal Time (UTC) indicated by a "Z".

3.2.7.3 Order relation on dateTime

In general, the order-relation on **dateTime** is a partial order since there is no determinate relationship between certain instants. For example, there is no determinate ordering between (a) 2000-01-20T12:00:00 and (b) 2000-01-20T12:00:00**Z**. Based on timezones currently in use, (c) could vary from 2000-01-20T12:00:00+12:00 to 2000-01-20T12:00:00-13:00. It is, however, possible for this range to expand or contract in the future, based on local laws. Because of this, the following definition uses a somewhat broader range of indeterminate values: +14:00..-14:00.

The following definition uses the notation S[year] to represent the year field of S, S[month] to represent the month field, and so on. The notation (Q & "-14:00") means adding the timezone -14:00 to Q, where Q did not already have a timezone. *This is a logical explanation of the process. Actual implementations are free to optimize as long as they produce the same results.*

The ordering between two **dateTime**s P and Q is defined by the following algorithm:

A.Normalize P and Q. That is, if there is a timezone present, but it is not Z, convert it to Z using the addition operation defined in Adding durations to dateTimes (§E)

- Thus 2000-03-04T23:00:00+03:00 normalizes to 2000-03-04T20:00:00Z

B. If P and Q either both have a time zone or both do not have a time zone, compare P and Q field by field from the year field down to the second field, and return a result as soon as it can be determined. That is:

1. For each i in {year, month, day, hour, minute, second}
    1. If P[i] and Q[i] are both not specified, continue to the next i
    2. If P[i] is not specified and Q[i] is, or vice versa, stop and return P <> Q
    3. If P[i] < Q[i], stop and return P < Q
    4. If P[i] > Q[i], stop and return P > Q
2. Stop and return P = Q

C.Otherwise, if P contains a time zone and Q does not, compare as follows:

1. P < Q if P < (Q with time zone +14:00)
2. P > Q if P > (Q with time zone -14:00)
3. P <> Q otherwise, that is, if (Q with time zone +14:00) < P < (Q with time zone -14:00)

D. Otherwise, if P does not contain a time zone and Q does, compare as follows:

1. P < Q if (P with time zone -14:00) < Q.
2. P > Q if (P with time zone +14:00) > Q.
3. P <> Q otherwise, that is, if (P with time zone +14:00) < Q < (P with time zone -14:00)

Examples:

Determinate	**Indeterminate**
2000-01-15T00:00:00 **<** 2000-02-15T00:00:00	2000-01-01T12:00:00 **<>** 1999-12-31T23:00:00Z
2000-01-15T12:00:00 **<** 2000-01-16T12:00:00Z	2000-01-16T12:00:00 **<>** 2000-01-16T12:00:00Z
	2000-01-16T00:00:00 **<>** 2000-01-16T12:00:00Z

3.2.7.4 Totally ordered dateTimes

Certain derived types from **dateTime** can be guaranteed have a total order. To do so, they must require that a specific set of fields are always specified, and that remaining fields (if any) are always unspecified. For example, the date datatype without time zone is defined to contain exactly year, month, and day. Thus dates without time zone have a total order among themselves.

3.2.7.5 Constraining facets

dateTime has the following constraining facets :

- pattern
- enumeration
- whiteSpace
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.2.8 time

[Definition:] **time** represents an instant of time that recurs every day. The value space of **time** is the space of *time of day* values as defined in § 5.3 of [ISO 8601]. Specifically, it is a set of zero-duration daily time instances.

Since the lexical representation allows an optional time zone indicator, **time** values are partially ordered because it may not be able to determine the order of two values one of which has a time zone and the other does not. The order relation on **time** values is the Order relation on dateTime (§3.2.7.3) using an arbitrary date. See also Adding durations to dateTimes (§E). Pairs of **time** values with or without time zone indicators are totally ordered.

3.2.8.1 Lexical representation

The lexical representation for **time** is the left truncated lexical representation for dateTime: hh:mm:ss.sss with optional following time zone indicator. For example, to indicate 1:20 pm for Eastern Standard Time which is 5 hours behind Coordinated Universal Time (UTC), one would write: 13:20:00-05:00. See also ISO 8601 Date and Time Formats (§D).

3.2.8.2 Canonical representation

The canonical representation for **time** is defined by prohibiting certain options from the Lexical representation (§3.2.8.1). Specifically, either the time zone must be omitted or, if present, the time zone must be Coordinated Universal Time (UTC) indicated by a "Z". Additionally, the canonical representation for midnight is 00:00:00.

3.2.8.3 Constraining facets

time has the following constraining facets :

- pattern
- enumeration
- whiteSpace
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.2.9 date

[Definition:] **date** represents a calendar date. The value space of **date** is the set of Gregorian calendar dates as defined in § 5.2.1 of [ISO 8601]. Specifically, it is a set of one-day long, non-periodic instances e.g. lexical 1999-10-26 to represent the calendar date 1999-10-26, independent of how many hours this day has.

Since the lexical representation allows an optional time zone indicator, **date** values are partially ordered because it may not be possible to unequivocally determine the order of two values one of which has a time zone and the other does not. If **date** values are considered as periods of time, the order relation on **date** values is the order relation on their starting instants. This is discussed in Order relation on dateTime (§3.2.7.3). See also Adding durations to dateTimes (§E). Pairs of **date** values with or without time zone indicators are totally ordered.

3.2.9.1 Lexical representation

The lexical representation for **date** is the reduced (right truncated) lexical representation for dateTime: CCYY-MM-DD. No left truncation is allowed. An optional following time zone qualifier is allowed as for dateTime. To accommodate year values outside the range from 0001 to 9999, additional digits can be added to the left of this representation and a preceding "-" sign is allowed.

For example, to indicate May the 31st, 1999, one would write: 1999-05-31. See also ISO 8601 Date and Time Formats (§D).

3.2.9.2 Constraining facets

date has the following constraining facets :

- pattern
- enumeration
- whiteSpace
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.2.10 gYearMonth

[Definition:] **gYearMonth** represents a specific gregorian month in a specific gregorian year. The value space of **gYearMonth** is the set of Gregorian calendar months as defined in § 5.2.1 of [ISO 8601]. Specifically, it is a set of one-month long, non-periodic instances e.g. 1999-10 to represent the whole month of 1999-10, independent of how many days this month has.

Since the lexical representation allows an optional time zone indicator, **gYearMonth** values are partially ordered because it may not be possible to unequivocally determine the order of two values one of which has a time zone and the other does not. If **gYearMonth** values are considered as periods of time, the order relation on **gYearMonth** values is the order relation on their starting instants. This is discussed in Order relation on dateTime (§3.2.7.3). See also Adding durations to dateTimes (§E). Pairs of **gYearMonth** values with or without time zone indicators are totally ordered.

> **NOTE:** Because month/year combinations in one calendar only rarely correspond to month/year combinations in other calendars, values of this type are not, in general, convertible to simple values corresponding to month/year

> combinations in other calendars. This type should therefore be used with caution in contexts where conversion to other calendars is desired.

3.2.10.1 Lexical representation

The lexical representation for **gYearMonth** is the reduced (right truncated) lexical representation for dateTime: CCYY-MM. No left truncation is allowed. An optional following time zone qualifier is allowed. To accommodate year values outside the range from 0001 to 9999, additional digits can be added to the left of this representation and a preceding "-" sign is allowed.

For example, to indicate the month of May 1999, one would write: 1999-05. See also ISO 8601 Date and Time Formats (§D).

3.2.10.2 Constraining facets

gYearMonth has the following constraining facets :

- pattern
- enumeration
- whiteSpace
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.2.11 gYear

[Definition:] **gYear** represents a gregorian calendar year. The value space of **gYear** is the set of Gregorian calendar years as defined in § 5.2.1 of [ISO 8601]. Specifically, it is a set of one-year long, non-periodic instances e.g. lexical 1999 to represent the whole year 1999, independent of how many months and days this year has.

Since the lexical representation allows an optional time zone indicator, **gYear** values are partially ordered because it may not be possible to unequivocally determine the order of two values one of which has a time zone and the other does not. If **gYear** values are considered as periods of time, the order relation on **gYear** values is the order relation on their starting instants. This is discussed in Order relation on dateTime (§3.2.7.3). See also Adding durations to dateTimes (§E). Pairs of **gYear** values with or without time zone indicators are totally ordered.

> **NOTE:** Because years in one calendar only rarely correspond to years in other calendars, values of this type are not, in general, convertible to simple values corresponding to years in other calendars. This type should therefore be used with caution in contexts where conversion to other calendars is desired.

3.2.11.1 Lexical representation

The lexical representation for **gYear** is the reduced (right truncated) lexical representation for dateTime: CCYY. No left truncation is allowed. An optional following time zone qualifier is allowed as for dateTime. To accommodate year values outside the range from 0001 to 9999, additional digits can be added to the left of this representation and a preceding "-" sign is allowed.

For example, to indicate 1999, one would write: 1999. See also ISO 8601 Date and Time Formats (§D).

3.2.11.2 Constraining facets

gYear has the following constraining facets :

- pattern
- enumeration
- whiteSpace
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.2.12 gMonthDay

[Definition:] **gMonthDay** is a gregorian date that recurs, specifically a day of the year such as the third of May. Arbitrary recurring dates are not supported by this datatype. The value space of **gMonthDay** is the set of *calendar dates*, as defined in § 3 of [ISO 8601]. Specifically, it is a set of one-day long, annually periodic instances.

Since the lexical representation allows an optional time zone indicator, **gMonthDay** values are partially ordered because it may not be possible to unequivocally determine the order of two values one of which has a time zone and the other does not. If **gMonthDay** values are considered as periods of time, the order relation on **gMonthDay** values is the order relation on their starting instants. This is discussed in Order relation on dateTime (§3.2.7.3). See also Adding durations to dateTimes (§E). Pairs of **gMonthDay** values with or without time zone indicators are totally ordered.

> **NOTE:** Because day/month combinations in one calendar only rarely correspond to day/month combinations in other calendars, values of this type do not, in general, have any straightforward or intuitive representation in terms of most other calendars. This type should therefore be used with caution in contexts where conversion to other calendars is desired.

3.2.12.1 Lexical representation

The lexical representation for **gMonthDay** is the left truncated lexical representation for date: --MM-DD. An optional following time zone qualifier is allowed as for date. No preceding sign is allowed. No other formats are allowed. See also ISO 8601 Date and Time Formats (§D).

This datatype can be used to represent a specific day in a month. To say, for example, that my birthday occurs on the 14th of September ever year.

3.2.12.2 Constraining facets

gMonthDay has the following constraining facets :

- pattern
- enumeration
- whiteSpace
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.2.13 gDay

[Definition:] **gDay** is a gregorian day that recurs, specifically a day of the month such as the 5th of the month. Arbitrary recurring days are not supported by this datatype. The value space of **gDay** is the space of a set of *calendar dates* as defined in § 3 of [ISO 8601]. Specifically, it is a set of one-day long, monthly periodic instances.

This datatype can be used to represent a specific day of the month. To say, for example, that I get my paycheck on the 15th of each month.

Since the lexical representation allows an optional time zone indicator, **gDay** values are partially ordered because it may not be possible to unequivocally determine the order of two values one of which has a time zone and the other does not. If **gDay** values are considered as periods of time, the order relation on **gDay** values is the order relation on their starting instants. This is discussed in Order relation on dateTime (§3.2.7.3). See also Adding durations to dateTimes (§E). Pairs of **gDay** values with or without time zone indicators are totally ordered.

> **NOTE:** Because days in one calendar only rarely correspond to days in other calendars, values of this type do not, in general, have any straightforward or intuitive representation in terms of most other calendars. This type should therefore be used with caution in contexts where conversion to other calendars is desired.

3.2.13.1 Lexical representation

The lexical representation for **gDay** is the left truncated lexical representation for date: ---DD . An optional following time zone qualifier is allowed as for date. No preceding sign is allowed. No other formats are allowed. See also ISO 8601 Date and Time Formats (§D).

3.2.13.2 Constraining facets

gDay has the following constraining facets :

- pattern
- enumeration
- whiteSpace
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.2.14 gMonth

[Definition:] **gMonth** is a gregorian month that recurs every year. The value space of **gMonth** is the space of a set of *calendar months* as defined in § 3 of [ISO 8601]. Specifically, it is a set of one-month long, yearly periodic instances.

This datatype can be used to represent a specific month. To say, for example, that Thanksgiving falls in the month of November.

Since the lexical representation allows an optional time zone indicator, **gMonth** values are partially ordered because it may not be possible to unequivocally determine the order of two values one of which has a time zone and the other does not. If **gMonth** values are considered as periods of time, the order relation on **gMonth** is the order relation on their starting instants. This is discussed in Order relation on dateTime (§3.2.7.3). See also Adding durations to dateTimes (§E). Pairs of **gMonth** values with or without time zone indicators are totally ordered.

> **NOTE:** Because months in one calendar only rarely correspond to months in other calendars, values of this type do not, in general, have any straightforward or intuitive representation in terms of most other calendars. This type should therefore be used with caution in contexts where conversion to other calendars is desired.

3.2.14.1 Lexical representation

The lexical representation for **gMonth** is the left and right truncated lexical representation for date: --MM--. An optional following time zone qualifier is allowed as for date. No preceding sign is allowed. No other formats are allowed. See also ISO 8601 Date and Time Formats (§D).

3.2.14.2 Constraining facets

gMonth has the following constraining facets :

- pattern
- enumeration
- whiteSpace
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.2.15 hexBinary

[Definition:] **hexBinary** represents arbitrary hex-encoded binary data. The value space of **hexBinary** is the set of finite-length sequences of binary octets.

3.2.15.1 Lexical Representation

hexBinary has a lexical representation where each binary octet is encoded as a character tuple, consisting of two hexadecimal digits ([0-9a-fA-F]) representing the octet code. For example, "0FB7" is a *hex* encoding for the 16-bit integer 4023 (whose binary representation is 111110110111).

3.2.15.2 Canonical Rrepresentation

The canonical representation for **hexBinary** is defined by prohibiting certain options from the Lexical Representation (§3.2.15.1). Specifically, the lower case hexadecimal digits ([a-f]) are not allowed.

3.2.15.3 Constraining facets

hexBinary has the following constraining facets :

- length
- minLength
- maxLength
- pattern
- enumeration
- whiteSpace

3.2.16 base64Binary

[Definition:] **base64Binary** represents Base64-encoded arbitrary binary data. The value space of **base64Binary** is the set of finite-length sequences of binary octets. For **base64Binary** data the entire binary stream is encoded using the Base64 Content-Transfer-Encoding defined in Section 6.8 of [RFC 2045].

3.2.16.1 Constraining facets

base64Binary has the following constraining facets :

- length
- minLength
- maxLength
- pattern
- enumeration
- whiteSpace

3.2.17 anyURI

[Definition:] **anyURI** represents a Uniform Resource Identifier Reference (URI). An **anyURI** value can be absolute or relative, and may have an optional fragment identifier (i.e., it may be a URI Reference). This type should be used to specify the intention that the value fulfills the role of a URI as defined by [RFC 2396], as amended by [RFC 2732].

The mapping from **anyURI** values to URIs is as defined in Section 5.4 Locator Attribute of [XML Linking Language] (see also Section 8 Character Encoding in URI References of [Character Model]). This means that a wide range of internationalized resource identifiers can be specified when an **anyURI** is called for, and still be understood as URIs per [RFC 2396], as amended by [RFC 2732], where appropriate to identify resources.

> **NOTE:** Each URI scheme imposes specialized syntax rules for URIs in that scheme, including restrictions on the syntax of allowed fragement identifiers. Because it is impractical for processors to check that a value is a context-appropriate URI reference, this specification follows the lead of [RFC 2396] (as amended by [RFC 2732]) in this matter: such rules and restrictions are not part of type validity and are not checked by minimally conforming processors. Thus in practice the above definition imposes only very modest obligations on minimally conforming processors.

3.2.17.1 Lexical representation

The lexical space of **anyURI** is finite-length character sequences which, when the algorithm defined in Section 5.4 of [XML Linking Language] is applied to them, result in strings which are legal URIs according to [RFC 2396], as amended by [RFC 2732].

> **NOTE:** Spaces are, in principle, allowed in the lexical space of **anyURI**, however, their use is highly discouraged (unless they are encoded by %20).

3.2.17.2 Constraining facets

anyURI has the following constraining facets :

- length
- minLength
- maxLength
- pattern
- enumeration
- whiteSpace

3.2.18 QName

[Definition:] **QName** represents XML qualified names. The value space of **QName** is the set of tuples {namespace name, local part}, where namespace name is an anyURI and local part is an NCName. The lexical space of **QName** is the set of strings that match the QName production of [Namespaces in XML].

> **NOTE:** The mapping between literals in the lexical space and values in the value space of **QName** requires a namespace declaration to be in scope for the context in which **QName** is used.

3.2.18.1 Constraining facets

QName has the following constraining facets :

- length
- minLength
- maxLength
- pattern
- enumeration
- whiteSpace

3.2.19 NOTATION

[Definition:] **NOTATION** represents the NOTATION attribute type from [XML 1.0 (Second Edition)]. The value space of **NOTATION** is the set QNames. The lexical space of **NOTATION** is the set of all names of notations declared in the current schema.

Schema Component Constraint: enumeration facet value required for NOTATION
It is an error for **NOTATION** to be used directly in a schema. Only datatypes that are derived from **NOTATION** by specifying a value for enumeration can be used in a schema.

For compatibility (see Terminology (§1.4)) **NOTATION** should be used only on attributes.

3.2.19.1 Constraining facets

NOTATION has the following constraining facets :

- length
- minLength
- maxLength
- pattern
- enumeration
- whiteSpace

3.3 Derived datatypes

This section gives conceptual definitions for all built-in derived datatypes defined by this specification. The XML representation used to define derived datatypes (whether built-in or user-derived) is given in section XML Representation of Simple Type Definition Schema Components (§4.1.2) and the complete definitions of the built-in derived datatypes are provided in Appendix A Schema for Datatype Definitions (normative) (§A).

3.3.1 normalizedString

[Definition:] **normalizedString** represents white space normalized strings. The value space of **normalizedString** is the set of strings that do not contain the carriage return (#xD), line feed (#xA) nor tab (#x9) characters. The lexical space of **normalizedString** is the set of strings that do not contain the carriage return (#xD) nor tab (#x9) characters. The base type of **normalizedString** is string.

3.3.1.1 Constraining facets

normalizedString has the following constraining facets :

- length
- minLength
- maxLength
- pattern
- enumeration
- whiteSpace

3.3.1.2 Derived datatypes

The following built-in datatypes are derived from **normalizedString**:

- token

3.3.2 token

[Definition:] **token** represents tokenized strings. The value space of **token** is the set of strings that do not contain the line feed (#xA) nor tab (#x9) characters, that have no leading or trailing spaces (#x20) and that have no internal sequences of two or more spaces. The lexical space of **token** is the set of strings that do not contain the line feed (#xA) nor tab (#x9) characters, that have no leading or trailing spaces (#x20) and that have no internal sequences of two or more spaces. The base type of **token** is normalizedString.

3.3.2.1 Constraining facets

token has the following constraining facets :

- length
- minLength

- maxLength
- pattern
- enumeration
- whiteSpace

3.3.2.2 Derived datatypes

The following built-in datatypes are derived from **token**:

- language
- NMTOKEN
- Name

3.3.3 language

[Definition:] **language** represents natural language identifiers as defined by [RFC 1766]. The value space of **language** is the set of all strings that are valid language identifiers as defined in the language identification section of [XML 1.0 (Second Edition)]. The lexical space of **language** is the set of all strings that are valid language identifiers as defined in the language identification section of [XML 1.0 (Second Edition)]. The base type of **language** is token.

3.3.3.1 Constraining facets

language has the following constraining facets :

- length
- minLength
- maxLength
- pattern
- enumeration
- whiteSpace

3.3.4 NMTOKEN

[Definition:] **NMTOKEN** represents the NMTOKEN attribute type from [XML 1.0 (Second Edition)]. The value space of **NMTOKEN** is the set of tokens that match the Nmtoken production in [XML 1.0 (Second Edition)]. The lexical space of **NMTOKEN** is the set of strings that match the Nmtoken production in [XML 1.0 (Second Edition)]. The base type of **NMTOKEN** is token.

For compatibility (see Terminology (§1.4)) **NMTOKEN** should be used only on attributes.

3.3.4.1 Constraining facets

NMTOKEN has the following constraining facets :

- length
- minLength
- maxLength
- pattern
- enumeration
- whiteSpace

3.3.4.2 Derived datatypes

The following built-in datatypes are derived from **NMTOKEN**:

- NMTOKENS

3.3.5 NMTOKENS

[Definition:] **NMTOKENS** represents the NMTOKENS attribute type from [XML 1.0 (Second Edition)]. The value space of **NMTOKENS** is the set of finite, non-zero-length sequences of NMTOKEN s. The lexical space of **NMTOKENS** is the set of white space separated lists of tokens, of which each token is in the lexical space of NMTOKEN. The itemType of **NMTOKENS** is NMTOKEN.

For compatibility (see Terminology (§1.4)) **NMTOKENS** should be used only on attributes.

3.3.5.1 Constraining facets

NMTOKENS has the following constraining facets :

- length
- minLength
- maxLength
- enumeration
- whiteSpace

3.3.6 Name

[Definition:] **Name** represents XML Names. The value space of **Name** is the set of all strings which match the Name production of [XML 1.0 (Second Edition)]. The lexical space of **Name** is the set of all strings which match the Name production of [XML 1.0 (Second Edition)]. The base type of **Name** is token.

3.3.6.1 Constraining facets

Name has the following constraining facets :

- length
- minLength
- maxLength
- pattern
- enumeration
- whiteSpace

3.3.6.2 Derived datatypes

The following built-in datatypes are derived from **Name**:

- NCName

3.3.7 NCName

[Definition:] **NCName** represents XML "non-colonized" Names. The value space of **NCName** is the set of all strings which match the NCName production of [Namespaces in XML]. The lexical space of **NCName** is the set of all strings which match the NCName production of [Namespaces in XML]. The base type of **NCName** is Name.

3.3.7.1 Constraining facets

NCName has the following constraining facets :

- length
- minLength
- maxLength
- pattern
- enumeration
- whiteSpace

3.3.7.2 Derived datatypes

The following built-in datatypes are derived from **NCName**:

- ID
- IDREF
- ENTITY

3.3.8 ID

[Definition:] **ID** represents the ID attribute type from [XML 1.0 (Second Edition)]. The value space of **ID** is the set of all strings that match the NCName production in [Namespaces in XML]. The lexical space of **ID** is the set of all strings that match the NCName production in [Namespaces in XML]. The base type of **ID** is NCName.

For compatibility (see Terminology (§1.4)) **ID** should be used only on attributes.

3.3.8.1 Constraining facets

ID has the following constraining facets :

- length
- minLength
- maxLength
- pattern
- enumeration
- whiteSpace

3.3.9 IDREF

[Definition:] **IDREF** represents the IDREF attribute type from [XML 1.0 (Second Edition)]. The value space of **IDREF** is the set of all strings that match the NCName production in [Namespaces in XML]. The lexical space of **IDREF** is the set of strings that match the NCName production in [Namespaces in XML]. The base type of **IDREF** is NCName.

For compatibility (see Terminology (§1.4)) this datatype should be used only on attributes.

3.3.9.1 Constraining facets

IDREF has the following constraining facets :

- length
- minLength
- maxLength
- pattern
- enumeration
- whiteSpace

3.3.9.2 Derived datatypes

The following built-in datatypes are derived from **IDREF**:

- IDREFS

3.3.10 IDREFS

[Definition:] **IDREFS** represents the IDREFS attribute type from [XML 1.0 (Second Edition)]. The value space of **IDREFS** is the set of finite, non-zero-length sequences of IDREFs. The lexical space of **IDREFS** is the set of white space separated lists of tokens, of which each token is in the lexical space of IDREF. The itemType of **IDREFS** is IDREF.

For compatibility (see Terminology (§1.4)) **IDREFS** should be used only on attributes.

3.3.10.1 Constraining facets

IDREFS has the following constraining facets :

- length
- minLength
- maxLength
- enumeration
- whiteSpace

3.3.11 ENTITY

[Definition:] **ENTITY** represents the ENTITY attribute type from [XML 1.0 (Second Edition)]. The value space of **ENTITY** is the set of all strings that match the NCName production in [Namespaces in XML] and have been declared as an unparsed entity in a document type definition. The lexical space of **ENTITY** is the set of all strings that match the NCName production in [Namespaces in XML]. The base type of **ENTITY** is NCName.

> **NOTE:** The value space of **ENTITY** is scoped to a specific instance document.

For compatibility (see Terminology (§1.4)) **ENTITY** should be used only on attributes.

3.3.11.1 Constraining facets

ENTITY has the following constraining facets :

- length
- minLength
- maxLength
- pattern
- enumeration
- whiteSpace

3.3.11.2 Derived datatypes

The following built-in datatypes are derived from **ENTITY**:

- ENTITIES

3.3.12 ENTITIES

[Definition:] **ENTITIES** represents the ENTITIES attribute type from [XML 1.0 (Second Edition)]. The value space of **ENTITIES** is the set of finite, non-zero-length sequences of ENTITY s that have been declared as unparsed entities in a document type definition. The lexical space of **ENTITIES** is the set of white space separated lists of tokens, of which each token is in the lexical space of ENTITY. The itemType of **ENTITIES** is ENTITY.

> **NOTE:** The value space of **ENTITIES** is scoped to a specific instance document.

For compatibility (see Terminology (§1.4)) **ENTITIES** should be used only on attributes.

3.3.12.1 Constraining facets

ENTITIES has the following constraining facets :

- length
- minLength
- maxLength
- enumeration
- whiteSpace

3.3.13 integer

[Definition:] **integer** is derived from decimal by fixing the value of fractionDigits to be 0. This results in the standard mathematical concept of the integer numbers. The value space of **integer** is the infinite set {...,-2,-1,0,1,2,...}. The base type of **integer** is decimal.

3.3.13.1 Lexical representation

integer has a lexical representation consisting of a finite-length sequence of decimal digits (#x30-#x39) with an optional leading sign. If the sign is omitted, "+" is assumed. For example: -1, 0, 12678967543233, +100000.

3.3.13.2 Canonical representation

The canonical representation for **integer** is defined by prohibiting certain options from the Lexical representation (§3.3.13.1). Specifically, the preceding optional "+" sign is prohibited and leading zeroes are prohibited.

3.3.13.3 Constraining facets

integer has the following constraining facets :

- totalDigits
- fractionDigits
- pattern
- whiteSpace
- enumeration
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.3.13.4 Derived datatypes

The following built-in datatypes are derived from **integer**:

- nonPositiveInteger
- long
- nonNegativeInteger

3.3.14 nonPositiveInteger

[Definition:] **nonPositiveInteger** is derived from integer by setting the value of maxInclusive to be 0. This results in the standard mathematical concept of the non-positive integers. The value space of **nonPositiveInteger** is the infinite set {...,-2,-1,0}. The base type of **nonPositiveInteger** is integer.

3.3.14.1 Lexical representation

nonPositiveInteger has a lexical representation consisting of a negative sign ("-") followed by a finite-length sequence of decimal digits (#x30-#x39). If the sequence of digits consists of all zeros then the sign is optional. For example: -1, 0, -12678967543233, -100000.

3.3.14.2 Canonical representation

The canonical representation for **nonPositiveInteger** is defined by prohibiting certain options from the Lexical representation (§3.3.14.1). Specifically, the negative sign ("-") is required with the token "0" and leading zeroes are prohibited.

3.3.14.3 Constraining facets

nonPositiveInteger has the following constraining facets :

- totalDigits
- fractionDigits

- pattern
- whiteSpace
- enumeration
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.3.14.4 Derived datatypes

The following built-in datatypes are derived from **nonPositiveInteger**:

- negativeInteger

3.3.15 negativeInteger

[Definition:] **negativeInteger** is derived from nonPositiveInteger by setting the value of maxInclusive to be -1. This results in the standard mathematical concept of the negative integers. The value space of **negativeInteger** is the infinite set {...,-2,-1}. The base type of **negativeInteger** is nonPositiveInteger.

3.3.15.1 Lexical representation

negativeInteger has a lexical representation consisting of a negative sign ("-") followed by a finite-length sequence of decimal digits (#x30-#x39). For example: -1, -12678967543233, -100000.

3.3.15.2 Canonical representation

The canonical representation for **negativeInteger** is defined by prohibiting certain options from the Lexical representation (§3.3.15.1). Specifically, leading zeroes are prohibited.

3.3.15.3 Constraining facets

negativeInteger has the following constraining facets :

- totalDigits
- fractionDigits
- pattern
- whiteSpace
- enumeration
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.3.16 long

[Definition:] **long** is derived from integer by setting the value of maxInclusive to be 9223372036854775807 and minInclusive to be -9223372036854775808. The base type of **long** is integer.

3.3.16.1 Lexical representation

long has a lexical representation consisting of an optional sign followed by a finite-length sequence of decimal digits (#x30-#x39). If the sign is omitted, "+" is assumed. For example: -1, 0, 12678967543233, +100000.

3.3.16.2 Canonical representation

The canonical representation for **long** is defined by prohibiting certain options from the Lexical representation (§3.3.16.1). Specifically, the the optional "+" sign is prohibited and leading zeroes are prohibited.

3.3.16.3 Constraining facets

long has the following constraining facets :

- totalDigits
- fractionDigits
- pattern
- whiteSpace
- enumeration
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.3.16.4 Derived datatypes

The following built-in datatypes are derived from **long**:

- int

3.3.17 int

[Definition:] **int** is derived from long by setting the value of maxInclusive to be 2147483647 and minInclusive to be -2147483648. The base type of **int** is long.

3.3.17.1 Lexical representation

int has a lexical representation consisting of an optional sign followed by a finite-length sequence of decimal digits (#x30-#x39). If the sign is omitted, "+" is assumed. For example: -1, 0, 126789675, +100000.

3.3.17.2 Canonical representation

The canonical representation for **int** is defined by prohibiting certain options from the Lexical representation (§3.3.17.1). Specifically, the the optional "+" sign is prohibited and leading zeroes are prohibited.

3.3.17.3 Constraining facets

int has the following constraining facets :

- totalDigits
- fractionDigits
- pattern
- whiteSpace
- enumeration
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.3.17.4 Derived datatypes

The following built-in datatypes are derived from **int**:

- short

3.3.18 short

[Definition:] **short** is derived from int by setting the value of maxInclusive to be 32767 and minInclusive to be -32768. The base type of **short** is int.

3.3.18.1 Lexical representation

short has a lexical representation consisting of an optional sign followed by a finite-length sequence of decimal digits (#x30-#x39). If the sign is omitted, "+" is assumed. For example: -1, 0, 12678, +10000.

3.3.18.2 Canonical representation

The canonical representation for **short** is defined by prohibiting certain options from the Lexical representation (§3.3.18.1). Specifically, the the optional "+" sign is prohibited and leading zeroes are prohibited.

3.3.18.3 Constraining facets

short has the following constraining facets :

- totalDigits
- fractionDigits
- pattern
- whiteSpace
- enumeration
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.3.18.4 Derived datatypes

The following built-in datatypes are derived from **short**:

- byte

3.3.19 byte

[Definition:] **byte** is derived from short by setting the value of maxInclusive to be 127 and minInclusive to be -128. The base type of **byte** is short.

3.3.19.1 Lexical representation

byte has a lexical representation consisting of an optional sign followed by a finite-length sequence of decimal digits (#x30-#x39). If the sign is omitted, "+" is assumed. For example: -1, 0, 126, +100.

3.3.19.2 Canonical representation

The canonical representation for **byte** is defined by prohibiting certain options from the Lexical representation (§3.3.19.1). Specifically, the the optional "+" sign is prohibited and leading zeroes are prohibited.

3.3.19.3 Constraining facets

byte has the following constraining facets :

- totalDigits
- fractionDigits
- pattern
- whiteSpace
- enumeration
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.3.20 nonNegativeInteger

[Definition:] **nonNegativeInteger** is derived from integer by setting the value of minInclusive to be 0. This results in the standard mathematical concept of the non-negative integers. The value space of **nonNegativeInteger** is the infinite set {0,1,2,...}. The base type of **nonNegativeInteger** is integer.

3.3.20.1 Lexical representation

nonNegativeInteger has a lexical representation consisting of an optional sign followed by a finite-length sequence of decimal digits (#x30-#x39). If the sign is omitted, "+" is assumed. For example: 1, 0, 12678967543233, +100000.

3.3.20.2 Canonical representation

The canonical representation for **nonNegativeInteger** is defined by prohibiting certain options from the Lexical representation (§3.3.20.1). Specifically, the the optional "+" sign is prohibited and leading zeroes are prohibited.

3.3.20.3 Constraining facets

nonNegativeInteger has the following constraining facets :

- totalDigits
- fractionDigits
- pattern
- whiteSpace
- enumeration
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.3.20.4 Derived datatypes

The following built-in datatypes are derived from **nonNegativeInteger**:

- unsignedLong
- positiveInteger

3.3.21 unsignedLong

[Definition:] **unsignedLong** is derived from nonNegativeInteger by setting the value of maxInclusive to be 18446744073709551615. The base type of **unsignedLong** is nonNegativeInteger.

3.3.21.1 Lexical representation

unsignedLong has a lexical representation consisting of a finite-length sequence of decimal digits (#x30-#x39). For example: 0, 12678967543233, 100000.

3.3.21.2 Canonical representation

The canonical representation for **unsignedLong** is defined by prohibiting certain options from the Lexical representation (§3.3.21.1). Specifically, leading zeroes are prohibited.

3.3.21.3 Constraining facets

unsignedLong has the following constraining facets :

- totalDigits
- fractionDigits
- pattern

- whiteSpace
- enumeration
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.3.21.4 Derived datatypes

The following built-in datatypes are derived from **unsignedLong**:

- unsignedInt

3.3.22 unsignedInt

[Definition:] **unsignedInt** is derived from unsignedLong by setting the value of maxInclusive to be 4294967295. The base type of **unsignedInt** is unsignedLong.

3.3.22.1 Lexical representation

unsignedInt has a lexical representation consisting of a finite-length sequence of decimal digits (#x30-#x39). For example: 0, 1267896754, 100000.

3.3.22.2 Canonical representation

The canonical representation for **unsignedInt** is defined by prohibiting certain options from the Lexical representation (§3.3.22.1). Specifically, leading zeroes are prohibited.

3.3.22.3 Constraining facets

unsignedInt has the following constraining facets :

- totalDigits
- fractionDigits
- pattern
- whiteSpace
- enumeration
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.3.22.4 Derived datatypes

The following built-in datatypes are derived from **unsignedInt**:

- unsignedShort

3.3.23 unsignedShort

[Definition:] **unsignedShort** is derived from unsignedInt by setting the value of maxInclusive to be 65535. The base type of **unsignedShort** is unsignedInt.

3.3.23.1 Lexical representation

unsignedShort has a lexical representation consisting of a finite-length sequence of decimal digits (#x30-#x39). For example: 0, 12678, 10000.

3.3.23.2 Canonical representation

The canonical representation for **unsignedShort** is defined by prohibiting certain options from the Lexical representation (§3.3.23.1). Specifically, the leading zeroes are prohibited.

3.3.23.3 Constraining facets

unsignedShort has the following constraining facets :

- totalDigits
- fractionDigits
- pattern
- whiteSpace
- enumeration
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.3.23.4 Derived datatypes

The following built-in datatypes are derived from **unsignedShort**:

- unsignedByte

3.3.24 unsignedByte

[Definition:] **unsignedByte** is derived from unsignedShort by setting the value of maxInclusive to be 255. The base type of **unsignedByte** is unsignedShort.

3.3.24.1 Lexical representation

unsignedByte has a lexical representation consisting of a finite-length sequence of decimal digits (#x30-#x39). For example: 0, 126, 100.

3.3.24.2 Canonical representation

The canonical representation for **unsignedByte** is defined by prohibiting certain options from the Lexical representation (§3.3.24.1). Specifically, leading zeroes are prohibited.

3.3.24.3 Constraining facets

unsignedByte has the following constraining facets :

- totalDigits
- fractionDigits
- pattern
- whiteSpace
- enumeration
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

3.3.25 positiveInteger

[Definition:] **positiveInteger** is derived from nonNegativeInteger by setting the value of minInclusive to be 1. This results in the standard mathematical concept of the positive integer numbers. The value space of **positiveInteger** is the infinite set {1,2,...}. The base type of **positiveInteger** is nonNegativeInteger.

3.3.25.1 Lexical representation

positiveInteger has a lexical representation consisting of an optional positive sign ("+") followed by a finite-length sequence of decimal digits (#x30-#x39). For example: 1, 12678967543233, +100000.

3.3.25.2 Canonical representation

The canonical representation for **positiveInteger** is defined by prohibiting certain options from the Lexical representation (§3.3.25.1). Specifically, the optional "+" sign is prohibited and leading zeroes are prohibited.

3.3.25.3 Constraining facets

positiveInteger has the following constraining facets :

- totalDigits
- fractionDigits
- pattern
- whiteSpace
- enumeration
- maxInclusive
- maxExclusive
- minInclusive
- minExclusive

4 Datatype components

The following sections provide full details on the properties and significance of each kind of schema component involved in datatype definitions. For each property, the kinds of values it is allowed to have is specified. Any property not identified as optional is required to be present; optional properties which are not present have absent as their value. Any property identified as a having a set, subset or list value may have an empty value unless this is explicitly ruled out: this is not the same as absent. Any property value identified as a superset or a subset of some set may be equal to that set, unless a proper superset or subset is explicitly called for.

For more information on the notion of datatype (schema) components, see Schema Component Details of [XML Schema Part 1: Structures].

4.1 Simple Type Definition

Simple Type definitions provide for:

- Establishing the value space and lexical space of a datatype, through the combined set of constraining facets specified in the definition;
- Attaching a unique name (actually a QName) to the value space and lexical space .

4.1.1 The Simple Type Definition Schema Component

The Simple Type Definition schema component has the following properties:

Schema Component: Simple Type Definition

`{name}`

Optional. An NCName as defined by [Namespaces in XML].

`{target namespace}`

Either absent or a namespace name, as defined in [Namespaces in XML].

`{variety}`

One of {*atomic*, *list*, *union*}. Depending on the value of {variety}, further properties are defined as follows:

atomic

`{primitive type definition}`

A built-in primitive datatype definition (or the simple ur-type definition).

list

`{item type definition}`

An atomic or union simple type definition.

union

`{member type definitions}`

A non-empty sequence of simple type definitions.

`{facets}`

A possibly empty set of Facets (§2.4).

`{fundamental facets}`

A set of Fundamental facets (§2.4.1)

`{base type definition}`

If the datatype has been derived by restriction then the Simple Type Definition component from which it is derived , otherwise the Simple Type Definition for anySimpleType (§4.1.6).

`{final}`

A subset of *{restriction, list, union}*.

`{annotation}`

Optional. An annotation.

Datatypes are identified by their {name} and {target namespace}. Except for anonymous datatypes (those with no {name}), datatype definitions must be uniquely identified within a schema.

If {variety} is atomic then the value space of the datatype defined will be a subset of the value space of {base type definition} (which is a subset of the value space of {primitive type definition}). If {variety} is list then the value space of the datatype defined will be the set of finite-length sequence of values from the value space of {item type definition}. If {variety} is union then the value space of the datatype defined will be the union of the value space s of each datatype in {member type definitions}.

If {variety} is atomic then the {variety} of {base type definition} must be atomic . If {variety} is list then the {variety} of {item type definition} must be either atomic or union . If {variety} is union then {member type definitions} must be a list of datatype definitions.

The value of {facets} consists of the set of facet s specified directly in the datatype definition unioned with the possibly empty set of {facets} of {base type definition}.

The value of {fundamental facets} consists of the set of fundamental facet s and their values.

If {final} is the empty set then the type can be used in deriving other types; the explicit values *restriction*, *list* and *union* prevent further derivations by restriction , list and union respectively.

4.1.2 XML Representation of Simple Type Definition Schema Components

The XML representation for a Simple Type Definition schema component is a <simpleType> element information item. The correspondences between the properties of the information item and properties of the component are as follows:

XML Representation Summary: `simpleType` **Element Information Item**

```
<simpleType
  final = (#all | (list | union | restriction))
  id = ID
  name = NCName
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?, (restriction | list | union))
</simpleType>
```

Datatype Definition Schema Component

Property	Representation
{name}	The actual value of the `name` [attribute], if present, otherwise null
{final}	A set corresponding to the actual value of the `final` [attribute], if present, otherwise of the actual value of the `finalDefault` [attribute] the ancestor schema element information item, if present, otherwise the empty string, as follows: **the empty string** the empty set; `#all` *{restriction, list, union}*; ***otherwise*** a set with members drawn from the set above, each being present or absent depending on whether the string contains an equivalently named space-delimited substring. **NOTE:** Although the `finalDefault` [attribute] of schema may include values other than *restriction*, *list* or *union*, those values are ignored in the determination of {final}
{target namespace}	The actual value of the `targetNamespace` [attribute] of the parent `schema` element information item.
{annotation}	The annotation corresponding to the <annotation> element information item in the [children], if present, otherwise null

A derived datatype can be derived from a primitive datatype or another derived datatype by one of three means: by *restriction*, by *list* or by *union*.

4.1.2.1 Derivation by restriction

XML Representation Summary: `restriction` Element Information Item

```
<restriction
  base = QName
  id = ID
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?, (simpleType?, (minExclusive | minInclusive | maxExclusive | maxInclusive
| totalDigits | fractionDigits | length | minLength | maxLength | enumeration | whiteSpace | pattern)
*))
</restriction>
```

Simple Type Definition Schema Component

Property	Representation
{variety}	The actual value of {variety} of {base type definition}
{facets}	The union of the set of Facets (§2.4) components resolved to by the facet [children] merged with {facets} from {base type definition}, subject to the Facet Restriction Valid constraints specified in Facets (§2.4).
{base type definition}	The Simple Type Definition component resolved to by the actual value of the `base` [attribute] or the <simpleType> [children], whichever is present.

Example

An electronic commerce schema might define a datatype called *Sku* (the barcode number that appears on products) from the built-in datatype string by supplying a value for the pattern facet.

```
<simpleType name='Sku'>
    <restriction base='string'>
      <pattern value='\d{3}-[A-Z]{2}'/>
```

```
    </restriction>
</simpleType>
```

In this case, *Sku* is the name of the new user-derived datatype, string is its base type and pattern is the facet.

4.1.2.2 Derivation by list

XML Representation Summary: `list` **Element Information Item**

```
<list
  id = ID
  itemType = QName
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?, (simpleType?))
</list>
```

Simple Type Definition Schema Component

Property	Representation
{variety}	list
{item type definition}	The Simple Type Definition component resolved to by the actual value of the `itemType` [attribute] or the <simpleType> [children], whichever is present.

A list datatype must be derived from an atomic or a union datatype, known as the itemType of the list datatype. This yields a datatype whose value space is composed of finite-length sequences of values from the value space of the itemType and whose lexical space is composed of white space separated lists of literals of the itemType .

Example

A system might want to store lists of floating point values.

```
<simpleType name='listOfFloat'>
  <list itemType='float'/>
</simpleType>
```

In this case, *listOfFloat* is the name of the new user-derived datatype, float is its itemType and list is the derivation method.

As mentioned in List datatypes (§2.5.1.2), when a datatype is derived from a list datatype, the following constraining facet s can be used:

- length
- maxLength
- minLength
- enumeration
- pattern
- whiteSpace

regardless of the constraining facet s that are applicable to the atomic datatype that serves as the itemType of the list .

For each of length , maxLength and minLength , the *unit of length* is measured in number of list items. The value of whiteSpace is fixed to the value *collapse*.

4.1.2.3 Derivation by union

XML Representation Summary: `union` **Element Information Item**

```
<union
  id = ID
```

```
  memberTypes = List of QName
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?, (simpleType*))
</union>
```

Simple Type Definition Schema Component

Property	Representation
{variety}	union
{member type definitions}	The sequence of Simple Type Definition components resolved to by the items in the actual value of the `memberTypes` [attribute], if any, in order, followed by the Simple Type Definition components resolved to by the <simpleType> [children], if any, in order. If {variety} is *union* for any Simple Type Definition components resolved to above, then the that Simple Type Definition is replaced by its {member type definitions}.

A union datatype can be derived from one or more atomic, list or other union datatypes, known as the memberTypes of that union datatype.

Example

As an example, taken from a typical display oriented text markup language, one might want to express font sizes as an integer between 8 and 72, or with one of the tokens "small", "medium" or "large". The union type definition below would accomplish that.

```
<xsd:attribute name="size">
  <xsd:simpleType>
    <xsd:union>
      <xsd:simpleType>
        <xsd:restriction base="xsd:positiveInteger">
          <xsd:minInclusive value="8"/>
          <xsd:maxInclusive value="72"/>
        </xsd:restriction>
      </xsd:simpleType>
      <xsd:simpleType>
        <xsd:restriction base="xsd:NMTOKEN">
          <xsd:enumeration value="small"/>
          <xsd:enumeration value="medium"/>
          <xsd:enumeration value="large"/>
        </xsd:restriction>
      </xsd:simpleType>
    </xsd:union>
  </xsd:simpleType>
</xsd:attribute>
<p>
<font size='large'>A header</font>
</p>
<p>
<font size='12'>this is a test</font>
</p>
```

As mentioned in Union datatypes (§2.5.1.3), when a datatype is derived from a union datatype, the only following constraining facet s can be used:

- pattern
- enumeration

regardless of the constraining facet s that are applicable to the datatypes that participate in the union

4.1.3 Constraints on XML Representation of Simple Type Definition

Schema Representation Constraint: Single Facet Value

Unless otherwise specifically allowed by this specification (Multiple patterns (§4.3.4.3) and Multiple enumerations (§4.3.5.3)) any given constraining facet can only be specifed once within a single derivation step.

Schema Representation Constraint: itemType attribute or simpleType child

Either the `itemType` [attribute] or the <simpleType> [child] of the <list> element must be present, but not both.

Schema Representation Constraint: base attribute or simpleType child

Either the `base` [attribute] or the `simpleType` [child] of the <restriction> element must be present, but not both.

Schema Representation Constraint: memberTypes attribute or simpleType children

Either the `memberTypes` [attribute] of the <union> element must be non-empty or there must be at least one `simpleType` [child].

4.1.4 Simple Type Definition Validation Rules

Validation Rule: Facet Valid

A value in a value space is facet-valid with respect to a constraining facet component if:

1 the value is facet-valid with respect to the particular constraining facet as specified below.

Validation Rule: Datatype Valid

A string is datatype-valid with respect to a datatype definition if:

1 it matches a literal in the lexical space of the datatype, determined as follows:
  1.1 if pattern is a member of {facets}, then the string must be pattern valid (§4.3.4.4);
  1.2 if pattern is not a member of {facets}, then
    1.2.1 if {variety} is atomic then the string must match a literal in the lexical space of {base type definition}
    1.2.2 if {variety} is list then the string must be a sequence of white space separated tokens, each of which matches a literal in the lexical space of {item type definition}
    1.2.3 if {variety} is union then the string must match a literal in the lexical space of at least one member of {member type definitions}

2 the value denoted by the literal matched in the previous step is a member of the value space of the datatype, as determined by it being Facet Valid (§4.1.4) with respect to each member of {facets} (except for pattern).

4.1.5 Constraints on Simple Type Definition Schema Components

Schema Component Constraint: applicable facets

The constraining facets which are allowed to be members of {facets} are dependent on {base type definition} as specified in the the following table:

{base type definition}	**applicable {facets}**
If {variety} is list, then	
[all datatypes]	length, minLength, maxLength, pattern, enumeration, whiteSpace
If {variety} is union, then	
[all datatypes]	pattern, enumeration
else if {variety} is atomic, then	
string	length, minLength, maxLength, pattern, enumeration, whiteSpace
boolean	pattern, whiteSpace
float	pattern, enumeration, whiteSpace, maxInclusive, maxExclusive, minInclusive, minExclusive
double	pattern, enumeration, whiteSpace, maxInclusive, maxExclusive, minInclusive, minExclusive
decimal	totalDigits, fractionDigits, pattern, whiteSpace, enumeration, maxInclusive, maxExclusive, minInclusive, minExclusive
duration	pattern, enumeration, whiteSpace, maxInclusive, maxExclusive, minInclusive, minExclusive
dateTime	pattern, enumeration, whiteSpace, maxInclusive, maxExclusive, minInclusive, minExclusive
time	pattern, enumeration, whiteSpace, maxInclusive, maxExclusive, minInclusive, minExclusive
date	pattern, enumeration, whiteSpace, maxInclusive, maxExclusive, minInclusive, minExclusive
gYearMonth	pattern, enumeration, whiteSpace, maxInclusive, maxExclusive, minInclusive, minExclusive
gYear	pattern, enumeration, whiteSpace, maxInclusive, maxExclusive, minInclusive, minExclusive

gMonthDay	pattern, enumeration, whiteSpace, maxInclusive, maxExclusive, minInclusive, minExclusive
gDay	pattern, enumeration, whiteSpace, maxInclusive, maxExclusive, minInclusive, minExclusive
gMonth	pattern, enumeration, whiteSpace, maxInclusive, maxExclusive, minInclusive, minExclusive
hexBinary	length, minLength, maxLength, pattern, enumeration, whiteSpace
base64Binary	length, minLength, maxLength, pattern, enumeration, whiteSpace
anyURI	length, minLength, maxLength, pattern, enumeration, whiteSpace
QName	length, minLength, maxLength, pattern, enumeration, whiteSpace
NOTATION	length, minLength, maxLength, pattern, enumeration, whiteSpace

Schema Component Constraint: list of atomic

If {variety} is list , then the {variety} of {item type definition} must be atomic or union .

Schema Component Constraint: no circular unions

If {variety} is union , then it is an error if {name} and {target namespace} match {name} and {target namespace} of any member of {member type definitions}.

4.1.6 Simple Type Definition for anySimpleType

There is a simple type definition nearly equivalent to the simple version of the ur-type definition present in every schema by definition. It has the following properties:

Schema Component: anySimpleType

`{name}`
anySimpleType
`{target namespace}`
http://www.w3.org/2001/XMLSchema
`{basetype definition}`
the ur-type definition
`{final}`
the empty set
`{variety}`
absent

4.2 Fundamental Facets

4.2.1 equal
4.2.2 ordered
4.2.3 bounded
4.2.4 cardinality
4.2.5 numeric

4.2.1 equal

Every value space supports the notion of equality, with the following rules:

- for any *a* and *b* in the value space , either *a* is equal to *b*, denoted *a* = *b*, or *a* is not equal to *b*, denoted *a* != *b*
- there is no pair *a* and *b* from the value space such that both *a* = *b* and *a* != *b*
- for all *a* in the value space , *a* = *a*
- for any *a* and *b* in the value space , *a* = *b* if and only if *b* = *a*
- for any *a*, *b* and *c* in the value space , if *a* = *b* and *b* = *c*, then *a* = *c*
- for any *a* and *b* in the value space if *a* = *b*, then *a* and *b* cannot be distinguished (i.e., equality is identity)

Note that a consequence of the above is that, given value space *A* and value space *B* where *A* and *B* are not related by restriction or union , for every pair of values *a* from *A* and *b* from *B*, *a* != *b*.

On every datatype, the operation Equal is defined in terms of the equality property of the value space : for any values *a, b* drawn from the value space , *Equal(a,b)* is true if *a* = *b*, and false otherwise.

NOTE: There is no schema component corresponding to the **equal** fundamental facet .

4.2.2 ordered

[Definition:] An **order relation** on a value space is a mathematical relation that imposes a total order or a partial order on the members of the value space .

[Definition:] A value space , and hence a datatype, is said to be **ordered** if there exists an order-relation defined for that value space .

[Definition:] A **partial order** is an order-relation that is **irreflexive**, **asymmetric** and **transitive**.

A partial order has the following properties:

- for no a in the value space , $a < a$ (irreflexivity)
- for all a and b in the value space , $a < b$ implies not($b < a$) (asymmetry)
- for all a, b and c in the value space , $a < b$ and $b < c$ implies $a < c$ (transitivity)

The notation $a <> b$ is used to indicate the case when $a \,!\!= b$ and neither $a < b$ nor $b < a$

[Definition:] A **total order** is an partial order such that for no a and b is it the case that $a <> b$.

A total order has all of the properties specified above for partial order , plus the following property:

- for all a and b in the value space , either $a < b$ or $b < a$ or $a = b$

NOTE: The fact that this specification does not define an order-relation for some datatype does not mean that some other application cannot treat that datatype as being ordered by imposing its own order relation.

ordered provides for:

- indicating whether an order-relation is defined on a value space , and if so, whether that order-relation is a partial order or a total order

4.2.2.1 The ordered Schema Component

Schema Component: ordered

`{value}`

One of *{false, partial, total}*.

{value} depends on {variety}, {facets} and {member type definitions} in the Simple Type Definition component in which a ordered component appears as a member of {fundamental facets}.

When {variety} is atomic , {value} is inherited from {value} of {base type definition}. For all primitive types {value} is as specified in the table in Fundamental Facets (§C.1).

When {variety} is list , {value} is *false*.

When {variety} is union , if {value} is *true* for every member of {member type definitions} and all members of {member type definitions} share a common ancestor, then {value} is *true*; else {value} is *false*.

4.2.3 bounded

[Definition:] A value u in an ordered value space U is said to be an **inclusive upper bound** of a value space V (where V is a subset of U) if for all v in V, $u >= v$.

[Definition:] A value *u* in an ordered value space *U* is said to be an **exclusive upper bound** of a value space *V* (where *V* is a subset of *U*) if for all *v* in *V*, *u* > *v*.

[Definition:] A value *l* in an ordered value space *L* is said to be an **inclusive lower bound** of a value space *V* (where *V* is a subset of *L*) if for all *v* in *V*, *l* <= *v*.

[Definition:] A value *l* in an ordered value space *L* is said to be an **exclusive lower bound** of a value space *V* (where *V* is a subset of *L*) if for all *v* in *V*, *l* < *v*.

[Definition:] A datatype is **bounded** if its value space has either an inclusive upper bound or an exclusive upper bound and either an inclusive lower bound and an exclusive lower bound .

bounded provides for:

- indicating whether a value space is bounded

4.2.3.1 The bounded Schema Component

Schema Component: bounded

`{value}`
A boolean.

{value} depends on {variety}, {facets} and {member type definitions} in the Simple Type Definition component in which a bounded component appears as a member of {fundamental facets}.

When {variety} is atomic , if one of minInclusive or minExclusive and one of maxInclusive or maxExclusive are among {facets} , then {value} is *true*; else {value} is *false*.

When {variety} is list , if length or both of minLength and maxLength are among {facets}, then {value} is *true*; else {value} is *false*.

When {variety} is union , if {value} is *true* for every member of {member type definitions} and all members of {member type definitions} share a common ancestor, then {value} is *true*; else {value} is *false*.

4.2.4 cardinality

[Definition:] Every value space has associated with it the concept of **cardinality**. Some value space s are finite, some are countably infinite while still others could conceivably be uncountably infinite (although no value space defined by this specification is uncountable infinite). A datatype is said to have the cardinality of its value space .

It is sometimes useful to categorize value space s (and hence, datatypes) as to their cardinality. There are two significant cases:

- value space s that are finite
- value space s that are countably infinite

cardinality provides for:

- indicating whether the cardinality of a value space is *finite* or *countably infinite*

4.2.4.1 The cardinality Schema Component

Schema Component: cardinality

`{value}`
One of *{finite, countably infinite}*.

{value} depends on {variety}, {facets} and {member type definitions} in the Simple Type Definition component in which a cardinality component appears as a member of {fundamental facets}.

When {variety} is atomic and {value} of {base type definition} is *finite*, then {value} is *finite*.

When {variety} is atomic and {value} of {base type definition} is *countably infinite* and **either** of the following conditions are true, then {value} is *finite*; else {value} is *countably infinite*:

1. one of length , maxLength , totalDigits is among {facets},
2. **all** of the following are true:
    1. one of minInclusive or minExclusive is among {facets}
    2. one of maxInclusive or maxExclusive is among {facets}
    3. **either** of the following are true:
        1. fractionDigits is among {facets}
        2. {base type definition} is one of date, gYearMonth, gYear, gMonthDay, gDay or gMonth or any type derived from them

When {variety} is list , if length or both of minLength and maxLength are among {facets}, then {value} is *finite*; else {value} is *countably infinite*.

When {variety} is union , if {value} is *finite* for every member of {member type definitions}, then {value} is *finite*; else {value} is *countably infinite*.

4.2.5 numeric

[Definition:] A datatype is said to be **numeric** if its values are conceptually quantities (in some mathematical number system).

[Definition:] A datatype whose values are not numeric is said to be **non-numeric**.

numeric provides for:

- indicating whether a value space is numeric

4.2.5.1 The numeric Schema Component

Schema Component: numeric

`{value}`
A boolean

{value} depends on {variety}, {facets}, {base type definition} and {member type definitions} in the Simple Type Definition component in which a cardinality component appears as a member of {fundamental facets}.

When {variety} is atomic , {value} is inherited from {value} of {base type definition}. For all primitive types {value} is as specified in the table in Fundamental Facets (§C.1).

When {variety} is list , {value} is *false*.

When {variety} is union , if {value} is *true* for every member of {member type definitions}, then {value} is *true*; else {value} is *false*.

4.3 Constraining Facets

4.3.1 length

[Definition:] **length** is the number of *units of length*, where *units of length* varies depending on the type that is being derived from. The value of **length** must be a nonNegativeInteger.

For string and datatypes derived from string, **length** is measured in units of characters as defined in [XML 1.0 (Second Edition)]. For anyURI, **length** is measured in units of characters (as for string). For hexBinary and base64Binary and datatypes derived from them, **length** is measured in octets (8 bits) of binary data. For datatypes derived by list , **length** is measured in number of list items.

> **NOTE:** For string and datatypes derived from string, **length** will not always coincide with "string length" as perceived by some users or with the number of storage units in some digital representation. Therefore, care should be taken when specifying a value for **length** and in attempting to infer storage requirements from a given value for **length**.

length provides for:

- Constraining a value space to values with a specific number of *units of length*, where *units of length* varies depending on {base type definition}.

Example

The following is the definition of a user-derived datatype to represent product codes which must be exactly 8 characters in length. By fixing the value of the **length** facet we ensure that types derived from productCode can change or set the values of other facets, such as **pattern**, but cannot change the length.

```
<simpleType name='productCode'>
   <restriction base='string'>
     <length value='8' fixed='true'/>
   </restriction>
</simpleType>
```

4.3.1.1 The length Schema Component

Schema Component: length

`{value}`
A nonNegativeInteger.
`{fixed}`
A boolean.
`{annotation}`
Optional. An annotation.

If {fixed} is *true*, then types for which the current type is the {base type definition} cannot specify a value for length other than {value}.

4.3.1.2 XML Representation of length Schema Components

The XML representation for a length schema component is a <length> element information item. The correspondences between the properties of the information item and properties of the component are as follows:

XML Representation Summary: `length` **Element Information Item**

```
<length
  fixed = boolean : false
  id = ID
  value = nonNegativeInteger
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?)
</length>
```

length Schema Component

Property	Representation
{value}	The actual value of the `value` [attribute]
{fixed}	The actual value of the `fixed` [attribute], if present, otherwise false
{annotation}	The annotations corresponding to all the <annotation> element information items in the [children], if any.

4.3.1.3 length Validation Rules

Validation Rule: Length Valid

A value in a value space is facet-valid with respect to length , determined as follows:
1 if the {variety} is atomic then
  1.1 if {primitive type definition} is string, then the length of the value, as measured in characters must be equal to {value};
  1.2 if {primitive type definition} is hexBinary or base64Binary, then the length of the value, as measured in octets of the binary data, must be equal to {value};
2 if the {variety} is list , then the length of the value, as measured in list items, must be equal to {value}

4.3.1.4 Constraints on length Schema Components

Schema Component Constraint: length and minLength or maxLength

It is an error for both length and either of minLength or maxLength to be members of {facets}.

Schema Component Constraint: length valid restriction

It is an error if length is among the members of {facets} of {base type definition} and {value} is not equal to the {value} of the parent length.

4.3.2 minLength

[Definition:] **minLength** is the minimum number of *units of length*, where *units of length* varies depending on the type that is being derived from. The value of **minLength** must be a nonNegativeInteger.

For string and datatypes derived from string, **minLength** is measured in units of characters as defined in [XML 1.0 (Second Edition)]. For hexBinary and base64Binary and datatypes derived from them, **minLength** is measured in octets (8 bits) of binary data. For datatypes derived by list , **minLength** is measured in number of list items.

> **NOTE:** For string and datatypes derived from string, **minLength** will not always coincide with "string length" as perceived by some users or with the number of storage units in some digital representation. Therefore, care should be taken when specifying a value for **minLength** and in attempting to infer storage requirements from a given value for **minLength**.

minLength provides for:

- Constraining a value space to values with at least a specific number of *units of length*, where *units of length* varies depending on {base type definition}.

Example

The following is the definition of a user-derived datatype which requires strings to have at least one character (i.e., the empty string is not in the value space of this datatype).

```
<simpleType name='non-empty-string'>
  <restriction base='string'>
    <minLength value='1'/>
  </restriction>
</simpleType>
```

4.3.2.1 The minLength Schema Component

Schema Component: minLength

{value}
  A nonNegativeInteger.
{fixed}
  A boolean.
{annotation}
  Optional. An annotation.

If {fixed} is *true*, then types for which the current type is the {base type definition} cannot specify a value for minLength other than {value}.

4.3.2.2 XML Representation of minLength Schema Component

The XML representation for a minLength schema component is a <minLength> element information item. The correspondences between the properties of the information item and properties of the component are as follows:

XML Representation Summary: `minLength` Element Information Item

```
<minLength
  fixed = boolean : false
  id = ID
  value = nonNegativeInteger
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?)
</minLength>
```

minLength Schema Component

Property	Representation
{value}	The actual value of the `value` [attribute]
{fixed}	The actual value of the `fixed` [attribute], if present, otherwise false
{annotation}	The annotations corresponding to all the <annotation> element information items in the [children], if any.

4.3.2.3 minLength Validation Rules

Validation Rule: minLength Valid

A value in a value space is facet-valid with respect to minLength , determined as follows:

1 if the {variety} is atomic then
  1.1 if {primitive type definition} is string, then the length of the value, as measured in characters must be greater than or equal to {value};
  1.2 if {primitive type definition} is hexBinary or base64Binary, then the length of the value, as measured in octets of the binary data, must be greater than or equal to {value};
2 if the {variety} is list , then the length of the value, as measured in list items, must be greater than or equal to {value}

4.3.2.4 Constraints on minLength Schema Components

Schema Component Constraint: minLength <= maxLength

If both minLength and maxLength are members of {facets}, then the {value} of minLength must be less than or equal to the {value} of maxLength.

Schema Component Constraint: minLength valid restriction

It is an error if minLength is among the members of {facets} of {base type definition} and {value} is less than the {value} of the parent minLength.

4.3.3 maxLength

[Definition:] **maxLength** is the maximum number of *units of length*, where *units of length* varies depending on the type that is being derived from. The value of **maxLength** must be a nonNegativeInteger.

For string and datatypes derived from string, **maxLength** is measured in units of characters as defined in [XML 1.0 (Second Edition)]. For hexBinary and base64Binary and datatypes derived from them, **maxLength** is measured in octets (8 bits) of binary data. For datatypes derived by list , **maxLength** is measured in number of list items.

> **NOTE:** For string and datatypes derived from string, **maxLength** will not always coincide with "string length" as perceived by some users or with the number of storage units in some digital representation. Therefore, care should be taken when specifying a value for **maxLength** and in attempting to infer storage requirements from a given value for **maxLength**.

maxLength provides for:

- Constraining a value space to values with at most a specific number of *units of length*, where *units of length* varies depending on {base type definition}.

Example

The following is the definition of a user-derived datatype which might be used to accept form input with an upper limit to the number of characters that are acceptable.

```
<simpleType name='form-input'>
  <restriction base='string'>
    <maxLength value='50'/>
  </restriction>
</simpleType>
```

4.3.3.1 The maxLength Schema Component

Schema Component: maxLength

`{value}`
A nonNegativeInteger.

`{fixed}`
A boolean.

`{annotation}`
Optional. An annotation.

If {fixed} is *true*, then types for which the current type is the {base type definition} cannot specify a value for maxLength other than {value}.

4.3.3.2 XML Representation of maxLength Schema Components

The XML representation for a maxLength schema component is a <maxLength> element information item. The correspondences between the properties of the information item and properties of the component are as follows:

XML Representation Summary: `maxLength` Element Information Item

```
<maxLength
  fixed = boolean : false
  id = ID
  value = nonNegativeInteger
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?)
</maxLength>
```

maxLength Schema Component

Property	Representation
{value}	The actual value of the `value` [attribute]
{fixed}	The actual value of the `fixed` [attribute], if present, otherwise false
{annotation}	The annotations corresponding to all the <annotation> element information items in the [children], if any.

4.3.3.3 maxLength Validation Rules

Validation Rule: maxLength Valid

A value in a value space is facet-valid with respect to maxLength , determined as follows:

1 if the {variety} is atomic then
  1.1 if {primitive type definition} is string, then the length of the value, as measured in characters must be less than or equal to {value};
  1.2 if {primitive type definition} is hexBinary or base64Binary, then the length of the value, as measured in octets of the binary data, must be less than or equal to {value};
2 if the {variety} is list , then the length of the value, as measured in list items, must be less than or equal to {value}

4.3.3.4 Constraints on maxLength Schema Components

Schema Component Constraint: maxLength valid restriction

It is an error if maxLength is among the members of {facets} of {base type definition} and {value} is greater than the {value} of the parent maxLength.

4.3.4 pattern

[Definition:] **pattern** is a constraint on the value space of a datatype which is achieved by constraining the lexical space to literals which match a specific pattern. The value of **pattern** must be a regular expression .

pattern provides for:

- Constraining a value space to values that are denoted by literals which match a specific regular expression .

Example

The following is the definition of a user-derived datatype which is a better representation of postal codes in the United States, by limiting strings to those which are matched by a specific regular expression .

```
<simpleType name='better-us-zipcode'>
  <restriction base='string'>
    <pattern value='[0-9]{5}(-[0-9]{4})?'/>
  </restriction>
</simpleType>
```

4.3.4.1 The pattern Schema Component

Schema Component: pattern

```
{value}
```

A regular expression .
`{annotation}`
Optional. An annotation.

4.3.4.2 XML Representation of pattern Schema Components

The XML representation for a pattern schema component is a <pattern> element information item. The correspondences between the properties of the information item and properties of the component are as follows:

XML Representation Summary: `pattern` **Element Information Item**

```
<pattern
  id = ID
  value = anySimpleType
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?)
</pattern>
```

{value} must be a valid regular expression .

pattern Schema Component

Property	Representation
{value}	The actual value of the `value` [attribute]
{annotation}	The annotations corresponding to all the <annotation> element information items in the [children], if any.

4.3.4.3 Constraints on XML Representation of pattern

Schema Representation Constraint: Multiple patterns
If multiple <pattern> element information items appear as [children] of a <simpleType>, the [value]s should be combined as if they appeared in a single regular expression as separate branch es.

NOTE: It is a consequence of the schema representation constraint Multiple patterns (§4.3.4.3) and of the rules for restriction that pattern facets specified on the *same* step in a type derivation are **OR**ed together, while pattern facets specified on *different* steps of a type derivation are **AND**ed together.

Thus, to impose two pattern constraints simultaneously, schema authors may either write a single pattern which expresses the intersection of the two pattern s they wish to impose, or define each pattern on a separate type derivation step.

4.3.4.4 pattern Validation Rules

Validation Rule: pattern valid
A literal in a lexical space is facet-valid with respect to pattern if:
1 the literal is among the set of character sequences denoted by the regular expression specified in {value}.

4.3.5 enumeration

[Definition:] **enumeration** constrains the value space to a specified set of values.

enumeration does not impose an order relation on the value space it creates; the value of the ordered property of the derived datatype remains that of the datatype from which it is derived .

enumeration provides for:

- Constraining a value space to a specified set of values.

Example

The following example is a datatype definition for a user-derived datatype which limits the values of dates to the three US holidays enumerated. This datatype definition would appear in a schema authored by an "end-user" and shows how to define a datatype by enumerating the values in its value space . The enumerated values must be type-valid literals for the base type .

```
<simpleType name='holidays'>
    <annotation>
        <documentation>some US holidays</documentation>
    </annotation>
    <restriction base='gMonthDay'>
      <enumeration value='--01-01'>
        <annotation>
            <documentation>New Year's day</documentation>
        </annotation>
      </enumeration>
      <enumeration value='--07-04'>
        <annotation>
            <documentation>4th of July</documentation>
        </annotation>
      </enumeration>
      <enumeration value='--12-25'>
        <annotation>
            <documentation>Christmas</documentation>
        </annotation>
      </enumeration>
    </restriction>
</simpleType>
```

4.3.5.1 The enumeration Schema Component

Schema Component: enumeration

`{value}`
A set of values from the value space of the {base type definition}.

`{annotation}`
Optional. An annotation.

4.3.5.2 XML Representation of enumeration Schema Components

The XML representation for an enumeration schema component is an <enumeration> element information item. The correspondences between the properties of the information item and properties of the component are as follows:

XML Representation Summary: `enumeration` Element Information Item

```
<enumeration
  id = ID
  value = anySimpleType
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?)
</enumeration>
```

{value} must be in the value space of {base type definition}.

enumeration Schema Component

Property	Representation
{value}	The actual value of the `value` [attribute]
{annotation}	The annotations corresponding to all the <annotation> element information items in the [children], if any.

4.3.5.3 Constraints on XML Representation of enumeration

Schema Representation Constraint: Multiple enumerations

If multiple <enumeration> element information items appear as [children] of a <simpleType> the {value} of the enumeration component should be the set of all such [value]s.

4.3.5.4 enumeration Validation Rules

Validation Rule: enumeration valid

A value in a value space is facet-valid with respect to enumeration if the value is one of the values specified in {value}

4.3.5.5 Constraints on enumeration Schema Components

Schema Component Constraint: enumeration valid restriction

It is an error if any member of {value} is not in the value space of {base type definition}.

4.3.6 whiteSpace

[Definition:] **whiteSpace** constrains the value space of types derived from string such that the various behaviors specified in Attribute Value Normalization in [XML 1.0 (Second Edition)] are realized. The value of **whiteSpace** must be one of {preserve, replace, collapse}.

preserve

No normalization is done, the value is not changed (this is the behavior required by [XML 1.0 (Second Edition)] for element content)

replace

All occurrences of #x9 (tab), #xA (line feed) and #xD (carriage return) are replaced with #x20 (space)

collapse

After the processing implied by **replace**, contiguous sequences of #x20's are collapsed to a single #x20, and leading and trailing #x20's are removed.

NOTE: The notation #xA used here (and elsewhere in this specification) represents the Universal Character Set (UCS) code point `hexadecimal A` (line feed), which is denoted by U+000A. This notation is to be distinguished from `
`, which is the XML character reference to that same UCS code point.

whiteSpace is applicable to all atomic and list datatypes. For all atomic datatypes other than string (and types derived by restriction from it) the value of **whiteSpace** is `collapse` and cannot be changed by a schema author; for string the value of **whiteSpace** is `preserve`; for any type derived by restriction from string the value of **whiteSpace** can be any of the three legal values. For all datatypes derived by list the value of **whiteSpace** is `collapse` and cannot be changed by a schema author. For all datatypes derived by union **whiteSpace** does not apply directly; however, the normalization behavior of union types is controlled by the value of **whiteSpace** on that one of the memberTypes against which the union is successfully validated.

NOTE: For more information on **whiteSpace**, see the discussion on white space normalization in Schema Component Details in [XML Schema Part 1: Structures].

whiteSpace provides for:

- Constraining a value space according to the white space normalization rules.

Example

The following example is the datatype definition for the token built-in derived datatype.

```
<simpleType name='token'>
    <restriction base='normalizedString'>
      <whiteSpace value='collapse'/>
    </restriction>
</simpleType>
```

4.3.6.1 The whiteSpace Schema Component

Schema Component: whiteSpace

`{value}`
One of `{preserve, replace, collapse}`.

`{fixed}`
A boolean.

`{annotation}`
Optional. An annotation.

If {fixed} is *true*, then types for which the current type is the {base type definition} cannot specify a value for whiteSpace other than {value}.

4.3.6.2 XML Representation of whiteSpace Schema Components

The XML representation for a whiteSpace schema component is a <whiteSpace> element information item. The correspondences between the properties of the information item and properties of the component are as follows:

XML Representation Summary: `whiteSpace` Element Information Item

```
<whiteSpace
  fixed = boolean : false
  id = ID
  value = (collapse | preserve | replace)
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?)
</whiteSpace>
```

whiteSpace Schema Component

Property	Representation
{value}	The actual value of the `value` [attribute]
{fixed}	The actual value of the `fixed` [attribute], if present, otherwise false
{annotation}	The annotations corresponding to all the <annotation> element information items in the [children], if any.

4.3.6.3 whiteSpace Validation Rules

NOTE: There are no Validation Rule s associated whiteSpace . For more information, see the discussion on white space normalization in Schema Component Details in [XML Schema Part 1: Structures].

4.3.6.4 Constraints on whiteSpace Schema Components

Schema Component Constraint: whiteSpace valid restriction

It is an error if whiteSpace is among the members of {facets} of {base type definition} and any of the following conditions is true:

1 {value} is *replace* or *preserve* and the {value} of the parent whiteSpace is *collapse*

2 {value} is *preserve* and the {value} of the parent whiteSpace is *replace*

4.3.7 maxInclusive

[Definition:] **maxInclusive** is the inclusive upper bound of the value space for a datatype with the ordered property. The value of **maxInclusive** must be in the value space of the base type .

maxInclusive provides for:

- Constraining a value space to values with a specific inclusive upper bound .

Example

The following is the definition of a user-derived datatype which limits values to integers less than or equal to 100, using maxInclusive .

```
<simpleType name='one-hundred-or-less'>
  <restriction base='integer'>
    <maxInclusive value='100'/>
  </restriction>
</simpleType>
```

4.3.7.1 The maxInclusive Schema Component

Schema Component: maxInclusive

`{value}`
A value from the value space of the {base type definition}.

`{fixed}`
A boolean.

`{annotation}`
Optional. An annotation.

If {fixed} is *true*, then types for which the current type is the {base type definition} cannot specify a value for maxInclusive other than {value}.

4.3.7.2 XML Representation of maxInclusive Schema Components

The XML representation for a maxInclusive schema component is a <maxInclusive> element information item. The correspondences between the properties of the information item and properties of the component are as follows:

XML Representation Summary: `maxInclusive` **Element Information Item**

```
<maxInclusive
  fixed = boolean : false
  id = ID
  value = anySimpleType
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?)
</maxInclusive>
```

{value} must be in the value space of {base type definition}.

maxInclusive Schema Component

Property	Representation
{value}	The actual value of the `value` [attribute]
{fixed}	The actual value of the `fixed` [attribute], if present, otherwise false, if present, otherwise false
{annotation}	The annotations corresponding to all the <annotation> element information items in the [children], if any.

4.3.7.3 maxInclusive Validation Rules

Validation Rule: maxInclusive Valid

A value in an ordered value space is facet-valid with respect to maxInclusive , determined as follows:

1 if the numeric property in {fundamental facets} is *true*, then the value must be numerically less than or equal to {value};
2 if the numeric property in {fundamental facets} is *false* (i.e., {base type definition} is one of the date and time related datatypes), then the value must be chronologically less than or equal to {value};

4.3.7.4 Constraints on maxInclusive Schema Components

Schema Component Constraint: minInclusive <= maxInclusive

It is an error for the value specified for minInclusive to be greater than the value specified for maxInclusive for the same datatype.

Schema Component Constraint: maxInclusive valid restriction

It is an error if any of the following conditions is true:

1 maxInclusive is among the members of {facets} of {base type definition} and {value} is greater than the {value} of the parent maxInclusive
2 maxExclusive is among the members of {facets} of {base type definition} and {value} is greater than or equal to the {value} of the parent maxExclusive
3 minInclusive is among the members of {facets} of {base type definition} and {value} is less than the {value} of the parent minInclusive
4 minExclusive is among the members of {facets} of {base type definition} and {value} is less than or equal to the {value} of the parent minExclusive

4.3.8 maxExclusive

[Definition:] **maxExclusive** is the exclusive upper bound of the value space for a datatype with the ordered property. The value of **maxExclusive** must be in the value space of the base type .

maxExclusive provides for:

- Constraining a value space to values with a specific exclusive upper bound .

Example

The following is the definition of a user-derived datatype which limits values to integers less than or equal to 100, using maxExclusive .

```
<simpleType name='less-than-one-hundred-and-one'>
  <restriction base='integer'>
    <maxExclusive value='101'/>
  </restriction>
</simpleType>
```

Note that the value space of this datatype is identical to the previous one (named 'one-hundred-or-less').

4.3.8.1 The maxExclusive Schema Component

Schema Component: maxExclusive

`{value}`
A value from the value space of the {base type definition}.
`{fixed}`
A boolean.
`{annotation}`
Optional. An annotation.

If {fixed} is *true*, then types for which the current type is the {base type definition} cannot specify a value for maxExclusive other than {value}.

4.3.8.2 XML Representation of maxExclusive Schema Components

The XML representation for a maxExclusive schema component is a <maxExclusive> element information item. The correspondences between the properties of the information item and properties of the component are as follows:

XML Representation Summary: `maxExclusive` **Element Information Item**

```
<maxExclusive
  fixed = boolean : false
  id = ID
  value = anySimpleType
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?)
</maxExclusive>
```

{value} must be in the value space of {base type definition}.

maxExclusive Schema Component

Property	Representation
{value}	The actual value of the `value` [attribute]
{fixed}	The actual value of the `fixed` [attribute], if present, otherwise false
{annotation}	The annotations corresponding to all the <annotation> element information items in the [children], if any.

4.3.8.3 maxExclusive Validation Rules

Validation Rule: maxExclusive Valid

A value in an ordered value space is facet-valid with respect to maxExclusive , determined as follows:

1 if the numeric property in {fundamental facets} is *true*, then the value must be numerically less than {value};

2 if the numeric property in {fundamental facets} is *false* (i.e., {base type definition} is one of the date and time related datatypes), then the value must be chronologically less than {value};

4.3.8.4 Constraints on maxExclusive Schema Components

Schema Component Constraint: maxInclusive and maxExclusive

It is an error for both maxInclusive and maxExclusive to be specified in the same derivation step of a datatype definition.

Schema Component Constraint: minExclusive <= maxExclusive

It is an error for the value specified for minExclusive to be greater than the value specified for maxExclusive for the same datatype.

Schema Component Constraint: maxExclusive valid restriction

It is an error if any of the following conditions is true:

1 maxExclusive is among the members of {facets} of {base type definition} and {value} is greater than the {value} of the parent maxExclusive

2 maxInclusive is among the members of {facets} of {base type definition} and {value} is greater than the {value} of the parent maxInclusive

3 minInclusive is among the members of {facets} of {base type definition} and {value} is less than or equal to the {value} of the parent minInclusive

4 minExclusive is among the members of {facets} of {base type definition} and {value} is less than or equal to the {value} of the parent minExclusive

4.3.9 minExclusive

[Definition:] **minExclusive** is the exclusive lower bound of the value space for a datatype with the ordered property. The value of **minExclusive** must be in the value space of the base type .

minExclusive provides for:

- Constraining a value space to values with a specific exclusive lower bound .

Example

The following is the definition of a user-derived datatype which limits values to integers greater than or equal to 100, using minExclusive .

```
<simpleType name='more-than-ninety-nine'>
  <restriction base='integer'>
    <minExclusive value='99'/>
  </restriction>
</simpleType>
```

Note that the value space of this datatype is identical to the previous one (named 'one-hundred-or-more').

4.3.9.1 The minExclusive Schema Component

Schema Component: minExclusive

`{value}`
A value from the value space of the {base type definition}.

`{fixed}`
A boolean.

`{annotation}`
Optional. An annotation.

If {fixed} is *true*, then types for which the current type is the {base type definition} cannot specify a value for minExclusive other than {value}.

4.3.9.2 XML Representation of minExclusive Schema Components

The XML representation for a minExclusive schema component is a <minExclusive> element information item. The correspondences between the properties of the information item and properties of the component are as follows:

XML Representation Summary: `minExclusive` **Element Information Item**

```
<minExclusive
  fixed = boolean : false
  id = ID
  value = anySimpleType
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?)
</minExclusive>
```

{value} must be in the value space of {base type definition}.

minExclusive Schema Component

Property	Representation
{value}	The actual value of the `value` [attribute]
{fixed}	The actual value of the `fixed` [attribute], if present, otherwise false
{annotation}	The annotations corresponding to all the <annotation> element information items in the [children], if any.

4.3.9.3 minExclusive Validation Rules

Validation Rule: minExclusive Valid

A value in an ordered value space is facet-valid with respect to minExclusive if:

1 if the numeric property in {fundamental facets} is *true*, then the value must be numerically greater than {value};

2 if the numeric property in {fundamental facets} is *false* (i.e., {base type definition} is one of the date and time related datatypes), then the value must be chronologically greater than {value};

4.3.9.4 Constraints on minExclusive Schema Components

Schema Component Constraint: minInclusive and minExclusive

It is an error for both minInclusive and minExclusive to be specified for the same datatype.

Schema Component Constraint: minExclusive < maxInclusive

It is an error for the value specified for minExclusive to be greater than or equal to the value specified for maxInclusive for the same datatype.

Schema Component Constraint: minExclusive valid restriction

It is an error if any of the following conditions is true:

1 minExclusive is among the members of {facets} of {base type definition} and {value} is less than the {value} of the parent minExclusive

2 maxInclusive is among the members of {facets} of {base type definition} and {value} is greater the {value} of the parent maxInclusive

3 minInclusive is among the members of {facets} of {base type definition} and {value} is less than the {value} of the parent minInclusive

4 maxExclusive is among the members of {facets} of {base type definition} and {value} is greater than or equal to the {value} of the parent maxExclusive

4.3.10 minInclusive

[Definition:] **minInclusive** is the inclusive lower bound of the value space for a datatype with the ordered property. The value of **minInclusive** must be in the value space of the base type .

minInclusive provides for:

- Constraining a value space to values with a specific inclusive lower bound .

Example

The following is the definition of a user-derived datatype which limits values to integers greater than or equal to 100, using minInclusive .

```
<simpleType name='one-hundred-or-more'>
  <restriction base='integer'>
    <minInclusive value='100'/>
  </restriction>
</simpleType>
```

4.3.10.1 The minInclusive Schema Component

Schema Component: minInclusive

`{value}`
A value from the value space of the {base type definition}.

`{fixed}`
A boolean.

`{annotation}`
Optional. An annotation.

If {fixed} is *true*, then types for which the current type is the {base type definition} cannot specify a value for minInclusive other than {value}.

4.3.10.2 XML Representation of minInclusive Schema Components

The XML representation for a minInclusive schema component is a <minInclusive> element information item. The correspondences between the properties of the information item and properties of the component are as follows:

XML Representation Summary: `minInclusive` Element Information Item

```
<minInclusive
  fixed = boolean : false
  id = ID
  value = anySimpleType
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?)
</minInclusive>
```

{value} must be in the value space of {base type definition}.

minInclusive Schema Component

Property	Representation
{value}	The actual value of the `value` [attribute]
{fixed}	The actual value of the `fixed` [attribute], if present, otherwise false
{annotation}	The annotations corresponding to all the <annotation> element information items in the [children], if any.

4.3.10.3 minInclusive Validation Rules

Validation Rule: minInclusive Valid

A value in an ordered value space is facet-valid with respect to minInclusive if:

1 if the numeric property in {fundamental facets} is *true*, then the value must be numerically greater than or equal to {value};

2 if the numeric property in {fundamental facets} is *false* (i.e., {base type definition} is one of the date and time related datatypes), then the value must be chronologically greater than or equal to {value};

4.3.10.4 Constraints on minInclusive Schema Components

Schema Component Constraint: minInclusive < maxExclusive

It is an error for the value specified for minInclusive to be greater than or equal to the value specified for maxExclusive for the same datatype.

Schema Component Constraint: minInclusive valid restriction

It is an error if any of the following conditions is true:

1 minInclusive is among the members of {facets} of {base type definition} and {value} is less than the {value} of the parent minInclusive

2 maxInclusive is among the members of {facets} of {base type definition} and {value} is greater the {value} of the parent maxInclusive

3 minExclusive is among the members of {facets} of {base type definition} and {value} is less than or equal to the {value} of the parent minExclusive

4 maxExclusive is among the members of {facets} of {base type definition} and {value} is greater than or equal to the {value} of the parent maxExclusive

4.3.11 totalDigits

[Definition:] **totalDigits** is the maximum number of digits in values of datatypes derived from decimal. The value of **totalDigits** must be a positiveInteger.

totalDigits provides for:

- Constraining a value space to values with a specific maximum number of decimal digits (#x30-#x39).

Example

The following is the definition of a user-derived datatype which could be used to represent monetary amounts, such as in a financial management application which does not have figures of $1M or more and only allows whole cents. This definition would appear in a schema authored by an "end-user" and shows how to define a datatype by specifying facet values which constrain the range of the base type in a manner specific to the base type (different than specifying max/min values as before).

```
<simpleType name='amount'>
  <restriction base='decimal'>
    <totalDigits value='8'/>
    <fractionDigits value='2' fixed='true'/>
  </restriction>
</simpleType>
```

4.3.11.1 The totalDigits Schema Component

Schema Component: totalDigits

`{value}`
A positiveInteger.

`{fixed}`
A boolean.

`{annotation}`
Optional. An annotation.

If {fixed} is *true*, then types for which the current type is the {base type definition} cannot specify a value for totalDigits other than {value}.

4.3.11.2 XML Representation of totalDigits Schema Components

The XML representation for a totalDigits schema component is a <totalDigits> element information item. The correspondences between the properties of the information item and properties of the component are as follows:

XML Representation Summary: `totalDigits` Element Information Item

```
<totalDigits
  fixed = boolean : false
  id = ID
  value = positiveInteger
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?)
</totalDigits>
```

totalDigits Schema Component

Property	Representation
{value}	The actual value of the `value` [attribute]
{fixed}	The actual value of the `fixed` [attribute], if present, otherwise false
{annotation}	The annotations corresponding to all the <annotation> element information items in the [children], if any.

4.3.11.3 totalDigits Validation Rules

Validation Rule: totalDigits Valid

A value in a value space is facet-valid with respect to totalDigits if:

1 the number of decimal digits in the value is less than or equal to {value};

4.3.11.4 Constraints on totalDigits Schema Components

Schema Component Constraint: totalDigits valid restriction

It is an error if totalDigits is among the members of {facets} of {base type definition} and {value} is greater than the {value} of the parent totalDigits

4.3.12 fractionDigits

[Definition:] **fractionDigits** is the maximum number of digits in the fractional part of values of datatypes derived from decimal. The value of **fractionDigits** must be a nonNegativeInteger .

fractionDigits provides for:

- Constraining a value space to values with a specific maximum number of decimal digits in the fractional part.

Example

The following is the definition of a user-derived datatype which could be used to represent the magnitude of a person's body temperature on the Celsius scale. This definition would appear in a schema authored by an "end-user" and shows how to define a datatype by specifying facet values which constrain the range of the base type .

```
<simpleType name='celsiusBodyTemp'>
  <restriction base='decimal'>
    <totalDigits value='4'/>
    <fractionDigits value='1'/>
    <minInclusive value='36.4'/>
    <maxInclusive value='40.5'/>
  </restriction>
</simpleType>
```

4.3.12.1 The fractionDigits Schema Component

Schema Component: fractionDigits

`{value}`
A nonNegativeInteger.

`{fixed}`
A boolean.

`{annotation}`
Optional. An annotation.

If {fixed} is *true*, then types for which the current type is the {base type definition} cannot specify a value for fractionDigits other than {value}.

4.3.12.2 XML Representation of fractionDigits Schema Components

The XML representation for a fractionDigits schema component is a <fractionDigits> element information item. The correspondences between the properties of the information item and properties of the component are as follows:

XML Representation Summary: `fractionDigits` **Element Information Item**

```
<fractionDigits
  fixed = boolean : false
  id = ID
  value = nonNegativeInteger
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?)
</fractionDigits>
```

fractionDigits Schema Component

Property	Representation
{value}	The actual value of the `value` [attribute]
{fixed}	The actual value of the `fixed` [attribute], if present, otherwise false
{annotation}	The annotations corresponding to all the <annotation> element information items in the [children], if any.

4.3.12.3 fractionDigits Validation Rules

Validation Rule: fractionDigits Valid

A value in a value space is facet-valid with respect to fractionDigits if:

1 the number of decimal digits in the fractional part of the value is less than or equal to {value};

4.3.12.4 Constraints on fractionDigits Schema Components

Schema Component Constraint: fractionDigits less than or equal to totalDigits

It is an error for fractionDigits to be greater than totalDigits .

5 Conformance

This specification describes two levels of conformance for datatype processors. The first is required of all processors. Support for the other will depend on the application environments for which the processor is intended.

[Definition:] **Minimally conforming** processors must completely and correctly implement the Constraint on Schemas and Validation Rule .

[Definition:] Processors which accept schemas in the form of XML documents as described in XML Representation of Simple Type Definition Schema Components (§4.1.2) (and other relevant portions of Datatype components (§4)) are additionally said to provide **conformance to the XML Representation of Schemas**, and must , when processing schema documents, completely and correctly correctly implement all Schema Representation Constraint s in this specification, and must adhere exactly to the specifications in XML Representation of Simple Type Definition Schema Components (§4.1.2) (and other relevant portions of Datatype components (§4)) for mapping the contents of such documents to schema components for use in validation.

> **NOTE:** By separating the conformance requirements relating to the concrete syntax of XML schema documents, this this specification admits processors which validate using schemas stored in optimized binary representations, dynamically created schemas represented as programming language data structures, or implementations in which particular schemas are compiled into executable code such as C or Java. Such processors can be said to be minimally conforming but not necessarily in conformance to the XML Representation of Schemas .

A Schema for Datatype Definitions (normative)

```
<?xml version='1.0'?>
<!-- XML Schema schema for XML Schemas: Part 2: Datatypes -->
<!DOCTYPE xs:schema PUBLIC "-//W3C//DTD XMLSCHEMA 200102//EN"
          "XMLSchema.dtd" [

<!--
     keep this schema XML1.0 DTD valid
  -->
        <!ENTITY % schemaAttrs 'xmlns:hfp CDATA #IMPLIED'>

        <!ELEMENT hfp:hasFacet EMPTY>
        <!ATTLIST hfp:hasFacet
                name NMTOKEN #REQUIRED>

        <!ELEMENT hfp:hasProperty EMPTY>
```

```
        <!ATTLIST hfp:hasProperty
                name NMTOKEN #REQUIRED
                value CDATA #REQUIRED>
<!--
        Make sure that processors that do not read the external
        subset will know about the various IDs we declare
  -->
        <!ATTLIST xs:simpleType id ID #IMPLIED>
        <!ATTLIST xs:maxExclusive id ID #IMPLIED>
        <!ATTLIST xs:minExclusive id ID #IMPLIED>
        <!ATTLIST xs:maxInclusive id ID #IMPLIED>
        <!ATTLIST xs:minInclusive id ID #IMPLIED>
        <!ATTLIST xs:totalDigits id ID #IMPLIED>
        <!ATTLIST xs:fractionDigits id ID #IMPLIED>
        <!ATTLIST xs:length id ID #IMPLIED>
        <!ATTLIST xs:minLength id ID #IMPLIED>
        <!ATTLIST xs:maxLength id ID #IMPLIED>
        <!ATTLIST xs:enumeration id ID #IMPLIED>
        <!ATTLIST xs:pattern id ID #IMPLIED>
        <!ATTLIST xs:appinfo id ID #IMPLIED>
        <!ATTLIST xs:documentation id ID #IMPLIED>
        <!ATTLIST xs:list id ID #IMPLIED>
        <!ATTLIST xs:union id ID #IMPLIED>
        ]>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
        targetNamespace="http://www.w3.org/2001/XMLSchema"
        version="Id: datatypes.xsd,v 1.52 2001/04/27 11:49:21 ht Exp "
        xmlns:hfp="http://www.w3.org/2001/XMLSchema-hasFacetAndProperty"
        elementFormDefault="qualified"
        blockDefault="#all"
        xml:lang="en">

  <xs:annotation>
   <xs:documentation source="http://www.w3.org/TR/2001/REC-xmlschema-2-20010502/datatyp
      The schema corresponding to this document is normative,
      with respect to the syntactic constraints it expresses in the
      XML Schema language.  The documentation (within &lt;documentation>
      elements) below, is not normative, but rather highlights important
      aspects of the W3C Recommendation of which this is a part
    </xs:documentation>
  </xs:annotation>

  <xs:annotation>
    <xs:documentation>
      First the built-in primitive datatypes.  These definitions are for
      information only, the real built-in definitions are magic.  Note in
      particular that there is no type named 'anySimpleType'.  The
      primitives should really be derived from no type at all, and
      anySimpleType should be derived as a union of all the primitives.
    </xs:documentation>

    <xs:documentation>
      For each built-in datatype in this schema (both primitive and
      derived) can be uniquely addressed via a URI constructed
      as follows:
        1) the base URI is the URI of the XML Schema namespace
        2) the fragment identifier is the name of the datatype

      For example, to address the int datatype, the URI is:

        http://www.w3.org/2001/XMLSchema#int

      Additionally, each facet definition element can be uniquely
      addressed via a URI constructed as follows:
        1) the base URI is the URI of the XML Schema namespace
```

```
      2) the fragment identifier is the name of the facet

    For example, to address the maxInclusive facet, the URI is:

      http://www.w3.org/2001/XMLSchema#maxInclusive

    Additionally, each facet usage in a built-in datatype definition
    can be uniquely addressed via a URI constructed as follows:
      1) the base URI is the URI of the XML Schema namespace
      2) the fragment identifier is the name of the datatype, followed
         by a period (".") followed by the name of the facet

    For example, to address the usage of the maxInclusive facet in
    the definition of int, the URI is:

      http://www.w3.org/2001/XMLSchema#int.maxInclusive

  </xs:documentation>
</xs:annotation>

<xs:simpleType name="string" id="string">
  <xs:annotation>
    <xs:appinfo>
      <hfp:hasFacet name="length"/>
      <hfp:hasFacet name="minLength"/>
      <hfp:hasFacet name="maxLength"/>
      <hfp:hasFacet name="pattern"/>
      <hfp:hasFacet name="enumeration"/>
      <hfp:hasFacet name="whiteSpace"/>
      <hfp:hasProperty name="ordered" value="false"/>
      <hfp:hasProperty name="bounded" value="false"/>
      <hfp:hasProperty name="cardinality" value="countably infinite"/>
      <hfp:hasProperty name="numeric" value="false"/>
    </xs:appinfo>
    <xs:documentation
              source="http://www.w3.org/TR/xmlschema-2/#string"/>
  </xs:annotation>
  <xs:restriction base="xs:anySimpleType">
    <xs:whiteSpace value="preserve" id="string.preserve"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="boolean" id="boolean">
  <xs:annotation>
    <xs:appinfo>
      <hfp:hasFacet name="pattern"/>
      <hfp:hasFacet name="whiteSpace"/>
      <hfp:hasProperty name="ordered" value="false"/>
      <hfp:hasProperty name="bounded" value="false"/>
      <hfp:hasProperty name="cardinality" value="finite"/>
      <hfp:hasProperty name="numeric" value="false"/>
    </xs:appinfo>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#boolean"/>
  </xs:annotation>
  <xs:restriction base="xs:anySimpleType">
    <xs:whiteSpace value="collapse" fixed="true"
      id="boolean.whiteSpace"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="float" id="float">
  <xs:annotation>
    <xs:appinfo>
      <hfp:hasFacet name="pattern"/>
```

```
        <hfp:hasFacet name="enumeration"/>
        <hfp:hasFacet name="whiteSpace"/>
        <hfp:hasFacet name="maxInclusive"/>
        <hfp:hasFacet name="maxExclusive"/>
        <hfp:hasFacet name="minInclusive"/>
        <hfp:hasFacet name="minExclusive"/>
        <hfp:hasProperty name="ordered" value="total"/>
        <hfp:hasProperty name="bounded" value="true"/>
        <hfp:hasProperty name="cardinality" value="finite"/>
        <hfp:hasProperty name="numeric" value="true"/>
      </xs:appinfo>
      <xs:documentation
        source="http://www.w3.org/TR/xmlschema-2/#float"/>
    </xs:annotation>
    <xs:restriction base="xs:anySimpleType">
      <xs:whiteSpace value="collapse" fixed="true"
        id="float.whiteSpace"/>
    </xs:restriction>
  </xs:simpleType>

  <xs:simpleType name="double" id="double">
    <xs:annotation>
      <xs:appinfo>
        <hfp:hasFacet name="pattern"/>
        <hfp:hasFacet name="enumeration"/>
        <hfp:hasFacet name="whiteSpace"/>
        <hfp:hasFacet name="maxInclusive"/>
        <hfp:hasFacet name="maxExclusive"/>
        <hfp:hasFacet name="minInclusive"/>
        <hfp:hasFacet name="minExclusive"/>
        <hfp:hasProperty name="ordered" value="total"/>
        <hfp:hasProperty name="bounded" value="true"/>
        <hfp:hasProperty name="cardinality" value="finite"/>
        <hfp:hasProperty name="numeric" value="true"/>
      </xs:appinfo>
      <xs:documentation
        source="http://www.w3.org/TR/xmlschema-2/#double"/>
    </xs:annotation>
    <xs:restriction base="xs:anySimpleType">
      <xs:whiteSpace value="collapse"  fixed="true"
        id="double.whiteSpace"/>
    </xs:restriction>
  </xs:simpleType>

  <xs:simpleType name="decimal" id="decimal">
    <xs:annotation>
      <xs:appinfo>
        <hfp:hasFacet name="totalDigits"/>
        <hfp:hasFacet name="fractionDigits"/>
        <hfp:hasFacet name="pattern"/>
        <hfp:hasFacet name="whiteSpace"/>
        <hfp:hasFacet name="enumeration"/>
        <hfp:hasFacet name="maxInclusive"/>
        <hfp:hasFacet name="maxExclusive"/>
        <hfp:hasFacet name="minInclusive"/>
        <hfp:hasFacet name="minExclusive"/>
        <hfp:hasProperty name="ordered" value="total"/>
        <hfp:hasProperty name="bounded" value="false"/>
        <hfp:hasProperty name="cardinality"
                value="countably infinite"/>
        <hfp:hasProperty name="numeric" value="true"/>
      </xs:appinfo>
      <xs:documentation
        source="http://www.w3.org/TR/xmlschema-2/#decimal"/>
    </xs:annotation>
```

```
   <xs:restriction base="xs:anySimpleType">
     <xs:whiteSpace value="collapse"  fixed="true"
       id="decimal.whiteSpace"/>
   </xs:restriction>
  </xs:simpleType>

  <xs:simpleType name="duration" id="duration">
   <xs:annotation>
     <xs:appinfo>
       <hfp:hasFacet name="pattern"/>
       <hfp:hasFacet name="enumeration"/>
       <hfp:hasFacet name="whiteSpace"/>
       <hfp:hasFacet name="maxInclusive"/>
       <hfp:hasFacet name="maxExclusive"/>
       <hfp:hasFacet name="minInclusive"/>
       <hfp:hasFacet name="minExclusive"/>
       <hfp:hasProperty name="ordered" value="partial"/>
       <hfp:hasProperty name="bounded" value="false"/>
       <hfp:hasProperty name="cardinality"
               value="countably infinite"/>
       <hfp:hasProperty name="numeric" value="false"/>
     </xs:appinfo>
     <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#duration"/>
   </xs:annotation>
   <xs:restriction base="xs:anySimpleType">
     <xs:whiteSpace value="collapse"  fixed="true"
       id="duration.whiteSpace"/>
   </xs:restriction>
  </xs:simpleType>

<xs:simpleType name="dateTime" id="dateTime">
   <xs:annotation>
   <xs:appinfo>
       <hfp:hasFacet name="pattern"/>
       <hfp:hasFacet name="enumeration"/>
       <hfp:hasFacet name="whiteSpace"/>
       <hfp:hasFacet name="maxInclusive"/>
       <hfp:hasFacet name="maxExclusive"/>
       <hfp:hasFacet name="minInclusive"/>
       <hfp:hasFacet name="minExclusive"/>
       <hfp:hasProperty name="ordered" value="partial"/>
       <hfp:hasProperty name="bounded" value="false"/>
       <hfp:hasProperty name="cardinality"
               value="countably infinite"/>
       <hfp:hasProperty name="numeric" value="false"/>
     </xs:appinfo>
     <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#dateTime"/>
   </xs:annotation>
   <xs:restriction base="xs:anySimpleType">
     <xs:whiteSpace value="collapse"  fixed="true"
       id="dateTime.whiteSpace"/>
   </xs:restriction>
 </xs:simpleType>

 <xs:simpleType name="time" id="time">
   <xs:annotation>
   <xs:appinfo>
       <hfp:hasFacet name="pattern"/>
       <hfp:hasFacet name="enumeration"/>
       <hfp:hasFacet name="whiteSpace"/>
       <hfp:hasFacet name="maxInclusive"/>
       <hfp:hasFacet name="maxExclusive"/>
       <hfp:hasFacet name="minInclusive"/>
```

```
      <hfp:hasFacet name="minExclusive"/>
      <hfp:hasProperty name="ordered" value="partial"/>
      <hfp:hasProperty name="bounded" value="false"/>
      <hfp:hasProperty name="cardinality"
              value="countably infinite"/>
      <hfp:hasProperty name="numeric" value="false"/>
    </xs:appinfo>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#time"/>
  </xs:annotation>
  <xs:restriction base="xs:anySimpleType">
    <xs:whiteSpace value="collapse"  fixed="true"
      id="time.whiteSpace"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="date" id="date">
 <xs:annotation>
  <xs:appinfo>
      <hfp:hasFacet name="pattern"/>
      <hfp:hasFacet name="enumeration"/>
      <hfp:hasFacet name="whiteSpace"/>
      <hfp:hasFacet name="maxInclusive"/>
      <hfp:hasFacet name="maxExclusive"/>
      <hfp:hasFacet name="minInclusive"/>
      <hfp:hasFacet name="minExclusive"/>
      <hfp:hasProperty name="ordered" value="partial"/>
      <hfp:hasProperty name="bounded" value="false"/>
      <hfp:hasProperty name="cardinality"
              value="countably infinite"/>
      <hfp:hasProperty name="numeric" value="false"/>
    </xs:appinfo>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#date"/>
  </xs:annotation>
  <xs:restriction base="xs:anySimpleType">
    <xs:whiteSpace value="collapse"  fixed="true"
      id="date.whiteSpace"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="gYearMonth" id="gYearMonth">
 <xs:annotation>
  <xs:appinfo>
      <hfp:hasFacet name="pattern"/>
      <hfp:hasFacet name="enumeration"/>
      <hfp:hasFacet name="whiteSpace"/>
      <hfp:hasFacet name="maxInclusive"/>
      <hfp:hasFacet name="maxExclusive"/>
      <hfp:hasFacet name="minInclusive"/>
      <hfp:hasFacet name="minExclusive"/>
      <hfp:hasProperty name="ordered" value="partial"/>
      <hfp:hasProperty name="bounded" value="false"/>
      <hfp:hasProperty name="cardinality"
              value="countably infinite"/>
      <hfp:hasProperty name="numeric" value="false"/>
    </xs:appinfo>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#gYearMonth"/>
  </xs:annotation>
  <xs:restriction base="xs:anySimpleType">
    <xs:whiteSpace value="collapse"  fixed="true"
      id="gYearMonth.whiteSpace"/>
  </xs:restriction>
</xs:simpleType>
```

```
 <xs:simpleType name="gYear" id="gYear">
   <xs:annotation>
   <xs:appinfo>
       <hfp:hasFacet name="pattern"/>
       <hfp:hasFacet name="enumeration"/>
       <hfp:hasFacet name="whiteSpace"/>
       <hfp:hasFacet name="maxInclusive"/>
       <hfp:hasFacet name="maxExclusive"/>
       <hfp:hasFacet name="minInclusive"/>
       <hfp:hasFacet name="minExclusive"/>
       <hfp:hasProperty name="ordered" value="partial"/>
       <hfp:hasProperty name="bounded" value="false"/>
       <hfp:hasProperty name="cardinality"
               value="countably infinite"/>
       <hfp:hasProperty name="numeric" value="false"/>
     </xs:appinfo>
     <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#gYear"/>
   </xs:annotation>
   <xs:restriction base="xs:anySimpleType">
     <xs:whiteSpace value="collapse"  fixed="true"
       id="gYear.whiteSpace"/>
   </xs:restriction>
 </xs:simpleType>

<xs:simpleType name="gMonthDay" id="gMonthDay">
   <xs:annotation>
     <xs:appinfo>
       <hfp:hasFacet name="pattern"/>
       <hfp:hasFacet name="enumeration"/>
       <hfp:hasFacet name="whiteSpace"/>
       <hfp:hasFacet name="maxInclusive"/>
       <hfp:hasFacet name="maxExclusive"/>
       <hfp:hasFacet name="minInclusive"/>
       <hfp:hasFacet name="minExclusive"/>
       <hfp:hasProperty name="ordered" value="partial"/>
       <hfp:hasProperty name="bounded" value="false"/>
       <hfp:hasProperty name="cardinality"
               value="countably infinite"/>
       <hfp:hasProperty name="numeric" value="false"/>
     </xs:appinfo>
      <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#gMonthDay"/>
   </xs:annotation>
   <xs:restriction base="xs:anySimpleType">
        <xs:whiteSpace value="collapse" fixed="true"
               id="gMonthDay.whiteSpace"/>
   </xs:restriction>
 </xs:simpleType>

 <xs:simpleType name="gDay" id="gDay">
   <xs:annotation>
 <xs:appinfo>
       <hfp:hasFacet name="pattern"/>
       <hfp:hasFacet name="enumeration"/>
       <hfp:hasFacet name="whiteSpace"/>
       <hfp:hasFacet name="maxInclusive"/>
       <hfp:hasFacet name="maxExclusive"/>
       <hfp:hasFacet name="minInclusive"/>
       <hfp:hasFacet name="minExclusive"/>
       <hfp:hasProperty name="ordered" value="partial"/>
       <hfp:hasProperty name="bounded" value="false"/>
       <hfp:hasProperty name="cardinality"
               value="countably infinite"/>
```

```
       <hfp:hasProperty name="numeric" value="false"/>
     </xs:appinfo>
     <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#gDay"/>
   </xs:annotation>
   <xs:restriction base="xs:anySimpleType">
        <xs:whiteSpace value="collapse"  fixed="true"
               id="gDay.whiteSpace"/>
   </xs:restriction>
 </xs:simpleType>

<xs:simpleType name="gMonth" id="gMonth">
   <xs:annotation>
 <xs:appinfo>
       <hfp:hasFacet name="pattern"/>
       <hfp:hasFacet name="enumeration"/>
       <hfp:hasFacet name="whiteSpace"/>
       <hfp:hasFacet name="maxInclusive"/>
       <hfp:hasFacet name="maxExclusive"/>
       <hfp:hasFacet name="minInclusive"/>
       <hfp:hasFacet name="minExclusive"/>
       <hfp:hasProperty name="ordered" value="partial"/>
       <hfp:hasProperty name="bounded" value="false"/>
       <hfp:hasProperty name="cardinality"
               value="countably infinite"/>
       <hfp:hasProperty name="numeric" value="false"/>
     </xs:appinfo>
     <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#gMonth"/>
   </xs:annotation>
   <xs:restriction base="xs:anySimpleType">
        <xs:whiteSpace value="collapse"  fixed="true"
               id="gMonth.whiteSpace"/>
   </xs:restriction>
 </xs:simpleType>

  <xs:simpleType name="hexBinary" id="hexBinary">
   <xs:annotation>
     <xs:appinfo>
       <hfp:hasFacet name="length"/>
       <hfp:hasFacet name="minLength"/>
       <hfp:hasFacet name="maxLength"/>
       <hfp:hasFacet name="pattern"/>
       <hfp:hasFacet name="enumeration"/>
       <hfp:hasFacet name="whiteSpace"/>
       <hfp:hasProperty name="ordered" value="false"/>
       <hfp:hasProperty name="bounded" value="false"/>
       <hfp:hasProperty name="cardinality"
               value="countably infinite"/>
       <hfp:hasProperty name="numeric" value="false"/>
     </xs:appinfo>
     <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#binary"/>
   </xs:annotation>
   <xs:restriction base="xs:anySimpleType">
     <xs:whiteSpace value="collapse" fixed="true"
       id="hexBinary.whiteSpace"/>
   </xs:restriction>
  </xs:simpleType>

<xs:simpleType name="base64Binary" id="base64Binary">
   <xs:annotation>
     <xs:appinfo>
       <hfp:hasFacet name="length"/>
       <hfp:hasFacet name="minLength"/>
```

```
      <hfp:hasFacet name="maxLength"/>
      <hfp:hasFacet name="pattern"/>
      <hfp:hasFacet name="enumeration"/>
      <hfp:hasFacet name="whiteSpace"/>
      <hfp:hasProperty name="ordered" value="false"/>
      <hfp:hasProperty name="bounded" value="false"/>
      <hfp:hasProperty name="cardinality"
              value="countably infinite"/>
      <hfp:hasProperty name="numeric" value="false"/>
    </xs:appinfo>
    <xs:documentation
              source="http://www.w3.org/TR/xmlschema-2/#base64Binary"/>
  </xs:annotation>
  <xs:restriction base="xs:anySimpleType">
    <xs:whiteSpace value="collapse" fixed="true"
      id="base64Binary.whiteSpace"/>
  </xs:restriction>
 </xs:simpleType>

 <xs:simpleType name="anyURI" id="anyURI">
  <xs:annotation>
    <xs:appinfo>
      <hfp:hasFacet name="length"/>
      <hfp:hasFacet name="minLength"/>
      <hfp:hasFacet name="maxLength"/>
      <hfp:hasFacet name="pattern"/>
      <hfp:hasFacet name="enumeration"/>
      <hfp:hasFacet name="whiteSpace"/>
      <hfp:hasProperty name="ordered" value="false"/>
      <hfp:hasProperty name="bounded" value="false"/>
      <hfp:hasProperty name="cardinality"
              value="countably infinite"/>
      <hfp:hasProperty name="numeric" value="false"/>
    </xs:appinfo>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#anyURI"/>
  </xs:annotation>
  <xs:restriction base="xs:anySimpleType">
    <xs:whiteSpace value="collapse"  fixed="true"
      id="anyURI.whiteSpace"/>
  </xs:restriction>
 </xs:simpleType>

<xs:simpleType name="QName" id="QName">
  <xs:annotation>
      <xs:appinfo>
      <hfp:hasFacet name="length"/>
      <hfp:hasFacet name="minLength"/>
      <hfp:hasFacet name="maxLength"/>
      <hfp:hasFacet name="pattern"/>
      <hfp:hasFacet name="enumeration"/>
      <hfp:hasFacet name="whiteSpace"/>
      <hfp:hasProperty name="ordered" value="false"/>
      <hfp:hasProperty name="bounded" value="false"/>
      <hfp:hasProperty name="cardinality"
              value="countably infinite"/>
      <hfp:hasProperty name="numeric" value="false"/>
    </xs:appinfo>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#QName"/>
  </xs:annotation>
  <xs:restriction base="xs:anySimpleType">
    <xs:whiteSpace value="collapse"  fixed="true"
      id="QName.whiteSpace"/>
  </xs:restriction>
```

```
</xs:simpleType>

 <xs:simpleType name="NOTATION" id="NOTATION">
  <xs:annotation>
      <xs:appinfo>
      <hfp:hasFacet name="length"/>
      <hfp:hasFacet name="minLength"/>
      <hfp:hasFacet name="maxLength"/>
      <hfp:hasFacet name="pattern"/>
      <hfp:hasFacet name="enumeration"/>
      <hfp:hasFacet name="whiteSpace"/>
      <hfp:hasProperty name="ordered" value="false"/>
      <hfp:hasProperty name="bounded" value="false"/>
      <hfp:hasProperty name="cardinality"
              value="countably infinite"/>
      <hfp:hasProperty name="numeric" value="false"/>
    </xs:appinfo>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#NOTATION"/>
    <xs:documentation>
      NOTATION cannot be used directly in a schema; rather a type
      must be derived from it by specifying at least one enumeration
      facet whose value is the name of a NOTATION declared in the
      schema.
    </xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:anySimpleType">
    <xs:whiteSpace value="collapse"  fixed="true"
      id="NOTATION.whiteSpace"/>
  </xs:restriction>
</xs:simpleType>

<xs:annotation>
  <xs:documentation>
    Now the derived primitive types
  </xs:documentation>
</xs:annotation>

<xs:simpleType name="normalizedString" id="normalizedString">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#normalizedString"/>
  </xs:annotation>
  <xs:restriction base="xs:string">
    <xs:whiteSpace value="replace"
      id="normalizedString.whiteSpace"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="token" id="token">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#token"/>
  </xs:annotation>
  <xs:restriction base="xs:normalizedString">
    <xs:whiteSpace value="collapse" id="token.whiteSpace"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="language" id="language">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#language"/>
  </xs:annotation>
  <xs:restriction base="xs:token">
```

```
    <xs:pattern
      value="([a-zA-Z]{2}|[iI]-[a-zA-Z]+|[xX]-[a-zA-Z]{1,8})(-[a-zA-Z]{1,8})*"
              id="language.pattern">
      <xs:annotation>
        <xs:documentation
              source="http://www.w3.org/TR/REC-xml#NT-LanguageID">
          pattern specifies the content of section 2.12 of XML 1.0e2
          and RFC 1766
        </xs:documentation>
      </xs:annotation>
    </xs:pattern>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="IDREFS" id="IDREFS">
  <xs:annotation>
    <xs:appinfo>
      <hfp:hasFacet name="length"/>
      <hfp:hasFacet name="minLength"/>
      <hfp:hasFacet name="maxLength"/>
      <hfp:hasFacet name="enumeration"/>
      <hfp:hasFacet name="whiteSpace"/>
      <hfp:hasProperty name="ordered" value="false"/>
      <hfp:hasProperty name="bounded" value="false"/>
      <hfp:hasProperty name="cardinality"
              value="countably infinite"/>
      <hfp:hasProperty name="numeric" value="false"/>
    </xs:appinfo>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#IDREFS"/>
  </xs:annotation>
  <xs:restriction>
    <xs:simpleType>
      <xs:list itemType="xs:IDREF"/>
    </xs:simpleType>
      <xs:minLength value="1" id="IDREFS.minLength"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="ENTITIES" id="ENTITIES">
  <xs:annotation>
    <xs:appinfo>
      <hfp:hasFacet name="length"/>
      <hfp:hasFacet name="minLength"/>
      <hfp:hasFacet name="maxLength"/>
      <hfp:hasFacet name="enumeration"/>
      <hfp:hasFacet name="whiteSpace"/>
      <hfp:hasProperty name="ordered" value="false"/>
      <hfp:hasProperty name="bounded" value="false"/>
      <hfp:hasProperty name="cardinality"
              value="countably infinite"/>
      <hfp:hasProperty name="numeric" value="false"/>
    </xs:appinfo>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#ENTITIES"/>
  </xs:annotation>
  <xs:restriction>
    <xs:simpleType>
      <xs:list itemType="xs:ENTITY"/>
    </xs:simpleType>
      <xs:minLength value="1" id="ENTITIES.minLength"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="NMTOKEN" id="NMTOKEN">
```

```
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#NMTOKEN"/>
  </xs:annotation>
  <xs:restriction base="xs:token">
    <xs:pattern value="\c+" id="NMTOKEN.pattern">
      <xs:annotation>
        <xs:documentation
              source="http://www.w3.org/TR/REC-xml#NT-Nmtoken">
          pattern matches production 7 from the XML spec
        </xs:documentation>
      </xs:annotation>
    </xs:pattern>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="NMTOKENS" id="NMTOKENS">
  <xs:annotation>
    <xs:appinfo>
      <hfp:hasFacet name="length"/>
      <hfp:hasFacet name="minLength"/>
      <hfp:hasFacet name="maxLength"/>
      <hfp:hasFacet name="enumeration"/>
      <hfp:hasFacet name="whiteSpace"/>
      <hfp:hasProperty name="ordered" value="false"/>
      <hfp:hasProperty name="bounded" value="false"/>
      <hfp:hasProperty name="cardinality"
              value="countably infinite"/>
      <hfp:hasProperty name="numeric" value="false"/>
    </xs:appinfo>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#NMTOKENS"/>
  </xs:annotation>
  <xs:restriction>
    <xs:simpleType>
      <xs:list itemType="xs:NMTOKEN"/>
    </xs:simpleType>
      <xs:minLength value="1" id="NMTOKENS.minLength"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="Name" id="Name">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#Name"/>
  </xs:annotation>
  <xs:restriction base="xs:token">
    <xs:pattern value="\i\c*" id="Name.pattern">
      <xs:annotation>
        <xs:documentation
                      source="http://www.w3.org/TR/REC-xml#NT-Name">
          pattern matches production 5 from the XML spec
        </xs:documentation>
      </xs:annotation>
    </xs:pattern>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="NCName" id="NCName">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#NCName"/>
  </xs:annotation>
  <xs:restriction base="xs:Name">
    <xs:pattern value="[\i-[:]][\c-[:]]*" id="NCName.pattern">
```

```
      <xs:annotation>
        <xs:documentation
              source="http://www.w3.org/TR/REC-xml-names/#NT-NCName">
          pattern matches production 4 from the Namespaces in XML spec
        </xs:documentation>
      </xs:annotation>
    </xs:pattern>
  </xs:restriction>
</xs:simpleType>

 <xs:simpleType name="ID" id="ID">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#ID"/>
  </xs:annotation>
  <xs:restriction base="xs:NCName"/>
 </xs:simpleType>

 <xs:simpleType name="IDREF" id="IDREF">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#IDREF"/>
  </xs:annotation>
  <xs:restriction base="xs:NCName"/>
 </xs:simpleType>

 <xs:simpleType name="ENTITY" id="ENTITY">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#ENTITY"/>
  </xs:annotation>
  <xs:restriction base="xs:NCName"/>
 </xs:simpleType>

<xs:simpleType name="integer" id="integer">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#integer"/>
  </xs:annotation>
  <xs:restriction base="xs:decimal">
    <xs:fractionDigits value="0" fixed="true" id="integer.fractionDigits"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="nonPositiveInteger" id="nonPositiveInteger">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#nonPositiveInteger"/>
  </xs:annotation>
  <xs:restriction base="xs:integer">
    <xs:maxInclusive value="0" id="nonPositiveInteger.maxInclusive"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="negativeInteger" id="negativeInteger">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#negativeInteger"/>
  </xs:annotation>
  <xs:restriction base="xs:nonPositiveInteger">
    <xs:maxInclusive value="-1" id="negativeInteger.maxInclusive"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="long" id="long">
```

```
  <xs:annotation>
    <xs:appinfo>
      <hfp:hasProperty name="bounded" value="true"/>
      <hfp:hasProperty name="cardinality" value="finite"/>
    </xs:appinfo>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#long"/>
  </xs:annotation>
  <xs:restriction base="xs:integer">
    <xs:minInclusive value="-9223372036854775808" id="long.minInclusive"/>
    <xs:maxInclusive value="9223372036854775807" id="long.maxInclusive"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="int" id="int">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#int"/>
  </xs:annotation>
  <xs:restriction base="xs:long">
    <xs:minInclusive value="-2147483648" id="int.minInclusive"/>
    <xs:maxInclusive value="2147483647" id="int.maxInclusive"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="short" id="short">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#short"/>
  </xs:annotation>
  <xs:restriction base="xs:int">
    <xs:minInclusive value="-32768" id="short.minInclusive"/>
    <xs:maxInclusive value="32767" id="short.maxInclusive"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="byte" id="byte">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#byte"/>
  </xs:annotation>
  <xs:restriction base="xs:short">
    <xs:minInclusive value="-128" id="byte.minInclusive"/>
    <xs:maxInclusive value="127" id="byte.maxInclusive"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="nonNegativeInteger" id="nonNegativeInteger">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#nonNegativeInteger"/>
  </xs:annotation>
  <xs:restriction base="xs:integer">
    <xs:minInclusive value="0" id="nonNegativeInteger.minInclusive"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="unsignedLong" id="unsignedLong">
  <xs:annotation>
    <xs:appinfo>
      <hfp:hasProperty name="bounded" value="true"/>
      <hfp:hasProperty name="cardinality" value="finite"/>
    </xs:appinfo>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#unsignedLong"/>
```

```
   </xs:annotation>
   <xs:restriction base="xs:nonNegativeInteger">
     <xs:maxInclusive value="18446744073709551615"
       id="unsignedLong.maxInclusive"/>
   </xs:restriction>
 </xs:simpleType>

 <xs:simpleType name="unsignedInt" id="unsignedInt">
   <xs:annotation>
     <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#unsignedInt"/>
   </xs:annotation>
   <xs:restriction base="xs:unsignedLong">
     <xs:maxInclusive value="4294967295"
       id="unsignedInt.maxInclusive"/>
   </xs:restriction>
 </xs:simpleType>

 <xs:simpleType name="unsignedShort" id="unsignedShort">
   <xs:annotation>
     <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#unsignedShort"/>
   </xs:annotation>
   <xs:restriction base="xs:unsignedInt">
     <xs:maxInclusive value="65535"
       id="unsignedShort.maxInclusive"/>
   </xs:restriction>
 </xs:simpleType>

 <xs:simpleType name="unsignedByte" id="unsignedBtype">
   <xs:annotation>
     <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#unsignedByte"/>
   </xs:annotation>
   <xs:restriction base="xs:unsignedShort">
     <xs:maxInclusive value="255" id="unsignedByte.maxInclusive"/>
   </xs:restriction>
 </xs:simpleType>

 <xs:simpleType name="positiveInteger" id="positiveInteger">
   <xs:annotation>
     <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#positiveInteger"/>
   </xs:annotation>
   <xs:restriction base="xs:nonNegativeInteger">
     <xs:minInclusive value="1" id="positiveInteger.minInclusive"/>
   </xs:restriction>
 </xs:simpleType>

<xs:simpleType name="derivationControl">
 <xs:annotation>
  <xs:documentation>
  A utility type, not for public use</xs:documentation>
 </xs:annotation>
 <xs:restriction base="xs:NMTOKEN">
  <xs:enumeration value="substitution"/>
  <xs:enumeration value="extension"/>
  <xs:enumeration value="restriction"/>
  <xs:enumeration value="list"/>
  <xs:enumeration value="union"/>
 </xs:restriction>
</xs:simpleType>

<xs:group name="simpleDerivation">
 <xs:choice>
```

```
   <xs:element ref="xs:restriction"/>
   <xs:element ref="xs:list"/>
   <xs:element ref="xs:union"/>
 </xs:choice>
</xs:group>

<xs:simpleType name="simpleDerivationSet">
 <xs:annotation>
  <xs:documentation>
  #all or (possibly empty) subset of {restriction, union, list}
  </xs:documentation>
  <xs:documentation>
  A utility type, not for public use</xs:documentation>
 </xs:annotation>
 <xs:union>
  <xs:simpleType>
   <xs:restriction base="xs:token">
    <xs:enumeration value="#all"/>
   </xs:restriction>
  </xs:simpleType>
  <xs:simpleType>
   <xs:restriction base="xs:derivationControl">
    <xs:enumeration value="list"/>
    <xs:enumeration value="union"/>
    <xs:enumeration value="restriction"/>
   </xs:restriction>
  </xs:simpleType>
 </xs:union>
</xs:simpleType>

 <xs:complexType name="simpleType" abstract="true">
   <xs:complexContent>
     <xs:extension base="xs:annotated">
       <xs:group ref="xs:simpleDerivation"/>
       <xs:attribute name="final" type="xs:simpleDerivationSet"/>
       <xs:attribute name="name" type="xs:NCName">
         <xs:annotation>
           <xs:documentation>
             Can be restricted to required or forbidden
           </xs:documentation>
         </xs:annotation>
       </xs:attribute>
     </xs:extension>
   </xs:complexContent>
 </xs:complexType>

 <xs:complexType name="topLevelSimpleType">
   <xs:complexContent>
     <xs:restriction base="xs:simpleType">
       <xs:sequence>
         <xs:element ref="xs:annotation" minOccurs="0"/>
         <xs:group ref="xs:simpleDerivation"/>
       </xs:sequence>
       <xs:attribute name="name" use="required"
            type="xs:NCName">
         <xs:annotation>
           <xs:documentation>
             Required at the top level
           </xs:documentation>
         </xs:annotation>
       </xs:attribute>
     </xs:restriction>
   </xs:complexContent>
 </xs:complexType>
```

```
<xs:complexType name="localSimpleType">
  <xs:complexContent>
    <xs:restriction base="xs:simpleType">
      <xs:sequence>
        <xs:element ref="xs:annotation" minOccurs="0"/>
        <xs:group ref="xs:simpleDerivation"/>
      </xs:sequence>
      <xs:attribute name="name" use="prohibited">
        <xs:annotation>
          <xs:documentation>
            Forbidden when nested
          </xs:documentation>
        </xs:annotation>
      </xs:attribute>
      <xs:attribute name="final" use="prohibited"/>
    </xs:restriction>
  </xs:complexContent>
</xs:complexType>

<xs:element name="simpleType" type="xs:topLevelSimpleType" id="simpleType">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#element-simpleType"/>
  </xs:annotation>
</xs:element>

<xs:group name="facets">
 <xs:annotation>
  <xs:documentation>
     We should use a substitution group for facets, but
     that's ruled out because it would allow users to
     add their own, which we're not ready for yet.
  </xs:documentation>
 </xs:annotation>
 <xs:choice>
  <xs:element ref="xs:minExclusive"/>
  <xs:element ref="xs:minInclusive"/>
  <xs:element ref="xs:maxExclusive"/>
  <xs:element ref="xs:maxInclusive"/>
  <xs:element ref="xs:totalDigits"/>
  <xs:element ref="xs:fractionDigits"/>
  <xs:element ref="xs:length"/>
  <xs:element ref="xs:minLength"/>
  <xs:element ref="xs:maxLength"/>
  <xs:element ref="xs:enumeration"/>
  <xs:element ref="xs:whiteSpace"/>
  <xs:element ref="xs:pattern"/>
 </xs:choice>
</xs:group>

<xs:group name="simpleRestrictionModel">
 <xs:sequence>
  <xs:element name="simpleType" type="xs:localSimpleType" minOccurs="0"/>
  <xs:group ref="xs:facets" minOccurs="0" maxOccurs="unbounded"/>
 </xs:sequence>
</xs:group>

<xs:element name="restriction" id="restriction">
 <xs:complexType>
  <xs:annotation>
    <xs:documentation
              source="http://www.w3.org/TR/xmlschema-2/#element-restriction">
        base attribute and simpleType child are mutually
        exclusive, but one or other is required
      </xs:documentation>
```

```
    </xs:annotation>
    <xs:complexContent>
      <xs:extension base="xs:annotated">
       <xs:group ref="xs:simpleRestrictionModel"/>
       <xs:attribute name="base" type="xs:QName" use="optional"/>
      </xs:extension>
    </xs:complexContent>
  </xs:complexType>
</xs:element>

<xs:element name="list" id="list">
 <xs:complexType>
  <xs:annotation>
    <xs:documentation
              source="http://www.w3.org/TR/xmlschema-2/#element-list">
        itemType attribute and simpleType child are mutually
        exclusive, but one or other is required
      </xs:documentation>
    </xs:annotation>
    <xs:complexContent>
      <xs:extension base="xs:annotated">
        <xs:sequence>
          <xs:element name="simpleType" type="xs:localSimpleType"
              minOccurs="0"/>
        </xs:sequence>
        <xs:attribute name="itemType" type="xs:QName" use="optional"/>
      </xs:extension>
    </xs:complexContent>
  </xs:complexType>
</xs:element>

<xs:element name="union" id="union">
 <xs:complexType>
  <xs:annotation>
    <xs:documentation
              source="http://www.w3.org/TR/xmlschema-2/#element-union">
        memberTypes attribute must be non-empty or there must be
        at least one simpleType child
      </xs:documentation>
    </xs:annotation>
    <xs:complexContent>
      <xs:extension base="xs:annotated">
        <xs:sequence>
          <xs:element name="simpleType" type="xs:localSimpleType"
              minOccurs="0" maxOccurs="unbounded"/>
        </xs:sequence>
        <xs:attribute name="memberTypes" use="optional">
          <xs:simpleType>
            <xs:list itemType="xs:QName"/>
          </xs:simpleType>
        </xs:attribute>
      </xs:extension>
    </xs:complexContent>
  </xs:complexType>
</xs:element>

<xs:complexType name="facet">
  <xs:complexContent>
    <xs:extension base="xs:annotated">
      <xs:attribute name="value" use="required"/>
      <xs:attribute name="fixed" type="xs:boolean" use="optional"
                    default="false"/>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
```

```
<xs:complexType name="noFixedFacet">
 <xs:complexContent>
  <xs:restriction base="xs:facet">
   <xs:sequence>
    <xs:element ref="xs:annotation" minOccurs="0"/>
   </xs:sequence>
   <xs:attribute name="fixed" use="prohibited"/>
  </xs:restriction>
 </xs:complexContent>
</xs:complexType>

 <xs:element name="minExclusive" id="minExclusive" type="xs:facet">
   <xs:annotation>
     <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#element-minExclusive"/>
   </xs:annotation>
 </xs:element>
 <xs:element name="minInclusive" id="minInclusive" type="xs:facet">
   <xs:annotation>
     <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#element-minInclusive"/>
   </xs:annotation>
 </xs:element>

 <xs:element name="maxExclusive" id="maxExclusive" type="xs:facet">
   <xs:annotation>
     <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#element-maxExclusive"/>
   </xs:annotation>
 </xs:element>
 <xs:element name="maxInclusive" id="maxInclusive" type="xs:facet">
   <xs:annotation>
     <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#element-maxInclusive"/>
   </xs:annotation>
 </xs:element>

 <xs:complexType name="numFacet">
   <xs:complexContent>
     <xs:restriction base="xs:facet">
      <xs:sequence>
        <xs:element ref="xs:annotation" minOccurs="0"/>
      </xs:sequence>
      <xs:attribute name="value" type="xs:nonNegativeInteger" use="required"/>
     </xs:restriction>
   </xs:complexContent>
 </xs:complexType>

 <xs:element name="totalDigits" id="totalDigits">
   <xs:annotation>
     <xs:documentation
       source="http://www.w3.org/TR/xmlschema-2/#element-totalDigits"/>
   </xs:annotation>
   <xs:complexType>
     <xs:complexContent>
       <xs:restriction base="xs:numFacet">
         <xs:sequence>
           <xs:element ref="xs:annotation" minOccurs="0"/>
         </xs:sequence>
         <xs:attribute name="value" type="xs:positiveInteger" use="required"/>
       </xs:restriction>
     </xs:complexContent>
   </xs:complexType>
 </xs:element>
```

```
<xs:element name="fractionDigits" id="fractionDigits" type="xs:numFacet">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#element-fractionDigits"/>
  </xs:annotation>
</xs:element>

<xs:element name="length" id="length" type="xs:numFacet">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#element-length"/>
  </xs:annotation>
</xs:element>
<xs:element name="minLength" id="minLength" type="xs:numFacet">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#element-minLength"/>
  </xs:annotation>
</xs:element>
<xs:element name="maxLength" id="maxLength" type="xs:numFacet">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#element-maxLength"/>
  </xs:annotation>
</xs:element>

<xs:element name="enumeration" id="enumeration" type="xs:noFixedFacet">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#element-enumeration"/>
  </xs:annotation>
</xs:element>

<xs:element name="whiteSpace" id="whiteSpace">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#element-whiteSpace"/>
  </xs:annotation>
  <xs:complexType>
    <xs:complexContent>
      <xs:restriction base="xs:facet">
        <xs:sequence>
          <xs:element ref="xs:annotation" minOccurs="0"/>
        </xs:sequence>
        <xs:attribute name="value" use="required">
          <xs:simpleType>
            <xs:restriction base="xs:NMTOKEN">
              <xs:enumeration value="preserve"/>
              <xs:enumeration value="replace"/>
              <xs:enumeration value="collapse"/>
            </xs:restriction>
          </xs:simpleType>
        </xs:attribute>
      </xs:restriction>
    </xs:complexContent>
  </xs:complexType>
</xs:element>

<xs:element name="pattern" id="pattern" type="xs:noFixedFacet">
  <xs:annotation>
    <xs:documentation
      source="http://www.w3.org/TR/xmlschema-2/#element-pattern"/>
  </xs:annotation>
</xs:element>
```

```
</xs:schema>
```

B DTD for Datatype Definitions (non-normative)

```
<!--
        DTD for XML Schemas: Part 2: Datatypes
        Id: datatypes.dtd,v 1.23 2001/03/16 17:36:30 ht Exp
        Note this DTD is NOT normative, or even definitive.
  -->

<!--
        This DTD cannot be used on its own, it is intended
        only for incorporation in XMLSchema.dtd, q.v.
  -->

<!-- Define all the element names, with optional prefix -->
<!ENTITY % simpleType "%p;simpleType">
<!ENTITY % restriction "%p;restriction">
<!ENTITY % list "%p;list">
<!ENTITY % union "%p;union">
<!ENTITY % maxExclusive "%p;maxExclusive">
<!ENTITY % minExclusive "%p;minExclusive">
<!ENTITY % maxInclusive "%p;maxInclusive">
<!ENTITY % minInclusive "%p;minInclusive">
<!ENTITY % totalDigits "%p;totalDigits">
<!ENTITY % fractionDigits "%p;fractionDigits">
<!ENTITY % length "%p;length">
<!ENTITY % minLength "%p;minLength">
<!ENTITY % maxLength "%p;maxLength">
<!ENTITY % enumeration "%p;enumeration">
<!ENTITY % whiteSpace "%p;whiteSpace">
<!ENTITY % pattern "%p;pattern">

<!--
        Customisation entities for the ATTLIST of each element
        type. Define one of these if your schema takes advantage
        of the anyAttribute='##other' in the schema for schemas
  -->

<!ENTITY % simpleTypeAttrs "">
<!ENTITY % restrictionAttrs "">
<!ENTITY % listAttrs "">
<!ENTITY % unionAttrs "">
<!ENTITY % maxExclusiveAttrs "">
<!ENTITY % minExclusiveAttrs "">
<!ENTITY % maxInclusiveAttrs "">
<!ENTITY % minInclusiveAttrs "">
<!ENTITY % totalDigitsAttrs "">
<!ENTITY % fractionDigitsAttrs "">
<!ENTITY % lengthAttrs "">
<!ENTITY % minLengthAttrs "">
<!ENTITY % maxLengthAttrs "">
<!ENTITY % enumerationAttrs "">
<!ENTITY % whiteSpaceAttrs "">
<!ENTITY % patternAttrs "">

<!-- Define some entities for informative use as attribute
        types -->
<!ENTITY % URIref "CDATA">
<!ENTITY % XPathExpr "CDATA">
<!ENTITY % QName "NMTOKEN">
<!ENTITY % QNames "NMTOKENS">
<!ENTITY % NCName "NMTOKEN">
<!ENTITY % nonNegativeInteger "NMTOKEN">
```

```
<!ENTITY % boolean "(true|false)">
<!ENTITY % simpleDerivationSet "CDATA">
<!--
        #all or space-separated list drawn from derivationChoice
  -->

<!--
        Note that the use of 'facet' below is less restrictive
        than is really intended:  There should in fact be no
        more than one of each of minInclusive, minExclusive,
        maxInclusive, maxExclusive, totalDigits, fractionDigits,
        length, maxLength, minLength within datatype,
        and the min- and max- variants of Inclusive and Exclusive
        are mutually exclusive. On the other hand,  pattern and
        enumeration may repeat.
  -->
<!ENTITY % minBound "(%minInclusive; | %minExclusive;)">
<!ENTITY % maxBound "(%maxInclusive; | %maxExclusive;)">
<!ENTITY % bounds "%minBound; | %maxBound;">
<!ENTITY % numeric "%totalDigits; | %fractionDigits;">
<!ENTITY % ordered "%bounds; | %numeric;">
<!ENTITY % unordered
   "%pattern; | %enumeration; | %whiteSpace; | %length; |
   %maxLength; | %minLength;">
<!ENTITY % facet "%ordered; | %unordered;">
<!ENTITY % facetAttr
        "value CDATA #REQUIRED
        id ID #IMPLIED">
<!ENTITY % fixedAttr "fixed %boolean; #IMPLIED">
<!ENTITY % facetModel "(%annotation;)?">
<!ELEMENT %simpleType;
        ((%annotation;)?, (%restriction; | %list; | %union;))>
<!ATTLIST %simpleType;
    name      %NCName; #IMPLIED
    final     %simpleDerivationSet; #IMPLIED
    id        ID       #IMPLIED
    %simpleTypeAttrs;>
<!-- name is required at top level -->
<!ELEMENT %restriction; ((%annotation;)?,
                         (%restriction1; |
                          ((%simpleType;)?,(%facet;)*)),
                         (%attrDecls;))>
<!ATTLIST %restriction;
    base      %QName;                 #IMPLIED
    id        ID       #IMPLIED
    %restrictionAttrs;>
<!--
        base and simpleType child are mutually exclusive,
        one is required.

        restriction is shared between simpleType and
        simpleContent and complexContent (in XMLSchema.xsd).
        restriction1 is for the latter cases, when this
        is restricting a complex type, as is attrDecls.
  -->
<!ELEMENT %list; ((%annotation;)?,(%simpleType;)?)>
<!ATTLIST %list;
    itemType      %QName;             #IMPLIED
    id        ID       #IMPLIED
    %listAttrs;>
<!--
        itemType and simpleType child are mutually exclusive,
        one is required
  -->
<!ELEMENT %union; ((%annotation;)?,(%simpleType;)*)>
```

```
<!ATTLIST %union;
    id            ID       #IMPLIED
    memberTypes   %QNames;            #IMPLIED
    %unionAttrs;>
<!--
        At least one item in memberTypes or one simpleType
        child is required
  -->

<!ELEMENT %maxExclusive; %facetModel;>
<!ATTLIST %maxExclusive;
        %facetAttr;
        %fixedAttr;
        %maxExclusiveAttrs;>
<!ELEMENT %minExclusive; %facetModel;>
<!ATTLIST %minExclusive;
        %facetAttr;
        %fixedAttr;
        %minExclusiveAttrs;>

<!ELEMENT %maxInclusive; %facetModel;>
<!ATTLIST %maxInclusive;
        %facetAttr;
        %fixedAttr;
        %maxInclusiveAttrs;>
<!ELEMENT %minInclusive; %facetModel;>
<!ATTLIST %minInclusive;
        %facetAttr;
        %fixedAttr;
        %minInclusiveAttrs;>

<!ELEMENT %totalDigits; %facetModel;>
<!ATTLIST %totalDigits;
        %facetAttr;
        %fixedAttr;
        %totalDigitsAttrs;>
<!ELEMENT %fractionDigits; %facetModel;>
<!ATTLIST %fractionDigits;
        %facetAttr;
        %fixedAttr;
        %fractionDigitsAttrs;>

<!ELEMENT %length; %facetModel;>
<!ATTLIST %length;
        %facetAttr;
        %fixedAttr;
        %lengthAttrs;>
<!ELEMENT %minLength; %facetModel;>
<!ATTLIST %minLength;
        %facetAttr;
        %fixedAttr;
        %minLengthAttrs;>
<!ELEMENT %maxLength; %facetModel;>
<!ATTLIST %maxLength;
        %facetAttr;
        %fixedAttr;
        %maxLengthAttrs;>

<!-- This one can be repeated -->
<!ELEMENT %enumeration; %facetModel;>
<!ATTLIST %enumeration;
        %facetAttr;
        %enumerationAttrs;>

<!ELEMENT %whiteSpace; %facetModel;>
```

```
<!ATTLIST %whiteSpace;
        %facetAttr;
        %fixedAttr;
        %whiteSpaceAttrs;>

<!-- This one can be repeated -->
<!ELEMENT %pattern; %facetModel;>
<!ATTLIST %pattern;
        %facetAttr;
        %patternAttrs;>
```

C Datatypes and Facets

C.1 Fundamental Facets

The following table shows the values of the fundamental facets for each built-in datatype.

	Datatype	**ordered**	**bounded**	**cardinality**	**numeric**
primitive	string	false	false	countably infinite	false
	boolean	false	false	finite	false
	float	total	true	finite	true
	double	total	true	finite	true
	decimal	total	false	countably infinite	true
	duration	partial	false	countably infinite	false
	dateTime	partial	false	countably infinite	false
	time	partial	false	countably infinite	false
	date	partial	false	countably infinite	false
	gYearMonth	partial	false	countably infinite	false
	gYear	partial	false	countably infinite	false
	gMonthDay	partial	false	countably infinite	false
	gDay	partial	false	countably infinite	false
	gMonth	partial	false	countably infinite	false
	hexBinary	false	false	countably infinite	false
	base64Binary	false	false	countably infinite	false
	anyURI	false	false	countably infinite	false
	QName	false	false	countably infinite	false
	NOTATION	false	false	countably infinite	false
	normalizedString	false	false	countably infinite	false
	token	false	false	countably infinite	false
	language	false	false	countably infinite	false
	IDREFS	false	false	countably infinite	false
	ENTITIES	false	false	countably infinite	false
	NMTOKEN	false	false	countably infinite	false
	NMTOKENS	false	false	countably infinite	false
	Name	false	false	countably infinite	false
	NCName	false	false	countably infinite	false
	ID	false	false	countably infinite	false
	IDREF	false	false	countably infinite	false
	ENTITY	false	false	countably infinite	false

derived	integer	total	false	countably infinite	true
	nonPositiveInteger	total	false	countably infinite	true
	negativeInteger	total	false	countably infinite	true
	long	total	true	finite	true
	int	total	true	finite	true
	short	total	true	finite	true
	byte	total	true	finite	true
	nonNegativeInteger	total	false	countably infinite	true
	unsignedLong	total	true	finite	true
	unsignedInt	total	true	finite	true
	unsignedShort	total	true	finite	true
	unsignedByte	total	true	finite	true
	positiveInteger	total	false	countably infinite	true

D ISO 8601 Date and Time Formats

D.1 ISO 8601 Conventions

The primitive datatypes duration, dateTime, time, date, gYearMonth, gMonthDay, gDay, gMonth and gYear use lexical formats inspired by [ISO 8601]. This appendix provides more detail on the ISO formats and discusses some deviations from them for the datatypes defined in this specification.

[ISO 8601] "specifies the representation of dates in the proleptic Gregorian calendar and times and representations of periods of time". The proleptic Gregorian calendar includes dates prior to 1582 (the year it came into use as an ecclesiastical calendar). It should be pointed out that the datatypes described in this specification do not cover all the types of data covered by [ISO 8601], nor do they support all the lexical representations for those types of data.

[ISO 8601] lexical formats are described using "pictures" in which characters are used in place of digits. For the primitive datatypes dateTime, time, date, gYearMonth, gMonthDay, gDay, gMonth and gYear. these characters have the following meanings:

- C -- represents a digit used in the thousands and hundreds components, the "century" component, of the time element "year". Legal values are from 0 to 9.
- Y -- represents a digit used in the tens and units components of the time element "year". Legal values are from 0 to 9.
- M -- represents a digit used in the time element "month". The two digits in a MM format can have values from 1 to 12.
- D -- represents a digit used in the time element "day". The two digits in a DD format can have values from 1 to 28 if the month value equals 2, 1 to 29 if the month value equals 2 and the year is a leap year, 1 to 30 if the month value equals 4, 6, 9 or 11, and 1 to 31 if the month value equals 1, 3, 5, 7, 8, 10 or 12.
- h -- represents a digit used in the time element "hour". The two digits in a hh format can have values from 0 to 23.
- m -- represents a digit used in the time element "minute". The two digits in a mm format can have values from 0 to 59.
- s -- represents a digit used in the time element "second". The two digits in a ss format can have values from 0 to 60. In the formats described in this specification the whole number of seconds may be followed by decimal seconds to an arbitrary level of precision. This is represented in the picture by "ss.sss". A value of 60 or more is allowed only in the case of leap seconds.

  Strictly speaking, a value of 60 or more is not sensible unless the month and day could represent March 31, June 30, September 30, or December 31 *in UTC*. Because the leap second is added or subtracted as the last second of the day in UTC time, the long (or short) minute could occur at other times in local time. In cases where the leap second is used with an inappropriate month and day it, and any fractional seconds, should considered as added or subtracted from the following minute.

For all the information items indicated by the above characters, leading zeros are required where indicated.

In addition to the above, certain characters are used as designators and appear as themselves in lexical formats.

- T -- is used as time designator to indicate the start of the representation of the time of day in dateTime.
- Z -- is used as time-zone designator, immediately (without a space) following a data element expressing the time of day in

Coordinated Universal Time (UTC) in dateTime, time, date, gYearMonth, gMonthDay, gDay, gMonth, and gYear.

In the lexical format for duration the following characters are also used as designators and appear as themselves in lexical formats:

- P -- is used as the time duration designator, preceding a data element representing a given duration of time.
- Y -- follows the number of years in a time duration.
- M -- follows the number of months or minutes in a time duration.
- D -- follows the number of days in a time duration.
- H -- follows the number of hours in a time duration.
- S -- follows the number of seconds in a time duration.

The values of the Year, Month, Day, Hour and Minutes components are not restricted but allow an arbitrary integer. Similarly, the value of the Seconds component allows an arbitrary decimal. Thus, the lexical format for duration and datatypes derived from it does not follow the alternative format of § 5.5.3.2.1 of [ISO 8601].

D.2 Truncated and Reduced Formats

[ISO 8601] supports a variety of "truncated" formats in which some of the characters on the left of specific formats, for example, the century, can be omitted. Truncated formats are, in general, not permitted for the datatypes defined in this specification with three exceptions. The time datatype uses a truncated format for dateTime which represents an instant of time that recurs every day. Similarly, the gMonthDay and gDay datatypes use left-truncated formats for date. The datatype gMonth uses a right and left truncated format for date.

[ISO 8601] also supports a variety of "reduced" or right-truncated formats in which some of the characters to the right of specific formats, such as the time specification, can be omitted. Right truncated formats are also, in general, not permitted for the datatypes defined in this specification with the following exceptions: right-truncated representations of dateTime are used as lexical representations for date, gMonth, gYear.

D.3 Deviations from ISO 8601 Formats

D.3.1 Sign Allowed

An optional minus sign is allowed immediately preceding, without a space, the lexical representations for duration, dateTime, date, gMonth, gYear.

D.3.2 No Year Zero

The year "0000" is an illegal year value.

D.3.3 More Than 9999 Years

To accommodate year values greater than 9999, more than four digits are allowed in the year representations of dateTime, date, gYearMonth, and gYear. This follows [ISO 8601 Draft Revision].

E Adding durations to dateTimes

Given a dateTime S and a duration D, this appendix specifies how to compute a dateTime E where E is the end of the time period with start S and duration D i.e. E = S + D. Such computations are used, for example, to determine whether a dateTime is within a specific time period. This appendix also addresses the addition of durations to the datatypes date, gYearMonth, gYear, gDay and gMonth, which can be viewed as a set of dateTimes. In such cases, the addition is made to the first or starting dateTime in the set.

This is a logical explanation of the process. Actual implementations are free to optimize as long as they produce the same results. The calculation uses the notation S[year] to represent the year field of S, S[month] to represent the month field, and so on. It also depends on the following functions:

- fQuotient(a, b) = the greatest integer less than or equal to a/b

    - fQuotient(-1,3) = -1
    - fQuotient(0,3)...fQuotient(2,3) = 0
    - fQuotient(3,3) = 1
    - fQuotient(3.123,3) = 1
- modulo(a, b) = a - fQuotient(a,b)*b
    - modulo(-1,3) = 2
    - modulo(0,3)...modulo(2,3) = 0...2
    - modulo(3,3) = 0
    - modulo(3.123,3) = 0.123
- fQuotient(a, low, high) = fQuotient(a - low, high - low)
    - fQuotient(0, 1, 13) = -1
    - fQuotient(1, 1, 13) ... fQuotient(12, 1, 13) = 0
    - fQuotient(13, 1, 13) = 1
    - fQuotient(13.123, 1, 13) = 1
- modulo(a, low, high) = modulo(a - low, high - low) + low
    - modulo(0, 1, 13) = 12
    - modulo(1, 1, 13) ... modulo(12, 1, 13) = 1...12
    - modulo(13, 1, 13) = 1
    - modulo(13.123, 1, 13) = 1.123
- maximumDayInMonthFor(yearValue, monthValue) =
    - M := modulo(monthValue, 1, 13)
    - Y := yearValue + fQuotient(monthValue, 1, 13)
    - Return a value based on M and Y:

31	M = January, March, May, July, August, October, or December
30	M = April, June, September, or November
29	M = February AND (modulo(Y, 400) = 0 OR (modulo(Y, 100) != 0) AND modulo(Y, 4) = 0)
28	Otherwise

E.1 Algorithm

Essentially, this calculation is equivalent to separating D into <year,month> and <day,hour,minute,second> fields. The <year,month> is added to S. If the day is out of range, it is *pinned* to be within range. Thus April 31 turns into April 30. Then the <day,hour,minute,second> is added. This latter addition can cause the year and month to change.

Leap seconds are handled by the computation by treating them as overflows. Essentially, a value of 60 seconds in S is treated as if it were a duration of 60 seconds added to S (with a zero seconds field). All calculations thereafter use 60 seconds per minute.

Thus the addition of either PT1M or PT60S to any dateTime will always produce the same result. This is a special definition of addition which is designed to match common practice, and -- most importantly -- be stable over time.

A definition that attempted to take leap-seconds into account would need to be constantly updated, and could not predict the results of future implementation's additions. The decision to introduce a leap second in UTC is the responsibility of the [International Earth Rotation Service (IERS)]. They make periodic announcements as to when leap seconds are to be added, but this is not known more than a year in advance. For more information on leap seconds, see [U.S. Naval Observatory Time Service Department].

The following is the precise specification. These steps must be followed in the same order. If a field in D is not specified, it is treated as if it were zero. If a field in S is not specified, it is treated in the calculation as if it were the minimum allowed value in that field, however, after the calculation is concluded, the corresponding field in E is removed (set to unspecified).

- *Months (may be modified additionally below)*
    - temp := S[month] + D[month]
    - E[month] := modulo(temp, 1, 13)
    - carry := fQuotient(temp, 1, 13)
- *Years (may be modified additionally below)*
    - E[year] := S[year] + D[year] + carry
- *Zone*
    - E[zone] := S[zone]
- *Seconds*

```
        ○ temp := S[second] + D[second]
        ○ E[second] := modulo(temp, 60)
        ○ carry := fQuotient(temp, 60)
    • Minutes
        ○ temp := S[minute] + D[minute] + carry
        ○ E[minute] := modulo(temp, 60)
        ○ carry := fQuotient(temp, 60)
    • Hours
        ○ temp := S[hour] + D[hour] + carry
        ○ E[hour] := modulo(temp, 24)
        ○ carry := fQuotient(temp, 24)
    • Days
        ○ if S[day] > maximumDayInMonthFor(E[year], E[month])
            ■ tempDays := maximumDayInMonthFor(E[year], E[month])
        ○ else if S[day] < 1
            ■ tempDays := 1
        ○ else
            ■ tempDays := S[day]
        ○ E[day] := tempDays + D[day] + carry
        ○ START LOOP
            ■ IF E[day] < 1
                ■ E[day] := E[day] + maximumDayInMonthFor(E[year], E[month] - 1)
                ■ carry := -1
            ■ ELSE IF E[day] > maximumDayInMonthFor(E[year], E[month])
                ■ E[day] := E[day] - maximumDayInMonthFor(E[year], E[month])
                ■ carry := 1
            ■ ELSE EXIT LOOP
            ■ temp := E[month] + carry
            ■ E[month] := modulo(temp, 1, 13)
            ■ E[year] := E[year] + fQuotient(temp, 1, 13)
            ■ GOTO START LOOP
```

Examples:

dateTime	duration	result
2000-01-12T12:13:14Z	P1Y3M5DT7H10M3.3S	2001-04-17T19:23:17.3Z
2000-01	-P3M	1999-10
2000-01-12	PT33H	2000-01-13

E.2 Commutativity and Associativity

Time durations are added by simply adding each of their fields, respectively, without overflow.

The order of addition of durations to instants *is* significant. For example, there are cases where:

((dateTime + duration1) + duration2) != ((dateTime + duration2) + duration1)

Example:

(2000-03-30 + P1D) + P1M = 2000-03-31 + P1M = 2001-**04-30**

(2000-03-30 + P1M) + P1D = 2000-04-30 + P1D = 2000-**05-01**

F Regular Expressions

A regular expression *R* is a sequence of characters that denote a **set of strings** *L(R)*. When used to constrain a lexical space , a **regular expression** *R* asserts that only strings in *L(R)* are valid literals for values of that type.

[Definition:] A **regular expression** is composed from zero or more branch es, separated by **|** characters.

Regular Expression
`[1]    regExp    ::=    branch ( '|' branch )*`

For all branch es *S*, and for all regular expression s *T*, valid regular expression s *R* are:	**Denoting the set of strings *L(R)* containing:**
(empty string)	the set containing just the empty string
S	all strings in *L(S)*
S|*T*	all strings in *L(S)* and all strings in *L(T)*

[Definition:] A **branch** consists of zero or more piece s, concatenated together.

Branch
`[2]    branch    ::=    piece*`

For all piece s *S*, and for all branch es *T*, valid branch es *R* are:	**Denoting the set of strings *L(R)* containing:**
S	all strings in *L(S)*
ST	all strings *st* with *s* in *L(S)* and *t* in *L(T)*

[Definition:] A **piece** is an atom , possibly followed by a quantifier .

Piece
`[3]    piece    ::=    atom quantifier?`

For all atom s *S* and non-negative integers *n*, *m* such that *n* <= *m*, valid piece s *R* are:	**Denoting the set of strings *L(R)* containing:**
S	all strings in *L(S)*
S?	the empty string, and all strings in *L(S)*.
*S**	All strings in *L(S?)* and all strings *st* with *s* in *L(S*)* and *t* in *L(S)*. *(all concatenations of zero or more strings from L(S))*
S+	All strings *st* with *s* in *L(S)* and *t* in *L(S*)*. *(all concatenations of one or more strings from L(S))*
S{n,m}	All strings *st* with *s* in *L(S)* and *t* in *L(S{n-1,m-1})*. *(All sequences of at least n, and at most m, strings from L(S))*
S{n}	All strings in *L(S{n,n})*. *(All sequences of exactly n strings from L(S))*
S{n,}	All strings in L(S{n}S*) *(All sequences of at least n, strings from L(S))*
S{0,m}	All strings *st* with *s* in *L(S?)* and *t* in *L(S{0,m-1})*. *(All sequences of at most m, strings from L(S))*
S{0,0}	The set containing only the empty string

NOTE: The regular expression language in the Perl Programming Language [Perl] does not include a quantifier of the form `S{,m)`, since it is logically equivalent to `S{0,m}`. We have, therefore, left this logical possibility out of the regular expression language defined by this specification. We welcome further input from implementors and schema authors on this issue.

[Definition:] A **quantifier** is one of `?`, `*`, `+`, `{n,m}` or `{n,}`, which have the meanings defined in the table above.

Quanitifer

```
[4]    quantifier    ::=    [?*+] | ( '{' quantity '}' )
[5]    quantity      ::=    quantRange | quantMin | QuantExact
[6]    quantRange    ::=    QuantExact ',' QuantExact
[7]    quantMin      ::=    QuantExact ','
[8]    QuantExact    ::=    [0-9]+
```

[Definition:] An **atom** is either a normal character , a character class , or a parenthesized regular expression .

Atom

```
[9]    atom    ::=    Char | charClass | ( '(' regExp ')' )
```

For all normal character s *c*, character class es *C*, and regular expression s *S*, valid atom s *R* are:	Denoting the set of strings *L(R)* containing:
c	the single string consisting only of *c*
C	all strings in *L(C)*
(*S*)	all strings in *L(S)*

[Definition:] A **metacharacter** is either `.`, `\`, `?`, `*`, `+`, `{`, `}` `(`, `)`, `[` or `]`. These characters have special meanings in regular expression s, but can be escaped to form atom s that denote the sets of strings containing only themselves, i.e., an escaped metacharacter behaves like a normal character .

[Definition:] A **normal character** is any XML character that is not a metacharacter. In regular expression s, a normal character is an atom that denotes the singleton set of strings containing only itself.

Normal Character

```
[10]    Char    ::=    [^.\?*+()|#x5B#x5D]
```

Note that a normal character can be represented either as itself, or with a character reference.

F.1 Character Classes

[Definition:] A **character class** is an atom *R* that identifies a **set of characters** *C(R)*. The set of strings *L(R)* denoted by a character class *R* contains one single-character string "*c*" for each character *c* in *C(R)*.

Character Class

```
[11]    charClass    ::=    charClassEsc | charClassExpr
```

A character class is either a character class escape or a character class expression .

[Definition:] A **character class expression** is a character group surrounded by `[` and `]` characters. For all character groups *G*, *[G]* is a valid **character class expression**, identifying the set of characters *C*(*[G]*) = *C*(*G*).

Character Class Expression
`[12]    charClassExpr    ::=    '[' charGroup ']'`

[Definition:] A **character group** is either a positive character group , a negative character group , or a character class subtraction .

Character Group
`[13] charGroup ::= posCharGroup	negCharGroup	charClassSub`

[Definition:] A **positive character group** consists of one or more character range s or character class escape s, concatenated together. A **positive character group** identifies the set of characters containing all of the characters in all of the sets identified by its constituent ranges or escapes.

Positive Character Group
`[14]    posCharGroup    ::=    ( charRange | charClassEsc )+`

For all character range s *R*, all character class escape s *E*, and all positive character group s *P*, valid positive character group s *G* are:	Identifying the set of characters *C(G)* containing:
R	all characters in *C(R)*.
E	all characters in *C(E)*.
RP	all characters in *C(R)* and all characters in *C(P)*.
EP	all characters in *C(E)* and all characters in *C(P)*.

[Definition:] A **negative character group** is a positive character group preceded by the ^ character. For all positive character group s *P*, ^*P* is a valid **negative character group**, and *C(^P)* contains all XML characters that are *not* in *C(P)*.

Negative Character Group
`[15]    negCharGroup    ::=    '^' posCharGroup`

[Definition:] A **character class subtraction** is a character class expression subtracted from a positive character group or negative character group , using the - character.

Character Class Subtraction
`[16]    charClassSub    ::=    ( posCharGroup | negCharGroup ) '-' charClassExpr`

For any positive character group or negative character group *G*, and any character class expression *C*, *G-C* is a valid character class subtraction , identifying the set of all characters in *C(G)* that are not also in *C(C)*.

[Definition:] A **character range** *R* identifies a set of characters *C(R)* containing all XML characters with UCS code points in a specified range.

Character Range

[17]	charRange	::=	seRange | XmlCharRef | XmlCharIncDash
[18]	seRange	::=	charOrEsc '-' charOrEsc
[19]	XmlCharRef	::=	('&#' [0-9]+ ';') | (' &#x' [0-9a-fA-F]+ ';')
[20]	charOrEsc	::=	XmlChar | SingleCharEsc
[21]	XmlChar	::=	[^\#x2D#x5B#x5D]
[22]	XmlCharIncDash	::=	[^\#x5B#x5D]

A single XML character is a character range that identifies the set of characters containing only itself. All XML characters are valid character ranges, except as follows:

- The `[`, `]`, and `\` characters are not valid character ranges;
- The `^` character is only valid at the beginning of a positive character group if it is part of a negative character group ; and
- The `-` character is a valid character range only at the beginning or end of a positive character group .

A character range may also be written in the form *s-e*, identifying the set that contains all XML characters with UCS code points greater than or equal to the code point of *s*, but not greater than the code point of *e*.

s-e is a valid character range iff:

- *s* is a single character escape , or an XML character;
- *s* is not `\`
- If s is the first character in a character class expression , then *s* is not `^`
- *e* is a single character escape , or an XML character;
- *e* is not `\` or `[`; and
- The code point of *e* is greater than or equal to the code point of *s*;

NOTE: The code point of a single character escape is the code point of the single character in the set of characters that it identifies.

F.1.1 Character Class Escapes

[Definition:] A **character class escape** is a short sequence of characters that identifies predefined character class. The valid character class escapes are the single character escape s, the multi-character escape s, and the category escape s (including the block escape s).

Character Class Escape

[23]	charClassEsc	::=	(SingleCharEsc | MultiCharEsc | catEsc | complEsc)

[Definition:] A **single character escape** identifies a set containing a only one character -- usually because that character is difficult or impossible to write directly into a regular expression .

Single Character Escape

[24]	SingleCharEsc	::=	'\' [nrt\\|.?*+(){}#x2D#x5B#x5D#x5E] #x2D#x5B#x5D#x5E]

The valid single character escape s are:	Identifying the set of characters *C(R)* containing:

`\n`	the newline character (#xA)
`\r`	the return character (#xD)
`\t`	the tab character (#x9)
`\\`	`\`
`|`	`|`
`\.`	`.`
`\-`	`-`
`\^`	`^`
`\?`	`?`
`\*`	`*`
`\+`	`+`
`\{`	`{`
`\}`	`}`
`\(`	`(`
`\)`	`)`
`\[`	`[`
`\]`	`]`

[Definition:] [Unicode Database] specifies a number of possible values for the "General Category" property and provides mappings mappings from code points to specific character properties. The set containing all characters that have property `X`, can be identified with a **category escape** `\p{X}`. The complement of this set is specified with the **category escape** `\P{X}`. (`[\P{X}]` = `[^\p{X}]`).

Category Escape

```
[25]    catEsc      ::=    '\p{' charProp '}'
[26]    complEsc    ::=    '\P{' charProp '}'
[27]    charProp    ::=    IsCategory | IsBlock
```

NOTE: [Unicode Database] is subject to future revision. For example, the mapping from code points to character properties might be updated. All minimally conforming processors must support the character properties defined defined in the version of [Unicode Database] that is current at the time this specification became a W3C Recommendation. However, implementors are encouraged to support the character properties defined in any future version.

The following table specifies the recognized values of the "General Category" property.

Category	Property	Meaning
Letters	L	All Letters
	Lu	uppercase
	Ll	lowercase
	Lt	titlecase
	Lm	modifier
	Lo	other
Marks	M	All Marks
	Mn	nonspacing

	Mc	spacing combining
	Me	enclosing
Numbers	N	All Numbers
	Nd	decimal digit
	Nl	letter
	No	other
Punctuation	P	All Punctuation
	Pc	connector
	Pd	dash
	Ps	open
	Pe	close
	Pi	initial quote (may behave like Ps or Pe depending on usage)
	Pf	final quote (may behave like Ps or Pe depending on usage)
	Po	other
Separators	Z	All Separators
	Zs	space
	Zl	line
	Zp	paragraph
Symbols	S	All Symbols
	Sm	math
	Sc	currency
	Sk	modifier
	So	other
Other	C	All Others
	Cc	control
	Cf	format
	Co	private use
	Cn	not assigned

Categories

```
[28]    IsCategory     ::=    Letters | Marks | Numbers | Punctuation |
                              Separators | Symbols | Others
[29]    Letters        ::=    'L' [ultmo]?
[30]    Marks          ::=    'M' [nce]?
[31]    Numbers        ::=    'N' [dlo]?
[32]    Punctuation    ::=    'P' [cdseifo]?
[33]    Separators     ::=    'Z' [slp]?
[34]    Symbols        ::=    'S' [mcko]?
[35]    Others         ::=    'C' [cfon]?
```

NOTE: The properties mentioned above exclude the `Cs` property. The `Cs` property identifies "surrogate" characters, which do not occur at the level of the "character abstraction" that XML instance documents operate on.

[Definition:] [Unicode Database] groups code points into a number of blocks such as Basic Latin (i.e., ASCII), Latin-1 Supplement, Hangul Jamo, CJK Compatibility, etc. The set containing all characters that have block name `X` (with all white space stripped out), can be identified with a **block escape** `\p{IsX}`. The complement of this set is specified with the **block escape** `\P{IsX}`. (`[\P{IsX}]` = `[^\p{IsX}]`).

Block Escape

```
[36]    IsBlock    ::=    'Is' [a-zA-Z0-9#x2D]+
```

The following table specifies the recognized block names (for more information, see the "Blocks.txt" file in [Unicode Database]).

Start Code	End Code	Block Name		Start Code	End Code	Block Name
#x0000	#x007F	BasicLatin		#x0080	#x00FF	Latin-1Supplement
#x0100	#x017F	LatinExtended-A		#x0180	#x024F	LatinExtended-B
#x0250	#x02AF	IPAExtensions		#x02B0	#x02FF	SpacingModifierLetters
#x0300	#x036F	CombiningDiacriticalMarks		#x0370	#x03FF	Greek
#x0400	#x04FF	Cyrillic		#x0530	#x058F	Armenian
#x0590	#x05FF	Hebrew		#x0600	#x06FF	Arabic
#x0700	#x074F	Syriac		#x0780	#x07BF	Thaana
#x0900	#x097F	Devanagari		#x0980	#x09FF	Bengali
#x0A00	#x0A7F	Gurmukhi		#x0A80	#x0AFF	Gujarati
#x0B00	#x0B7F	Oriya		#x0B80	#x0BFF	Tamil
#x0C00	#x0C7F	Telugu		#x0C80	#x0CFF	Kannada
#x0D00	#x0D7F	Malayalam		#x0D80	#x0DFF	Sinhala
#x0E00	#x0E7F	Thai		#x0E80	#x0EFF	Lao
#x0F00	#x0FFF	Tibetan		#x1000	#x109F	Myanmar
#x10A0	#x10FF	Georgian		#x1100	#x11FF	HangulJamo
#x1200	#x137F	Ethiopic		#x13A0	#x13FF	Cherokee
#x1400	#x167F	UnifiedCanadianAboriginalSyllabics		#x1680	#x169F	Ogham
#x16A0	#x16FF	Runic		#x1780	#x17FF	Khmer
#x1800	#x18AF	Mongolian		#x1E00	#x1EFF	LatinExtendedAdditional
#x1F00	#x1FFF	GreekExtended		#x2000	#x206F	GeneralPunctuation
#x2070	#x209F	SuperscriptsandSubscripts		#x20A0	#x20CF	CurrencySymbols
#x20D0	#x20FF	CombiningMarksforSymbols		#x2100	#x214F	LetterlikeSymbols
#x2150	#x218F	NumberForms		#x2190	#x21FF	Arrows
#x2200	#x22FF	MathematicalOperators		#x2300	#x23FF	MiscellaneousTechnical
#x2400	#x243F	ControlPictures		#x2440	#x245F	OpticalCharacterRecognition
#x2460	#x24FF	EnclosedAlphanumerics		#x2500	#x257F	BoxDrawing
#x2580	#x259F	BlockElements		#x25A0	#x25FF	GeometricShapes
#x2600	#x26FF	MiscellaneousSymbols		#x2700	#x27BF	Dingbats

#x2800	#x28FF	BraillePatterns		#x2E80	#x2EFF	CJKRadicalsSupplement
#x2F00	#x2FDF	KangxiRadicals		#x2FF0	#x2FFF	IdeographicDescriptionCharacters
#x3000	#x303F	CJKSymbolsandPunctuation		#x3040	#x309F	Hiragana
#x30A0	#x30FF	Katakana		#x3100	#x312F	Bopomofo
#x3130	#x318F	HangulCompatibilityJamo		#x3190	#x319F	Kanbun
#x31A0	#x31BF	BopomofoExtended		#x3200	#x32FF	EnclosedCJKLettersandMonths
#x3300	#x33FF	CJKCompatibility		#x3400	#x4DB5	CJKUnifiedIdeographsExtensionA
#x4E00	#x9FFF	CJKUnifiedIdeographs		#xA000	#xA48F	YiSyllables
#xA490	#xA4CF	YiRadicals		#xAC00	#xD7A3	HangulSyllables
#xD800	#xDB7F	HighSurrogates		#xDB80	#xDBFF	HighPrivateUseSurrogates
#xDC00	#xDFFF	LowSurrogates		#xE000	#xF8FF	PrivateUse
#xF900	#xFAFF	CJKCompatibilityIdeographs		#xFB00	#xFB4F	AlphabeticPresentationForms
#xFB50	#xFDFF	ArabicPresentationForms-A		#xFE20	#xFE2F	CombiningHalfMarks
#xFE30	#xFE4F	CJKCompatibilityForms		#xFE50	#xFE6F	SmallFormVariants
#xFE70	#xFEFE	ArabicPresentationForms-B		#xFEFF	#xFEFF	Specials
#xFF00	#xFFEF	HalfwidthandFullwidthForms		#xFFF0	#xFFFD	Specials
#x10300	#x1032F	OldItalic		#x10330	#x1034F	Gothic
#x10400	#x1044F	Deseret		#x1D000	#x1D0FF	ByzantineMusicalSymbols
#x1D100	#x1D1FF	MusicalSymbols		#x1D400	#x1D7FF	MathematicalAlphanumericSymbols
#x20000	#x2A6D6	CJKUnifiedIdeographsExtensionB		#x2F800	#x2FA1F	CJKCompatibilityIdeographsSupplement
#xE0000	#xE007F	Tags		#xF0000	#xFFFFD	PrivateUse
#x100000	#x10FFFD	PrivateUse				

NOTE: [Unicode Database] is subject to future revision. For example, the grouping of code points into blocks might might be updated. All minimally conforming processors must support the blocks defined in the version of [Unicode Database] that is current at the time this specification became a W3C Recommendation. However, implementors are encouraged to support the blocks defined in any future version of the Unicode Standard.

For example, the block escape for identifying the ASCII characters is `\p{IsBasicLatin}`.

[Definition:] A **multi-character escape** provides a simple way to identify a commonly used set of characters:

Multi-Character Escape

```
[37]    MultiCharEsc    ::=    '.' | ('\' [sSiIcCdDwW])
```

Character sequence	Equivalent character class
.	[^\n\r]
\s	[#x20\t\n\r]
\S	[^\s]
\i	the set of initial name characters, those match ed by Letter | '_' | ':'

\I	[^\i]
\c	the set of name characters, those match ed by NameChar
\C	[^\c]
\d	\p{Nd}
\D	[^\d]
\w	[#x0000-#x10FFFF]-[\p{P}\p{Z}\p{C}] (*all characters except the set of "punctuation", "separator" and "other" characters*)
\W	[^\w]

> **NOTE:** The regular expression language defined here does not attempt to provide a general solution to "regular expressions" over UCS character sequences. In particular, it does not easily provide for matching sequences of base characters and combining marks. The language is targeted at support of "Level 1" features as defined in [Unicode Regular Expression Guidelines]. It is hoped that future versions of this specification will provide support for "Level 2" features.

G Glossary (non-normative)

The listing below is for the benefit of readers of a printed version of this document: it collects together all the definitions which appear in the document above.

atomic

> **Atomic** datatypes are those having values which are regarded by this specification as being indivisible.

base type

> Every datatype that is derived by **restriction** is defined in terms of an existing datatype, referred to as its **base type**. **base type**s can be either primitive or derived .

bounded

> A datatype is **bounded** if its value space has either an inclusive upper bound or an exclusive upper bound and either an inclusive lower bound and an exclusive lower bound .

built-in

> **Built-in** datatypes are those which are defined in this specification, and can be either primitive or derived ;

canonical lexical representation

> A **canonical lexical representation** is a set of literals from among the valid set of literals for a datatype such that there is a one-to-one mapping between literals in the **canonical lexical representation** and values in the value space .

cardinality

> Every value space has associated with it the concept of **cardinality**. Some value space s are finite, some are countably infinite while still others could conceivably be uncountably infinite (although no value space defined by this specification is uncountable infinite). A datatype is said to have the cardinality of its value space .

conformance to the XML Representation of Schemas

> Processors which accept schemas in the form of XML documents as described in XML Representation of Simple Type Definition Schema Components (§4.1.2) (and other relevant portions of Datatype components (§4)) are additionally said to provide **conformance to the XML Representation of Schemas**, and must , when processing schema documents, completely and correctly implement all Schema Representation Constraint s in this specification, and must adhere exactly to the specifications in XML Representation of Simple Type Definition Schema Components (§4.1.2) (and other relevant portions of Datatype components (§4)) for mapping the contents of such documents to schema components for use in validation.

constraining facet

> A **constraining facet** is an optional property that can be applied to a datatype to constrain its value space .

Constraint on Schemas

> **Constraint on Schemas**

datatype

> In this specification, a **datatype** is a 3-tuple, consisting of a) a set of distinct values, called its value space , b) a set of lexical representations, called its lexical space , and c) a set of facet s that characterize properties of the value space , individual values or lexical items.

derived

> **Derived** datatypes are those that are defined in terms of other datatypes.

error

error

exclusive lower bound

A value l in an ordered value space L is said to be an **exclusive lower bound** of a value space V (where V is a subset of L) if for all v in V, $l < v$.

exclusive upper bound

A value u in an ordered value space U is said to be an **exclusive upper bound** of a value space V (where V is a subset of U) if for all v in V, $u > v$.

facet

A **facet** is a single defining aspect of a value space. Generally speaking, each facet characterizes a value space along independent axes or dimensions.

for compatibility

for compatibility

fundamental facet

A **fundamental facet** is an abstract property which serves to semantically characterize the values in a value space.

inclusive lower bound

A value l in an ordered value space L is said to be an **inclusive lower bound** of a value space V (where V is a subset of L) if for all v in V, $l <= v$.

inclusive upper bound

A value u in an ordered value space U is said to be an **inclusive upper bound** of a value space V (where V is a subset of U) if for all v in V, $u >= v$.

itemType

The atomic datatype that participates in the definition of a list datatype is known as the **itemType** of that list datatype.

lexical space

A **lexical space** is the set of valid *literals* for a datatype.

list

List datatypes are those having values each of which consists of a finite-length (possibly empty) sequence of values of an atomic datatype.

match

match

may

may

memberTypes

The datatypes that participate in the definition of a union datatype are known as the **memberTypes** of that union datatype.

minimally conforming

Minimally conforming processors must completely and correctly implement the Constraint on Schemas and Validation Rule.

must

must

non-numeric

A datatype whose values are not numeric is said to be **non-numeric**.

numeric

A datatype is said to be **numeric** if its values are conceptually quantities (in some mathematical number system).

ordered

A value space, and hence a datatype, is said to be **ordered** if there exists an order-relation defined for that value space.

order-relation

An **order relation** on a value space is a mathematical relation that imposes a total order or a partial order on the members of the value space.

partial order

A **partial order** is an order-relation that is **irreflexive**, **asymmetric** and **transitive**.

primitive

Primitive datatypes are those that are not defined in terms of other datatypes; they exist *ab initio*.

regular expression

A **regular expression** is composed from zero or more branches, separated by **|** characters.

restriction

A datatype is said to be derived by **restriction** from another datatype when values for zero or more constraining facets are specified that serve to constrain its value space and/or its lexical space to a subset of those of its base type.

Schema Representation Constraint

Schema Representation Constraint

total order

A **total order** is an partial order such that for no a and b is it the case that $a <> b$.

union

Union datatypes are those whose value spaces and lexical spaces are the union of the value spaces and lexical space s of one or more other datatypes.

user-derived

User-derived datatypes are those derived datatypes that are defined by individual schema designers.

Validation Rule

Validation Rule

value space

A **value space** is the set of values for a given datatype. Each value in the **value space** of a datatype is denoted by one or more literals in its lexical space .

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