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Data Format Description Language (DFDL) v1.0 Specification

Status of This Document

This document provides information to the OGF community on a standard Data Format Description Language (DFDL). Distribution is unlimited

Abstract

This document provides a definition of a standard Data Format Description Language (DFDL). This language allows description of dense binary and legacy data formats in a vendor-neutral declarative manner. DFDL is an extension to the XML Schema Description Language (XSDL).

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1. Introduction

Data interchange is critically important for most computing. Grid computing and all forms of distributed computing require distributed software and hardware resources to work together. Inevitably, these resources read and write data in a variety of formats. General tools for data interchange are essential to solving such problems. Scalable and High Performance Computing (HPC) applications require high-performance data handling, so data interchange standards must enable efficient representation of data. Data Format Description Language (DFDL) enables powerful data interchange and very high-performance data handling.

We envisage three dominant kinds of data in the future, as follows:

1. Textual data defined by a format specific schema such as XML or JSON.
2. Binary data in standard formats.
3. Data with DFDL descriptors.

Textual XML data is the most successful data interchange standard to date. All such data are by definition new, by which we mean created in the XML era. Because of the large overhead that XML tagging imposes, there is often a need to compress and decompress XML data. However, there is a high-cost for compression and decompression that is unacceptable to some applications. Standardized binary data are also relatively new, and is suitable for larger data because of the reduced costs of encoding and more compact size. Examples of standard binary formats are data described by modern versions of ASN.1, or the use of XDR. These techniques lack the self-describing nature of XML-data. Scientific formats, such as NetCDF and HDF are used by some communities to provide self-describing binary data. In the future, there may be standardized binary-encoded XML data as there is a W3C working group that has been formed on this subject.

It is an important observation that both XML format and standardized binary formats are *prescriptive* in that they specify or prescribe a representation of the data. To use them your applications must be written to conform to their encodings and mechanisms of expression. DFDL suggests an entirely different scheme. The approach is *descriptive* in that one chooses an appropriate data representation for an application based on its needs and one then describes the format using DFDL so that multiple programs can directly interchange the described data. DFDL descriptions can be provided by the creator of the format, or developed as needed by third parties intending to use the format. That is, DFDL is not a format for data; it is a way of describing any data format. DFDL is intended for data commonly found in scientific and numeric computations, as well as record-oriented representations found in commercial data processing.

DFDL can be used to describe legacy data files, to simplify transfer of data across domains without requiring global standard formats, or to allow third-party tools to easily access multiple formats. DFDL can also be a powerful tool for supporting backward compatibility as formats evolve.

DFDL is designed to provide flexibility and also permit implementations that achieve very high levels of performance. DFDL descriptions are separable and native applications do not need to use DFDL libraries to parse their data formats. DFDL parsers can also be highly efficient. The DFDL language is designed to permit implementations that use lazy evaluation of formats and to support seekable, random access to data. The following goals can be achieved by DFDL implementations:

- Density. Fewest bytes to represent information content (without resorting to compression). Fastest possible I/O.
- Optimized I/O. Applications can write data aligned to byte, word, or even page boundaries and to use memory-mapped I/O to insure access to data content with the smallest number of machine cycles for common use cases without sacrificing general access.

DFDL can describe the same types of abstract data that other binary or textual data formats can describe and, furthermore, it can describe almost any possible representation scheme for those data. For example, DFDL can provide multiple representations of the same logical data and that data are optimized for specific uses. It is the spirit of DFDL to support canonical data descriptions

that correspond closely to the original in-memory representation of the data, and also to provide sufficient information to write as well as to read the given format.

1.1 Why is DFDL Needed?

DFDL is needed in an era where there are so many standard data formats available, because there are a number of social phenomena in the way software is developed that have lead to the situation today where DFDL is needed to standardize descriptions of diverse data formats.
First, programs are very often written speculatively, that is, without any advance understanding of how important they will become. Given this situation, little effort is expended on data formats since it remains easier to program the I/O in the most straightforward way possible with the programming tools in use. Even something as simple as using an XML-based data format is harder than just using the native I/O libraries of a programming language.
In time, however, it is realized that a software program is important because either many people are using it, or it has become important for business or organizational needs to start using it in larger scale deployments. At that point it is often too late to go back and change the data formats. For example, there may be real or perceived business costs to delaying the deployment of a program for a rewrite just to change the data formats, particularly if such rewriting will reduce the performance of the program and increase the costs of deployment. (It takes *longer* to program, but at least it's *slower* when you are done☺)
Additionally, the need for data format standardization for interchange with other software may not be clear at the point where a program first becomes 'important'. Eventually, however, the need for data interchange with the program becomes apparent.
The above phenomena are not something that is going away any time soon. There are, of course, efforts to smoothly integrate standardized data format handling into programming languages. Nevertheless, we see a critical role for DFDL since it allows after-the-fact description of a data format.

1.2 What is DFDL?

DFDL is a language for describing data formats. A DFDL description allows data to be read from its native format and to be presented as an instance of an information set or indeed converted to the corresponding XML document. DFDL also allows data to be taken from an instance of an information set and written out to its native format.
DFDL achieves this by leveraging W3C XML Schema Definition Language (XSDL) 1.0. [XSDLV1]
An XML schema is written for the logical model of the data. The schema is augmented with special DFDL annotations. These annotations are used to describe the native representation of the data. This is an established approach that is already being used today in commercial systems.

1.2.1 Simple Example

Consider the following XML data:

```
<w>5</w>
<x>7839372</x>
<y>8.6E-200</y>
<z>-7.1E8</z>
```

The logical model for this data can be described by the following fragment of an XML schema document that simply provides description of the name and type of each element:

```
  <xs:complexType name="example1">
       <xs:sequence>
        <xs:element name="w" type="xs:int"/>
        <xs:element name="x" type="xs:int"/>
        <xs:element name="y" type="xs:double"/>
        <xs:element name="z" type="xs:float"/>
       </xs:sequence>
  </xs:complexType>
```

Now, suppose we have the same data but represented in a non-XML format. A binary representation of the data could be visualized like this (shown as hexadecimal):

```
0000 0005 0077 9e8c
169a 54dd 0a1b 4a3f
ce29 46f6
```

To describe this in DFDL, we take our original XML schema document that described the data model and we annotate the type definition as follows:

```
<xs:complexType >
      <xs:sequence dfdl:byteOrder="bigEndian">
       <xs:element name="w" type="xs:int">
          <xs:annotation>
            <xs:appinfo source="http://www.ogf.org/dfdl/">
                <dfdl:element representation="binary"
                   binaryNumberRep="binary"
                   byteOrder="bigEndian"
                   lengthKind="implicit"/>
              </xs:appinfo>
          </xs:annotation>
       </xs:element>
        <xs:element name="x" type="xs:int ">
          <xs:annotation>
            <xs:appinfo source="http://www.ogf.org/dfdl/">
                <dfdl:element representation="binary"
                   binaryNumberRep="binary"
                   byteOrder="bigEndian"
                   lengthKind="implicit"/>
              </xs:appinfo>
          </xs:annotation>
       </xs:element>
        <xs:element name="y" type="xs:double">
          <xs:annotation>
            <xs:appinfo source="http://www.ogf.org/dfdl/">
                <dfdl:element representation="binary"
                   binaryFloatRep="ieee"
                   byteOrder="bigEndian"
                   lengthKind="implicit"/>
              </xs:appinfo>
          </xs:annotation>
       </xs:element>
        <xs:element name="z" type="xs:float" >
          <xs:annotation>
            <xs:appinfo source="http://www.ogf.org/dfdl/">
                <dfdl:element representation="binary"
                   byteOrder="bigEndian"
                   lengthKind="implicit"
                   binaryFloatRep="ieee" />
              </xs:appinfo>
          </xs:annotation>
       </xs:element>
      </xs:sequence>
    </xs:complexType>
```

This simple DFDL annotation expresses that the data are represented in a binary format and that the byte order will be big endian. This is all that a DFDL parser needs to read the data.

Consider if the same data are represented in a text format:

```
5,7839372,8.6E-200,-7.1E8
```

Once again, we can annotate the same data model, this time with properties that provide the character encoding, the field separator (comma) and the decimal separator (period):

```
<xs:complexType >
       <xs:sequence >
              <xs:annotation>
                <xs:appinfo source="http://www.ogf.org/dfdl/">
                    <dfdl:sequence encoding="UTF-8" byteOrder="bigEndian"
                              separator="," />
                  </xs:appinfo>
              </xs:annotation>

              <xs:element name="w" type="xs:int">
                <xs:annotation>
                  <xs:appinfo source="http://www.ogf.org/dfdl/">
                    <dfdl:element representation="text"
                         encoding="UTF-8"
                         textNumberRep ="standard"
                          textNumberPattern="####0"
                          textStandardGroupingSeparator=","
                         textStandardDecimalSeparator="."
                         lengthKind="delimited"/>
                   </xs:appinfo>
                  </xs:annotation>
                </xs:element>

              <xs:element name="x" type="xs:int">
                <xs:annotation>
                  <xs:appinfo source="http://www.ogf.org/dfdl/">
                    <dfdl:element representation="text"
                         encoding="UTF-8"
                         textNumberRep ="standard"
                          textNumberPattern="#######0"
                          textStandardGroupingSeparator=","
                         textStandardDecimalSeparator="."
                         lengthKind="delimited"/>
                   </xs:appinfo>
                  </xs:annotation>
                </xs:element>

              <xs:element name="y" type="xs:double">
                <xs:annotation>
                  <xs:appinfo source="http://www.ogf.org/dfdl/">
                    <dfdl:element representation="text"
                         encoding="UTF-8"
                         textNumberRep ="standard"
                          textNumberPattern="0.0E+000"
                          textStandardGroupingSeparator=","
                         textStandardDecimalSeparator="."
                         lengthKind="delimited"/>
                   </xs:appinfo>
                  </xs:annotation>
                </xs:element>

              <xs:element name="z" type="xs:float">
                <xs:annotation>
                  <xs:appinfo source="http://www.ogf.org/dfdl/">
                    <dfdl:element representation="text"
                         encoding="UTF-8"
                         textNumberRep ="standard"
                          textNumberPattern="0.0E0"
                          textStandardGroupingSeparator=","
                         textStandardDecimalSeparator="."
                         lengthKind="delimited"/>
```

```
                </xs:appinfo>
              </xs:annotation>
            </xs:element>

      </xs:sequence>
</xs:complexType>
```

1.3 What DFDL is not

DFDL maps data from a non-XML representation to an instance of an information set. This can be thought of as a data transformation. However, DFDL is not intended to be a general transformation language and, in particular, DFDL does not intend to provide a mechanism to map data to arbitrary XML models. There are two specific limitations on the data models that DFDL can work to:

1. DFDL uses a subset of XML Schema, in particular, you cannot use XML attributes in the data model.
2. The order of the data in the data model must correspond to the order and structure of the data being described.

This latter point deserves some elaboration. The XML schema used must be suitable for describing the physical data format. There must be a correspondence between the XML schema's constructs and the physical data structures. For example, generally the elements in the XML schema must match the order of the physical data. DFDL does allow for certain physically unordered formats as well.

The key concept here is that when using DFDL, you do not get to design an XML schema to your preference and then populate it from data. That would involve describing the data format, and describing a transformation for mapping it to the XML schema you have designed. DFDL is only about the format part of this problem. There are other languages, such as XSLT, which are for transformation. In DFDL, you describe only the format of the data, and this format constrains the nature of the XML schema you must use in its description.

1.4 Scope of version 1.0

The goals of version 1.0 are as follows:

1. Leverage XML technology and concepts
2. Support very efficient parsers/formatters
3. Avoid features that require unnecessary data copying
4. Support round-tripping, that is, read and write data in a described format from the same description
5. Keep simple cases simple
6. Simple descriptions should be "human readable" to the same degree that XSDL is.

The general features of version 1.0 are as follows:

a) Text and binary data parsing and unparsing
b) Validate the data when parsing and unparsing using XSDL validation.
c) Defaulted input and output for missing values
d) Reference – use of a previously read value in subsequent expressions
e) Choice – capability to select among format variations
f) Hidden sequence of elements - description of an intermediate representation not exposed in the final result
g) Basic Math – in DFDL expressions
h) Out-of-band value handling
i) Speculative parsing to resolve uncertainty.
j) Very general parsing capability: Lookahead/Push-back

Version 1.0 of DFDL is a language capable of expressing a wide range of binary and text-based data formats.
DFDL is capable of describing binary data as found in the data structures of COBOL, C, PL1, Fortran, etc. In particular, it is able to describe repeating sub-arrays where the length of an array is stored in another location of the structure.
DFDL is capable of describing a wide variety of textual data formats such as HL7, X12, and SWIFT. Textual data formats often use syntax delimiters, such as initiators, separators and terminators to delimit fields.
DFDL has certain composition properties. I.e., two formats can be nested or concatenated and a working format results.
The following topics have been deferred to future versions of the standard:

- Extensibility: There are real examples of proprietary data format description languages that we use as our base of experience from which to derive standard DFDL. However, there are no examples of extensible format description languages. Therefore, while extensibility is desirable in DFDL, there is not yet a base of experience with extensibility from which to derive a standard.
- Rich Layering: Some formats require data to be described in multiple passes. Combining these into one DFDL schema requires very rich layering functionality. In these layers one element's value content becomes the representation of another element. DFDL V1.0 allows description of only a limited kind of layering.

1.5 Related standards

1. Prescriptive systems:
    a. JSON
    b. W3C binary XML (http://www.w3.org/XML/Binary/)

2. Descriptive systems:
    a. ASN1 Encoding Control Notation
    b. ITU-T X.692

2. Notational and Definitional Conventions

The key words *must*, *must not*, *required*, *shall*, *shall not*, *should*, *should not*, *recommended*, *may*, *may not* and *optional* in this document are to be interpreted as described in [RFC 2119]. Note that for reasons of clarity these words do not always include all the required capitalized in this document.

Examples are for illustration purposes only and for clarity do not included the required DFDL properties.

2.1 Failure Types

- Where the phrase "must be consistent with" is used, it is assumed that a conforming DFDL implementation must check for the consistency and issue appropriate diagnostic messages when an inconsistency is found.
- There are several kinds of failures that can occur when a DFDL processor is handling data and/or a DFDL schema.

2.2 Schema Definition Error

When the DFDL schema itself contains an error, it implies that the DFDL processor cannot process data because the DFDL schema is not meaningful. It may be ambiguous, or contain conflicting definitions. Equivalently, we can say that there is no possible data that conforms to the schema; hence, the schema cannot be meaningful. All conforming DFDL processors must detect all schema definition errors, and must issue some kind of appropriate diagnostic message. The behavior of a DFDL processor after a schema definition error is detected is out of scope for this specification.
When a Schema definition error can be detected given only the schema, it is desirable, though not required by the DFDL standard, that such errors be detected and diagnostic messages issued before any data are processed. Of course not all schema definition errors can be detected without reference to data as some representation properties may obtain their values from the data (see section 2.3.1 Ambiguity of Data Formats).
The expression language included within DFDL is strongly, statically type checkable. This means that type checking of expressions can be performed without processing data, and implementations are encouraged to perform this checking statically so that schema definition errors having to do with type inconsistencies can be detected before processing data.

Note that schema definition errors cannot be suppressed by points of uncertainty.

2.3 Processing Errors:

If a DFDL schema contains no schema definition errors, then there is the additional possibility that when processing data using a DFDL schema, the data do not conform to the format described by the schema. This is known as a *processing error*.

Processing errors can be suppressed by a point of uncertainty. See section 9.1.1 Resolving Points of Uncertainty.

It is expected that DFDL implementations will provide additional mechanisms for dealing with effective processing errors such as the means of specifying retry points or the means of skipping some data so as to recover from the error in some way.
Exceptions that occur in the evaluation of the DFDL expression language are processing errors.

Non-conformance with the *xs:minOccurs* constraint is a processing error. Non-conformance with the *xs:maxOccurs* constraint is a validation error.

2.3.1 Ambiguity of Data Formats

A data format using delimiters may be ambiguous if the delimiters are not distinct and a data format description which has fixed data requirements (some elements having required fixed values), may be ambiguous even with fixed length elements. [1]
If the delimiter string values are stored within the data, perhaps as elements of a header part of the data, then this ambiguity certainly cannot be examined until the data is available.
Given an ambiguous grammar, a DFDL implementation may successfully parse a particular input data stream. That is, the part of the schema with the ambiguity may not be exercised by a particular data stream, or the data may parse successfully anyway because the ambiguity may not cause any kind of failure or processing error.
Hence, to insure compatible behavior, DFDL v1.0 implementations MUST NOT detect grammar ambiguities as errors. Implementations are of course free to issue warnings to help users identify these situations, but ambiguity is neither a Schema Definition Error nor a Processing Error.

2.3.1.1 Unparsing Must be Unambiguous

Usually, the behavior of the unparser is symmetric to the behavior of the parser; however, there are cases where the DFDL schema will accept several equivalent representations for the same logical data. In this case it would be ambiguous which of these equivalent representations should be produced by the unparser. The DFDL standard contains representation properties which are used to eliminate this ambiguity. It is a schema definition error if a DFDL schema is being used to unparse data and there is any ambiguity about the representation.

2.3.2 Schema Component Constraint: Unique Particle Attribution

A DFDL processor MUST implement the Schema Component Constraint: Unique Particle Attribution defined in *XML Schema Part 1: Structures* [XSDLV1] that applies to the DFDL schema subset.

Two elements **overlap** if

- They are both element declaration particles whose declarations have the same name and target namespace.

A content model will violate the unique attribution constraint if it contains two particles which overlap and which either

- Are both in the particles of a *choice* group

Or

- Either may validate adjacent information items and the first has xs:minOccurs less than xs:maxOccurs.

[1] A very complex analysis is required to identify this sort of grammar ambiguity in general. While we believe this may be decidable for DFDL v1.0, future versions of DFDL may add features (such as recursive types) which make this analysis undecidable.

2.4 Validation Errors

Logical validation checks are constraints expressed in XSDL and they apply to the logical content of the infoset. Hence, parsing must successfully construct the infoset from the representation in order for validation checks to be meaningful. This implies that validation errors cannot affect the ability of a DFDL processor to successfully parse or unparse data.

DFDL processors may provide both validating and non-validating behaviors on either or both of parse and unparse. (A DFDL implementation could support validate on parse, but not support it on unparse and still be considered conforming.)

The behavior of a DFDL processor after a validation error is not specified by the DFDL language. An unparse validation error is defined in terms of a parse validation error. Specifically, an unparse validation error occurs when the physical representation being output would generate a validation error when parsing the data representation using the same DFDL schema.
When resolving points of uncertainty, validation errors are ignored.

The following DFDL schema constructs are allowed in DFDL and are checked when validating:

1. XSDL pattern facet - (for xs:string type elements only)
2. XSDL minLength, maxLength
3. XSDL minInclusive, minExclusive, maxInclusive, maxExclusive
4. XSDL enumeration
5. XSDL maxOccurs

Note that validation is distinct from the checking of DFDL assert or discriminator predicates. When a DFDL discriminator or assert is used to discriminate a choice or other point of uncertainty when parsing, then that assert or discriminator is essential to parsing and it is evaluated irrespective of whether validation is enabled or disabled.

Note that validation errors cannot be suppressed by points of uncertainty.

3. Glossary

Adjacent - Two parts of the input/output stream are adjacent if they are at consecutive addresses.

Addressable Unit, or Unit - This is the unit of storage that makes up the input or output stream holding the representation of the data. The units are bits, bytes, or characters.

Applicable properties - All the DFDL properties that apply to that type of schema construct. For example all the DFDL properties that apply to an xs:simpleType.

Array - The set of adjacent elements whose XSDL element declaration specifies the potential for it to have more than one occurrence (xs:maxOccurs > 1 or unbounded). Of course any given array instance can have any number of elements, including zero elements or exactly 1 element as long as the occurrence constraints are met. If xs:maxOccurs is 'unbounded' then there is no constraint to the maximum number of occurrences. An optional element (xs:maxOccurs=1, xs:minOccurs=0) is not considered to be an array as described in this document. (The term for any variable-occurrence item, generalizing the notion of variable- occurrence array and optional element is 'variable-occurrence item'.) Note that a sequence is not to be confused with an array. A sequence is a complex tuple type for an element; the children of a sequence can be of different types. All elements of an array have the same type and have the same information item members except for the value member.

Array Element – an element declaration or reference with xs:maxOccurs>1 or unbounded.

Augmented infoset - When unparsing one begins with the DFDL schema and conceptually with the logical infoset. As the values of items are filled in by defaulting, and by use of the DFDL outputValueCalc property (including on hidden items), these new item values augment the infoset. The resulting infoset is called the augmented infoset.

Byte - The term “byte” refers to an 8-bit octet.

Component - A construct within a DFDL schema that may contain a DFDL annotation..

Content - The content is the bits of data that are interpreted to compute a logical value

Contiguous - An element has a contiguous representation if all parts of its representation are adjacent in the input/output stream. Most simple types have contiguous representations naturally. Groups containing elements that are themselves contiguous are also considered to have contiguous representations irrespective of alignment fill or padding of any kind that exists within the group. Similarly, arrays containing elements that are themselves contiguous are also contiguous. An example of a non-contiguous representation would be a nillable element, where a flag is used to determine whether or not the element is nil, and the location of that flag is not adjacent to the value representation.

Delimiter - A character or string used to separate, or mark the start and end of, items of data. In DFDL, dfdl:lengthKind 'delimited' searches for separators and terminators.

Delimiter scanning - When parsing, the process of scanning for a specific item in the data which marks the end of an item, or the beginning of a subsequent item is referred to as delimiter scanning, or simply scanning for short. Scanning also takes into account escape schemes so as to allow the delimiters to appear within data if properly escaped.

DFDL – Data Format Description Language

DFDL Processor - A program that uses DFDL schemas in order to process data described by them.

DFDL Schema - an XML schema containing DFDL annotations to describe data format.

Dynamic extent - This is a characteristic of the data stream. When parsing a declaration or definition, the collection of bits within the data stream that contain any aspect of the representation of that element make up the element's dynamic extent.

Dynamic scope - This is a characteristic of parts of the DFDL schema. When a definition or declaration contains or references another declaration or definition, then the contained definition or declaration is said to be in the dynamic scope of the enclosing one. The important characteristic of dynamic scoping is that it traverses references. When parsing, the dynamic scope of an element declaration includes all definitions and declarations used as part of parsing that element.

Element - A part of the data described by an element declaration in the schema and presented as an element information item in the infoset.

Explicit properties - The explicit properties are the combination of any defined locally on the annotation and any defined on the dfdl:defineFormat annotation referenced by a local dfdl:ref property.

Fixed-Occurrence Item - An array has fixed number of occurrences when xs:minOccurs = xs:maxOccurs, or when the DFDL representation properties preclude a variable number of occurrences. An optional element has a fixed number of occurrences when the DFDL representation properties preclude a variable number of occurrences.

Format Annotations - the syntactic elements by which format information is decorated onto XML schemas

Format Properties - the attributes on format annotations which specify characteristics of data format.

Framing - framing is the term we use to describe the delimiters, length fields, and other parts of the data stream which are present, and may be necessary to determine the length or position of the content of an element.

Item - A DFDL information set consists of a number of ***information items***; or just *items* for short.

Length - When discussing data items and their representations, the term 'length' is used to refer to the measure of the size of the representation of an item in units of bits, bytes, or characters. The length of an array is the number of bits, bytes, or characters making up its representation, and has nothing to do with the number of occurrences, or dimensionality, of the array. Any item or array has length. Only arrays and optional elements have occurrences.

Lexical scope - In a DFDL Schema document, the lexical scope of any element is the collection of schema declarations, definitions, and annotations contained within the element textually.

Local properties – Local properties are the properties defined on an annotation in either short, attribute or element form

Logical layer - A DFDL Schema with all the DFDL annotations ignored is an ordinary XSDL schema. The logical structure described by this XSDL is called the DFDL *logical layer*.

Optional Element - this term refers to an element declaration or reference with xs:maxOccurs='1', and xs:minOccurs='0'.

Optional Item - an item with xs:minOccurs='0', so that it is in fact possible for there to be no occurrences at all. Optional Elements are optional items obviously, but Variable-occurrence arrays where xs:minOccurs=0 are also optional items.

Number of Occurrences - used to discuss dimensionality of arrays and the presence/absence of optional elements.

Potentially represented - an element declaration in the schema describes a *potentially represented* item if that element declaration does not have an inputValueCalc property. Whether the element declaration describes an item that is actually represented or not depends on whether the element declaration is for a required or optional element, and whether the element has a corresponding value in the augmented infoset.

Physical layer – A DFDL Schema adds format annotations onto an XSDL language schema. The annotations describe the physical representation or physical layer of the data.

Point of uncertainty - A point of uncertainty occurs in the data stream when there is more than one schema component that might occur at that point.

Representation Property – The properties on a component format annotations that affect the representation of the element. These are all the properties with the exception of dfdl:ref.

Required Element - A scalar element is required. An element of a fixed-occurrence array is required. An element of a variable-occurrence array is required if its index is less than or equal to the value of xs:minOccurs. All other elements are not required.

Required property – A DFDL property that must have a value. The required properties for each xs:schema component are listed in the Property Precedence tables in section 23.

Scalar Element – Not an array and not optional. Specifically xs:maxOccurs=1 and xs:minOccurs=1. Scalar is not to be confused with 'simple'. Scalar is only about the dimensionality of the data, not its complexity/simplicity.

Scan – examine the input data bytes looking for delimiters such as separators and terminators.

Scanned length: When dfdl:lengthKind="delimited", or "pattern", and additionally when dfdl:lengthKind="endOfParent", and the parent has scanned length (recursively).

Schema - The set of all declarations and definitions in the schema, including all included and imported schemas taken together. This includes both the XSDL declarations and definitions, and the DFDL definitions provided in the top-level DFDL annotations.

Schema Definition Order – the order that the schema components are defined in a schema document.

Specified length - An item has specified length when dfdl:lengthKind="implicit", "explicit", or "prefixed", and additionally, if dfdl:lengthKind="endOfParent", and the parent has specified length (recursively).

Speculative Parsing – When the parser reaches a point of uncertainty it attempts to parse each option in turn until one is known to exist or known not to exist.

Target length - When unparsing, the length (in dfdl:lengthUnits) of an item's representation is the target length. The length of the logical data item in the infoset may be shorter or longer than the target length, in which case padding or truncation may be required to make the logical data conform to the target length. Rules for when padding and truncation occur, and how they are applied is specific to simple data types, and are controlled by a number of DFDL format properties.

Unpadded length - This is the length of the representation an item of the infoset, prior to any filling or padding which might be introduced due to dfdl:lengthKind="prefixed" or dfdl:lengthKind="explicit". It is equal to or smaller than the target length.

Variable-Occurrence Item - Optional elements have a variable number of occurrences (0 or 1) and arrays also can have a variable number of occurrences (when xs:minOccurs < xs:maxOccurs). So when we say an item with a variable number of occurrences, this can mean either an optional element, or an array where xs:minOccurs < xs:maxOccurs. In either array or optional elements, we have the additional constraint that the DFDL representation properties do not preclude a variable number of occurrences.[2]

[2] When dfdl:occursCountKind='expression' and dfdl:occursCount has a literal constant as its value, or an expression that statically evaluates to a constant, then the DFDL properties are specifying exactly the number of occurrences for all instances and so are said to preclude a variable number of occurrences. If dfdl:occursCount has a formula as its expressed value, then the DFDL properties do not preclude a variable number of occurrences.

4. The DFDL Information Set (Infoset)

This section defines an abstract data set called the ***DFDL Information Set*** (***Infoset***). Its purpose is to define the content that must be provided:

- To an invoking application by a DFDL parser when parsing DFDL-described data using a DFDL Schema;
- To a DFDL unparser by an invoking application when generating DFDL-described data using a DFDL Schema

The DFDL Infoset contains enough information so that a DFDL schema can be defined that will unparse the infoset and reparse the resultant datastream to produce the same infoset..
There is no requirement for DFDL-described data to be valid in order to have a DFDL information set.
DFDL information sets may be created by methods (not described in this specification) other than parsing DFDL-described data.
A DFDL information set consists of a number of ***information items***; or just *items* for short. The information set for any well-formed DFDL-described data will contain at least a document information item and one element information item. An information item is an abstract description of a part of some DFDL-described data: each information item has a set of associated named ***members***. In this specification, the member names are shown in square brackets, **[thus]**. The types of information item are listed in Section 4.1 Information Items.
The DFDL Information Set does not require or favor a specific interface or class of interfaces. This specification presents the information set as a modified tree for the sake of clarity and simplicity, but there is no requirement that the DFDL Information Set be made available through a tree structure; other types of interfaces, including (but not limited to) event-based and query-based interfaces, are also capable of providing information conforming to the DFDL Information Set.
The terms "information set" and "information item" are similar in meaning to the generic terms "tree" and "node", as they are used in computing. However, the former terms are used in this specification to reduce possible confusion with other specific data models.
The DFDL Information Set is similar in purpose to the XML Information Set [XMLInfo], however, it is not identical, nor a perfect subset, as there are important differences.

4.1 Information Items

An information set contains two different types of information items, as explained in the following sections. Every information item has members. For ease of reference, each member is given a name, indicated **[thus]**.

4.1.1 Document Information Item

There is exactly one ***document information item*** in the information set, and all other information items are accessible through the [root] member of the document information item.
There is no specific DFDL schema component that corresponds to this item. It is a concrete artifact describing the information set.
The document information item has the following members:

1. **[root]** The element information item corresponding to the root element declaration of the DFDL Schema.

2. **[dfdlVersion]** String. The version of the DFDL specification to which this information set conforms. For DFDL V1.0 this is 'dfdl-1.0'

3. **[schema]** String. A reference to a DFDL schema associated with this information set, if any. If not empty, the value must be an absolute Schema Component Designator [http://www.w3.org/TR/xmlschema-ref].

4.1.2 Element Information Items

There is an ***element information item*** for each value parsed from the non-hidden DFDL-described data. This corresponds to an instance of a non-hidden element declaration of simple type in the DFDL Schema and is known as a ***simple element information item***.
There is an ***element information item*** for each explicitly declared structure in the DFDL-described data. This corresponds to an instance of an element declaration of complex type in the DFDL Schema and is known as a ***complex element information item***.
In this information set, as in an XML document, an array is just a set of adjacent elements with the same name and namespace. (To represent the array explicitly, introduce a new complex type element to contain the array elements only.)
One of the element information items is the [root] member of the document information item, corresponding to the root element declaration of a DFDL Schema, and all other element information items are accessible by recursively following its [children] member.
An element information item has the following members:

1. **[namespace]** String. The namespace, if any, of the element. If the element does not belong to a namespace, the value is the empty string.

2. **[name]** String. The local part of the element name.

3. **[document]** The document information item representing the DFDL information set that contains this element. This element is empty except in the root element of an information set.

4. **[datatype]** String. The name of the XML Schema 1.0 built-in simple type to which the value corresponds. DFDL supports a subset of these types listed in section 5.1 DFDL Subset of XML Schema. In a complex element information item this member has no value.

5. **[dataValue]** The value in the value space (as defined by XML Schema Part 2: Datatypes [XSDLV1]) of the [datatype] member or special value *nil***.** In a complex element information item this member has no value.
   For information items of datatype xs:string, the value is the ISO 10646 character codes of the string and 'implicit' (also known as logical), left-to-right bidirectional ordering and orientation. During parsing, characters whose value is unknown or unrepresentable in ISO 10646 are replaced by the Unicode Replacement Character U+FFFD. During unparsing, characters that are unrepresentable in the target encoding will be replaced by the replacement character for that encoding.

6. **[children]** An ordered set of zero or more element information items. The order they appear in the set is the order implied by the DFDL Schema. ‘Ordered set’ is not formally defined here, but two operations are assumed: ‘count’ gives the number of information items, and ‘at (index)’ gives the element at ordinal position ‘index’ starting from 1. In a simple element information item this member has no value. In a document information item this member contains exactly one element information item.

7. **[parent]** The complex element information item which contains this information item in its [children] member. In the root element of an information set this member is empty.

8. **[schema]** String. A reference to a schema component associated with this information item, if any. If not empty, the value must be an absolute or relative Schema Component Designator.

4.2 "No Value"

Some members may sometimes have the value ***no value***, and it is said that such a member has no value. This value is distinct from all other values. In particular it is distinct from the empty

string, the empty set, and the empty list, each of which simply has no members, and the special value *nil*.

4.3 DFDL Information Item Order

On parsing and unparsing information items will be presented in the order they are defined in the DFDL Schema.

4.4 DFDL Infoset Object model

By way of illustration, the DFDL information set is presented below as an object model using a Unified Modeling Language (UML) class diagram, augmented using the Object Constraint Language (OCL) [http://www.omg.org/technology/documents/modeling_spec_catalog.htm].
The structure of the information set follows the Composite design pattern. In case of inconsistency or ambiguity, the preceding discussion takes precedence.
DFDL is able to describe the format of the physical representation for data whose structure conforms to this model. Note that this model allows hierarchically nested data, but does not allow representation of arbitrary connected graphs of data objects.

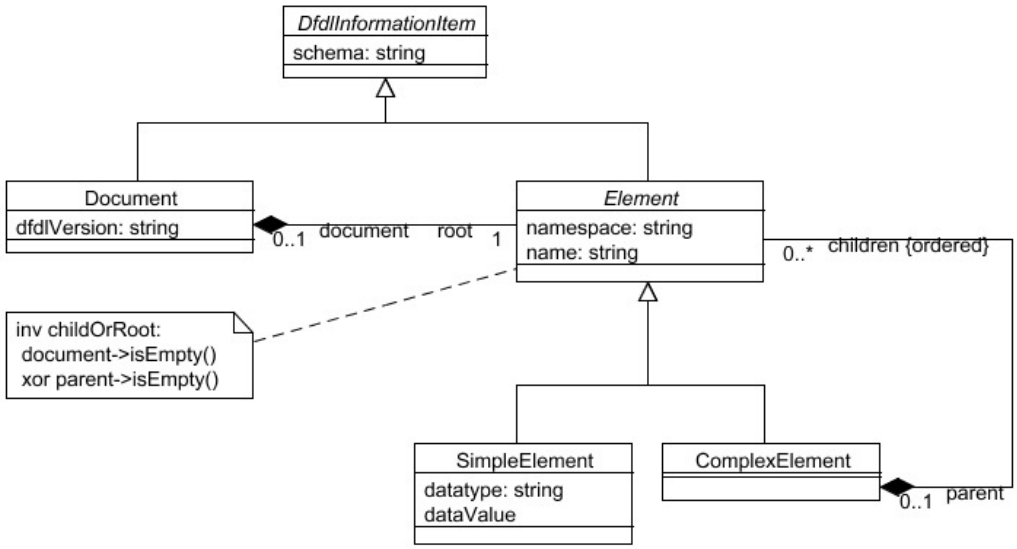

Figure 1 DFDL Infoset Object Model

4.5 DFDL Augmented Infoset

When unparsing one begins with the DFDL schema and conceptually with the logical infoset. As the values of items are filled in by defaulting, and by use of the dfdl:outputValueCalc property (including on hidden items) (see section 117 Calculated Value Properties.), these new item values augment the infoset. The resulting infoset is called the augmented infoset.

An element declaration in the schema describes a *potentially represented* item if that element declaration does not have a dfdl:inputValueCalc property (see section 17 Calculated Value Properties.). Whether the element declaration describes an item that is actually represented or not depends on whether the element declaration is for a required or optional element, and whether the element has a corresponding value in the augmented infoset.

In expressions, the function dfdl:representationLength() can be called to determine the representation length of an item. If an element declaration is not potentially represented, then dfdl:representationLength() is defined to return 0.

When unparsing, an element declaration and the infoset are considered as follows below. An implementation may use any technique consistent with this algorithm:

a) If the element declaration has a dfdl:outputValueCalc property then the expression which is the dfdl:outputValueCalc property value is evaluated and the resulting value becomes the value of the element item in the augmented infoset. Any pre-existing value for the infoset item is superseded by this new value.
References to other augmented infoset items from within the outputValueCalc expression must obtain their values from the augmented infoset directly (when the value is already present) or by recursively using these methods (a) and (b) as needed.

b) If the element declaration has no corresponding value in the augmented infoset, and the element declaration is for a *required* item, and it *has a default value specified*, then an element item having the default value is created in the augmented infoset.

c) If any infoset item's value is requested recursively as a part of (a) above and (a) does not apply, and the corresponding value is not present, and (b) does not apply then it is a processing error.
Given this augmented infoset, then if the potentially represented element declaration has a corresponding infoset item then that item is converted to its representation according to its DFDL properties. If the element declaration is for a required item, and there is no value in the augmented infoset then it is a processing error.
Because rule (a) above is used even if the augmented infoset item already exists and has a value, it is possible for an outputValueCalc expression to be evaluated multiple times. DFDL implementations are free to cache values and avoid this repeated evaluation for efficiency, as the semantics of DFDL require that the outputValueCalc expression return the same value every time it is evaluated.

5. DFDL Schema Component Model

When using DFDL, the format of data is described by means of a *DFDL Schema*.
The DFDL Schema Component Model is shown in conceptual UML in Figure 2. First we show the model for elements, groups and the top of the type hierarchy.

The shaded boxes have direct corresponding element syntax and therefore appear in DFDL schema

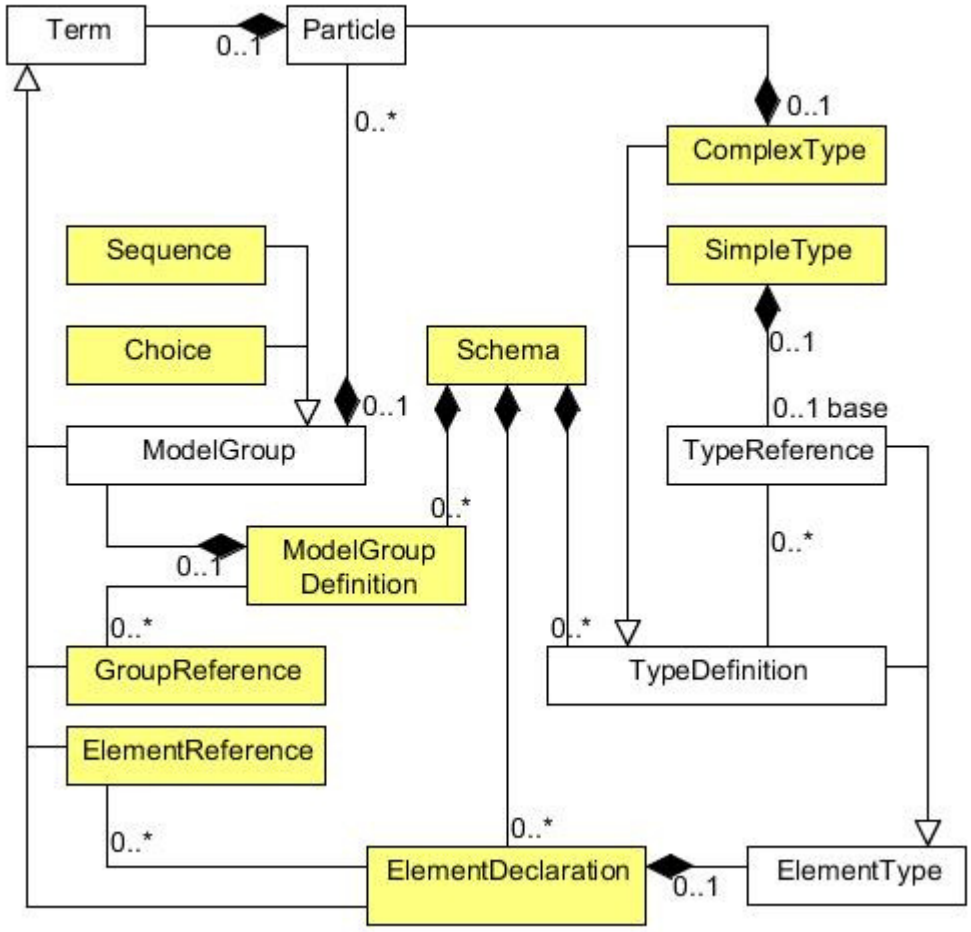

Figure 2 DFDL Schema UML diagram

The simple types are shown in Figure 3. The graph shows all the types defined by XML Schema version 1.0, and the subset of these types supported by DFDL are shown as shaded.

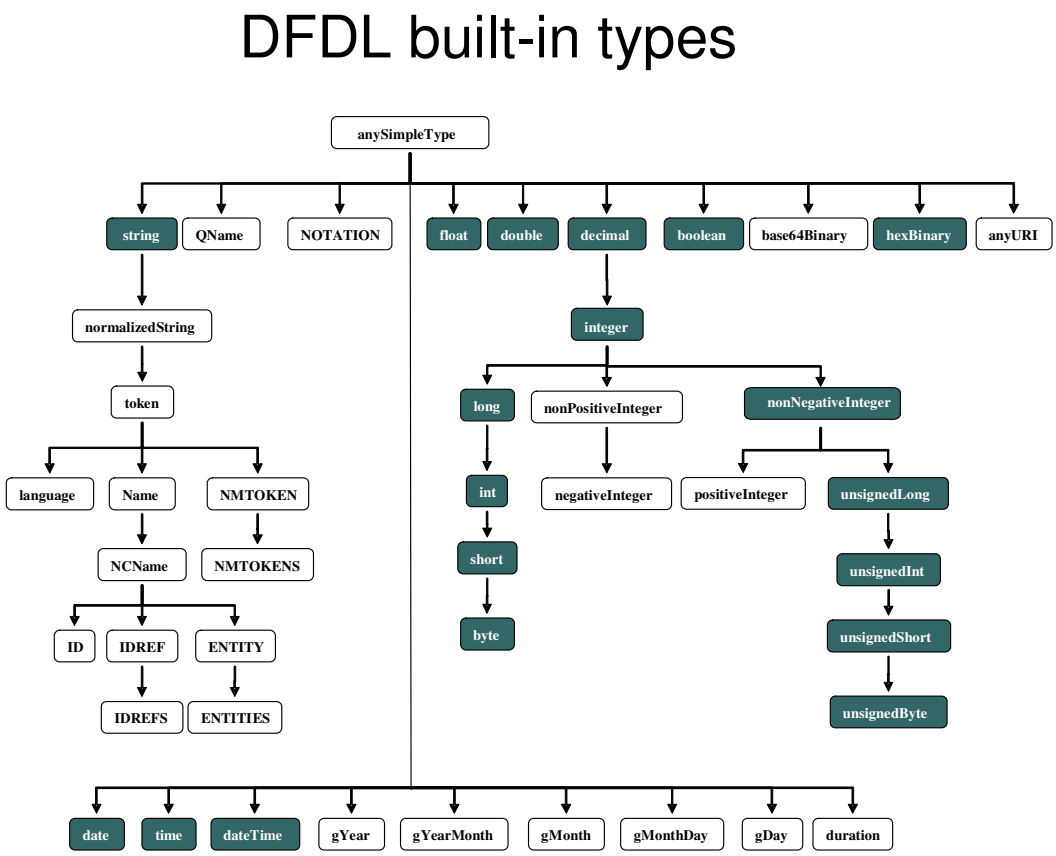

Figure 3 DFDL simple types

These types are defined as they are in XML Schema, with exceptions for:

String – In DFDL a string can contain any character codes. None are reserved. (Including the character with character code U+0000, which is not permitted in XML documents.)

Each object defined by a class in the above UML is called a *DFDL Schema component*.

We express the DFDL Schema Model using a subset of the XML Schema Description Language (XSDL). XSDL provides a standardized schema language suitable for expressing the DFDL Schema Model.

A DFDL Schema is an XML schema containing only a restricted subset of the constructs available in full W3C XML Schema Description Language. Within this XML schema, special DFDL annotations are distributed that carry the information about the data format or representation.

A DFDL Schema is a valid XML schema. However, the converse is not true since the DFDL Schema Model does not include many concepts that appear in XML schema.

5.1 DFDL Subset of XML Schema

The DFDL subset of XSDL is a general model for hierarchically-nested data. It avoids the XSDL features used to describe the peculiarities of XML as a syntactic textual representation of data, and features that are simply not needed by DFDL.

The following lists detail the similarities and differences between general XSDL and this subset.

DFDL Schemas consist of:

- Standard XSDL namespace management
- Standard XSDL import and management for multiple file schemas
- Local element declarations with dimensionality via xs:maxOccurs and xs:minOccurs.
- Global element declarations
- ComplexType definitions with empty or element-only content
- DFDL appinfo annotations describing the data format
- These simple types: string, float, double, decimal, integer, long, int, short, byte, nonNegativeInteger, unsignedLong, unsignedInt, unsignedShort, unsignedByte, boolean, date, time, dateTime, hexBinary
- These facets: minLength, maxLength, minInclusive, maxInclusive, minExclusive, maxExclusive, totalDigits, fractionDigits, enumeration, pattern (for xs:string type only)
- Fixed values
- Default values
- 'sequence' model groups (without xs:minOccurs and xs:maxOccurs)
- 'choice' model groups (without xs:minOccurs and xs:maxOccurs)
- Simple type derivations derived by restriction from the allowed built-in types
- Reusable Groups: named model group definitions can only contain one model group
- Element references with dimensionality via xs:maxOccurs and xs:minOccurs.
- Group references without dimensionality
- xs:nillable="true" only on elements of simple type.
- Appinfo annotations for sources other than DFDL are permitted and ignored
- Unions; the memberTypes must be derived from the same simple type. DFDL annotations are not permitted on union members.[3]
- XML Entities

Note: xs:nonNegativeInteger is treated as an unsigned xs:integer.

The following constructs from XML Schema are not used as part of the DFDL Schema Model of DFDL v1.0 schemas; however, they are all reserved[4] for future use since the data model may be extended to use them in future versions of DFDL:

- Attribute declarations (local or global)
- Attribute references
- Attribute group definitions
- complexType derivations where the base type is not AnyType.
- complex types having mixed content or simple content
- List simple types
- Union simple types where the member types are not derived from the same simple type.
- These atomic simple types: normalizedString, token, Name, NCName, QName, language, positiveInteger, nonPositiveInteger, negativeInteger, gYear, gYearMonth, gMonth, gMonthDay, gDay, ID, IDREF, IDREFS, ENTITIES, ENTITY, NMTOKEN, NMTOKENS, NOTATION, anyURI, base64Binary
- xs:maxOccurs and xs:minOccurs on model groups
- xs:minOccurs = 0 on branches of xs:choice model groups
- Identity Constraints
- Substitution Groups
- 'all' groups
- xs:any element wildcards

[3] The purpose of unions is to allow multiple constraints via facets such as multiple independent range restrictions on numbers. This enhances the ability to do rich validation of data.
[4] By reserved we mean that conforming DFDL v1.0 implementations MAY NOT assign semantics to them.

- Redefine - This version of DFDL does not support xs:redefine. DFDL schemas must not contain xs:redefine directly or indirectly in schemas they import or include.
- Nillability on elements of complex type.
- whitespace facet
- recursively-defined types and elements (defined by way of type, group, or element references)

5.2 XSD Facets, min/maxOccurs, default, and fixed

XSD element declarations and references can carry several attributes and properties that express constraints on the described data. These constraints are mainly use for validation but are also used by the dfdl:checkConstraints DFDL expression language function. These attributes and properties include:

- the facets
- xs:minOccurs, xs:maxOccurs
- default
- fixed

The facets are:

- minLength maxLength
- pattern
- enumeration
- maxInclusive, maxExclusive, minExclusive, minInclusive
- totalDigits, fractionDigits

The following sections describe these in more detail.

5.2.1 MinOccurs and MaxOccurs

The xs:minOccurs value is used:

- To determine if an element declaration or reference is scalar or array
- To determine the required minimum number of occurrences of an array both when parsing and unparsing

The xs:maxOccurs value is used:

- To determine if an element declaration or reference is scalar or array
- When dfdl:occursCountKind="fixed", then the xs:maxOccurs value is the fixed number of occurrences of the array elements. It is a schema definition error if xs:minOccurs is not equal to xs:maxOccurs.
- If validating, to determine the maximum acceptable number of occurrences of an array both when parsing and unparsing.

It is a processing error when an array is found to have a number of occurrences not conforming to the xs:minOccurs constraints in the absence of a default value specification.
Note that specifically, this is not a validation error, it is a processing error. For example, if the array occurrences are delimited, we might be able to successfully separate them from each other and the surrounding data depending on the delimiter specifications; however, if the number of these occurrences is not conforming to the xs:minOccurs cardinality constraints then it is a processing error.

5.2.2 MinLength, MaxLength

These facets are used:

- When dfdl:lengthKind="implicit". In that case the length is given by the value of xs:maxLength. In this case minLength if specified is required to be equal to maxLength (schema definition error otherwise).
- For validation of variable length string elements.

It is a processing error when a fixed-length string is found to have a number of characters not equal to the fixed number. For example, if a fixed-length string also has delimiters we might be able to successfully separate it from the surrounding elements depending on the delimiter specifications; however, if the length of the fixed-length string is not equal to the number specified as the fixed length then it is a processing error (not simply a validation error).

5.2.3 MaxInclusive, MaxExclusive, MinExclusive, MinInclusive, TotalDigits, FractionDigits

- Used for validation only

The format of numbers is not derived from these facets. Rather dfdl properties are used to specify the format.

5.2.4 Pattern

- Allowed only on elements of type xs:string or derived from it.
- Used for validation only

It is important to avoid confusion of the pattern facet with other uses of regular expressions that are needed in DFDL. For example, to determine the length of an element by regular expression matching.

Note: in XSD, pattern is about the lexical representation of the data, and since all is text there, everything has a lexical representation. In DFDL only strings are guaranteed to have a lexical and logical value that is identical.

5.2.5 Enumeration

Enumerations are used to provide a list of valid values in XSD.

- Used for validation only

Note: in DFDL we do not use XSD enumeration as a means to define symbolic constants. These are captured using dfdl:defineVariable constructs so they can be referenced from expressions.

5.2.6 Default

The 'default' attribute is used:

- To provide the logical value of a required element while parsing when the element is missing. See 13.15 Nils and Default processing
- To provide the logical value of a required element when unparsing when element is missing. See 13.15 Nils and Default processing

5.2.7 Fixed

The 'fixed' attribute is used:

- To constrain the logical value of an element when validating.
- To provide the logical value of a required element while parsing when the element is missing. See 13.15 Nils and Default processing
- To provide the logical value of a required element when unparsing when element is missing. See 13.15 Nils and Default processing

6. DFDL Syntax Basics

Using DFDL, a data format is described by placing special annotations at various positions within an XML schema. This XML schema conveys the basic structure of the data format, while the annotations fill in the detail. Annotations are used to describe aspects such as the file encoding and byte ordering, as well as declaring variables for reference elsewhere, and specifying properties that govern the capabilities of the DFDL processor. A DFDL processor requires these annotations, along with the structural information of the enclosing XML schema, to make sense of the physical data model.

6.1 Namespaces

The xs:appinfo source URI http://www.ogf.org/dfdl/ is used to distinguish DFDL annotations from other annotations.
The element and attribute names in the DFDL syntax are in a namespace defined by the URI http://www.ogf.org/dfdl/dfdl-1.0/. All symbols in this namespace are reserved. DFDL implementations may not provide extensions to the DFDL standard using names in this namespace. Within this specification, the namespace prefix for DFDL is “dfdl” referring to the namespace http://www.ogf.org/dfdl/dfdl-1.0/.

Attributes on DFDL annotations that are not in the DFDL or notarget namespace are ignored.

A DFDL Schema document contains XML schema annotation elements that define and assign names to parts of the format specification. These names are defined using the target namespace of the schema document where they reside. A DFDL schema document can include or import another schema document, and namespaces work in the usual manner for XML schema documents. The *schema* is the schema including all additional schemas referenced through import and include. Generally, in this specification, when we refer to the DFDL Schema we mean the schema. When we refer to a specific document we will use the term DFDL Schema document.

6.2 The DFDL Annotation Elements

DFDL annotations must be positioned specifically where DFDL annotations are allowed within an XML schema document. These positions are known as *annotation points*. When an annotation is positioned at an annotation point, it binds some additional information to the schema component that encloses it. The description of a data format is achieved by correctly placing annotations on the structural components of the schema.
DFDL specifies a collection of annotations for different purposes.

Annotation Element(s)	*Description*
assert	Defines a test to be used to ensure the data are well formed. Assert is used only when parsing data. See section 7.3
choice	Defines the physical data format properties of an xs:choice group. See section 7.1.1
discriminator	Defines a test to be used when resolving a point of uncertainty such as choice branches or optional elements. A dfdl:discriminator is used only when parsing data to resolve the point of uncertainty to one of the alternatives. See section 7.4
defineEscapeScheme	Defines a named, reusable escapeScheme See section 7.5
defineFormat	Defines a reusable data format by collecting together other

	annotations and associating them with a name that can be referenced from elsewhere. See section 7.2
defineVariable	Defines a variable that can be referenced elsewhere. This can be used to communicate a parameter from one part of processing to another part. See section 7.7
element	Defines the physical data format properties of an xs:element and xs:element reference. See section 7.1.1
escapeScheme	Defines the scheme by which quotation marks and escape characters can be specified. This is for use with delimited text formats. See section 7.6
format	Defines the physical data format properties for multiple DFDL schema constructs. Used on an xs:schema and as a child of a dfdl:defineFormat annotation. This includes aspects such as the encodings, field separator, and many more. See section 7.1
group	Defines the physical data format properties of an xs:group reference. See section 7.1.1
newVariableInstance	Creates a new instance of a variable. See section 7.8
property	Used in the syntax of format annotations. See section 7.1.3.2.
setVariable	Sets the value of a variable whose declaration is in scope See section 7.9
sequence	Defines the physical data format properties of an xs:sequence group. See section 7.1.1
simpleType	Defines the physical data format properties of an xs:simpleType. See section 7.1.1

Table 1 - DFDL Annotation Elements

6.3 DFDL Properties

Properties on DFDL annotations may be one or more of the following types

- DFDL string literal
  The property value is a string that represents a sequence of literal bytes or characters which appear in the data stream.
- DFDL expression
  The property value is a DFDL subset XPath 2.0 expression that returns a value derived from other property values and/or from the DFDL infoset.
- DFDL regular expression
  The property value is a regular expression that can be used as a pattern to calculate the length of an element by applying that pattern to the sequence of literal bytes or characters which appear in the data stream.
- Enumeration
  The property value is one of the allowed values listed in the property description. An enumeration is of type string unless otherwise stated.
- Logical Value.
  The property value is a string that describes a logical value. The type of the logical value is one of the XML schema simple types.

- QName
  The property value is an XML Qualified Name as specified in “Namespaces in XML “ [XMLNS10]

Some properties accept a list or union of types

- List of DFDL String Literals or Logical Values
  The property value is a space-separated list of the specified type. When parsing, if more than one string literal in the list matches the portion of the data stream being evaluated then the longest matching value in the list must be used. When unparsing, the first value in the list must be used
- Union of types and expressions.
  The property value is a union of DFDL expression and exactly one of the other types. The expression must resolve to a value of the other type.
- Union of types.
  The property value is a union of two or more types. The type is dependent on the value of another property. For example dfdl:nilValue can be a List of DFDL String Literals or a List of Strings depending on dfdl:nilKind

6.3.1 DFDL String Literals

DFDL String Literals represent a sequence of literal bytes or characters which appear in the data stream. This presents the following challenges

- the literal characters in the data stream might not be in the same encoding as the DFDL schema
- it may be necessary to specify a literal character which is not valid in an XML document
- it may be necessary to specify one or more raw byte values

The DFDL specification defines a language for describing any arbitrary sequence of bytes and characters. The full grammar is supplied in Appendix E, but the essential details are given below.

A DFDL string literal can describe any of the following types of literal data in any combination:
- a single literal character in any encoding
- a string of literal characters in any encoding
- a bi-directional character string
- one or more characters from a set of related characters (e.g. end-of-line characters)
- a literal byte value

6.3.1.1 Character strings in DFDL String Literals

A literal string in a DFDL Schema is written in the character set encoding specified by the XML directive that begins all XML documents:

```
<?xml version="1.0" encoding="UTF-8" ?>
```

In this example, the DFDL schema is written in UTF-8, so any literal strings contained in it, and particularly string literals found in its representation property bindings in the format annotations, are expressed in UTF-8.
However, these strings are being used to describe features of text data that are commonly in other character sets. For example, we may have EBCDIC data that is comma separated. A comma in EBCDIC does not have the same character code as a Unicode comma. However, when we indicate that an item is "," (comma) separated and we specify this using a string literal along with specifying the 'encoding' property to be 'ebcdic-cp-us' then this means that the data are separated by EBCDIC commas regardless of what character set encoding is used to write the DFDL Schema.

```
<?xml version="1.0" encoding="UTF-8" ?>
....
```

```
....
....<dfdl:format encoding='ebcdic-cp-us' separator=","/>
.....
```

When a DFDL processor uses the separator expressed in this manner, the string literal "," is *translated* into the character set encoding of the data it is separating as specified by the encoding representation property. Hence, in this case we would be searching the data for a character with codepoint 0x6B (the EBCDIC comma), not a UTF-8 or Unicode (0x2C) comma which is what exists in the DFDL schema document file.

Character strings can include bidirectional data.

6.3.1.2 DFDL Character Entities in String Literals

DFDL character entities specify a single Unicode character and provides a convenient way to specify code points that appear in the data stream but would be difficult to specify in XML strings. For example, common non-printable characters or code points, such as 0x00, that are not valid in XML documents. DFDL entities are based on XML entities, which can also be used in a DFDL schema.

DfdlCharEntity	::=	DfdlEntity | DecimalCodePoint | HexadecimalCodePoint
DfdlEntity	::=	'%' DfdlEntityName ';'
DfdlEntityName	::=	'NUL'|'SOH'|'STX'|'ETX'| 'EOT'|'ENQ'|'ACK'|'BEL'| 'BS'|'HT'|'LF'|'VT'|'FF'| 'CR'|'SO'|'SI'|'DLE'| 'DC1'|'DC2'|'DC3'|'DC4'| 'NAK'|'SYN'|'ETB'|'CAN'| 'EM'|'SUB'|'ESC'|'FS'| 'GS'|'RS'|'US'|'SP'| 'DEL'|'NBSP'|'NEL'|'LS'
DecimalCodePoint	::=	'%#' [0-9]+ ';'
HexadecimalCodePoint	::=	'%#x' [0-9a-fA-F]+ ';'

Table 2 DFDL Character Entity syntax

%% - Inserts a single literal "%" into the string literal. This "%" is subject to character set translation as is any other character.

A HexadecimalCodePoint provides a hexadecimal representation of the character's code point in ISO/IEC 10646.
A DecimalCodePoint provides a decimal representation of the character's code point in ISO/IEC 10646.
A dfdlEntityName one of the mnemonics given in the following tables.

Mnemonic	*Meaning*	*Unicode value*
NUL	null	U+0000
SOH	start of heading	U+0001
STX	start of text	U+0002
ETX	end of text	U+0003
EOT	end of transmission	U+0004
ENQ	enquiry	U+0005
ACK	acknowledge	U+0006
BEL	bell	U+0007

BS	backspace	U+0008
HT	horizontal tab	U+0009
LF	line feed	U+000A
VT	vertical tab	U+000B
FF	form feed	U+000C
CR	carriage return	U+000D
SO	shift out	U+000E
SI	shift in	U+000F
DLE	data link escape	U+0010
DC1	device control 1	U+0011
DC2	device control 2	U+0012
DC3	device control 3	U+0013
DC4	device control 4	U+0014
NAK	negative acknowledge	U+0015
SYN	synchronous idle	U+0016
ETB	end of transmission block	U+0017
CAN	cancel	U+0018
EM	end of medium	U+0019
SUB	substitute	U+001A
ESC	escape	U+001B
FS	file separator	U+001C
GS	group separator	U+001D
RS	record separator	U+001E
US	unit separator	U+001F
SP	space	U+0020
DEL	delete	U+007F
NBSP	no break space	U+00A0
NEL	Next line	U+0085
LS	Line separator	U+2028

Table 3 DFDL Entities

6.3.1.3 DFDL Character Classes Entities in DFDL String Literals

The following DFDL character classes are provided to specify one or more characters from a set of related characters.

DfdlCharClass	::=	'%' DfdlCharClassName ';'
DfdlCharClassName	::=	'NL' | 'WSP' | 'WSP*' | 'WSP+' | 'ES'

Table 4 DFDL Character Class Entity syntax

Mnemonic	*Meaning*	*Unicode value*
NL	Newline On parse any NL character or combination of characters On unparse the value of the dfdl:outputNewLine property is output	• U+000A LF • U+000D CR • U+000D U+000A CRLF • U+0085 NEL • U+2028 LS
WSP	Single whitespace On parse any white space character On unparse a space (U+0020) is output	• U0009-U000D (Control characters) • U0020 SPACE • U0085 NEL

		• U00A0 NBSP • U1680 OGHAM SPACE MARK • U180E MONGOLIAN VOWEL SEPARATOR • U2000-U200A (different sorts of spaces) • U2028 LSP • U2029 PSP • U202F NARROW NBSP • U205F MEDIUM MATHEMATICAL SPACE • U3000 IDEOGRAPHIC SPACE
WSP*	Optional Whitespaces On parse whitespace characters are ignored On unparse nothing is output	Same as WSP
WSP+	Whitespaces On parse one or more whitespace characters are ignored. It is an processing error if no whitespace character is found On unparse a space (U+0020) is output	Same as WSP
ES	Empty String Used in space separated lists when empty string is one of the values (may only be used for the nilValue property)	

Table 5 DFDL Generic Entities

Using these DFDL entities one can create string literals which are a mix of text and hex-specified data.

6.3.1.4 DFDL Byte Value Entities in DFDL String Literals

DFDL byte value entities provide a way to specify a single byte as it appears in the data stream without any character set translation. To specify a string of byte values, a sequence of two or more byte value entities must be used.

ByteValue	::=	'%#r' [0-9a-fA-F]{2} ';'

Table 6 DFDL Byte Value Entity syntax

6.3.2 DFDL Expressions

Some DFDL properties allow DFDL expressions [see section 23 Expression language] to be used so that the property can be set dynamically at processing-time.

The general syntax of expressions is “{“ expression “}”

The rules for recognizing DFDL expressions are

- Must start with a '{' in the first position and end with '}' in the last position.
- '{' in any other position if treated as a literal
- '}' in any position other than the last position is treated as a literal.
- '{{' as the first characters are treated as the literal '{' and not a DFDL expression.

DFDL expressions reference other items in the infoset or augmented infoset using absolute or relative paths. Relative paths are evaluated when the component containing the expression is referenced not when it is declared. For example a global element may have a DFDL property which is an expression that contains a relative path to another element. The relative path is evaluated when the global element is referenced from an element reference.
DFDL expressions that are used to provide the value of DFDL properties in the dfd:format annotation on the xs:schema MAY NOT contain relative paths.

6.3.3 DFDL Regular Expressions

The DFDL lengthPattern property expects a regular expression to be specified. The DFDL Regular Expression language is defined in the section 24 DFDL Regular Expressions.

6.3.4 Enumerations in DFDL

Some DFDL properties accept an enumerated list of valid values. It is a schema definition error if a value other than one of the enumerated values is specified. The case of the specified value must match the enumeration. An enumeration is of type string unless otherwise stated.

7. Syntax of DFDL Annotation Elements

This section describes the syntax of each of the DFDL annotation elements along with discussion of their basic meanings.

The DFDL annotation elements are listed in Table 1 - DFDL Annotation Elements

7.1 Component Format Annotations

A data format can be 'used' or put into effect for a part of the schema by use of the component format annotation elements.
There are specific annotations for each type of schema component that supports only the representation properties applicable to that component. The table below gives the specific annotation for each schema component.

Schema component	*DFDL annotation*
xs:choice	dfdl:choice
xs:element	dfdl:element
xs:element reference	dfdl:element
xs:group reference	dfdl:group
xs:schema	dfdl:format
xs:sequence	dfdl:sequence
xs:simpleType	dfdl:simpleType

Table 7 DFDL Component Annotations

In addition the dfdl:format annotation is used in a dfdl:defineFormat annotation to define a named reusable set of representation properties that can be referenced from any component specific format annotation.
A dfdl:format annotation at the top level of a schema, that is as an annotation child element on the xs:schema, provides a set of default properties for the lexically enclosed schema document. See 8.1 Providing Defaults for DFDL properties.

Example of dfdl component annotation:

```
<xs:schema ...>
...
 <xs:element name="foo">

    <xs:annotation>
      <xs:appinfo source="http://www.ogf.org/dfdl/">
        <dfdl:element ref="aBaseConfig"
                      representation="text"
                      encoding="UTF-8"/>
      </xs:appinfo>
   </xs:annotation>
  <xs:complexType>
...content here is described by the specified representation properties
...
</xs:element>
...
</xs:schema>
```

7.1.1 Syntax of Component Format Annotations

Property Name	Description

ref	QName Reference to a named dfdl:defineFormat annotation that provides a reusable set of DFDL format properties The ref property is always local to the component format annotation on which it is used, even when specified on a format annotation on the xs:schema element. See 7.2 dfdl:defineFormat - Reusable Data Format Definitions Annotation: dfdl:element, dfdl:simpleType, dfdl:sequence, dfdl:choice, dfdl:group
representation properties	All other attributes on format annotation elements are representation property bindings. These are defined in sections starting with section 9 DFDL Processing Introduction Annotation: dfdl:element, dfdl:simpleType, dfdl:sequence, dfdl:choice, dfdl:group

Table 8 Component Annotation Syntax

7.1.2 Ref Property

A named, reusable, dfdl:defineFormat definition is used by referring to its name from a format annotation using the 'ref' attribute. For example:

```
<dfdl:element ref="reusableDef" encoding="ebcdic-cp-us" />
```

The behavior of this dfdl:defineFormat definition is as if all representation properties defined by the named dfdl:defineFormat definition were instead written directly on this format annotation; however, these are superseded by any representation properties that are defined here such as the encoding property in the example above.

7.1.3 Property Binding Syntax

The format properties may be specified in one of three forms:

1. Attribute form
2. Element form
3. Short form

A DFDL property may be specified using any form with the following exceptions

- The ref property may be specified in attribute or short form
- The escapeSchemeRef property may be specified in attribute or short form
- The hiddenGroupRef property may be specified in attribute or short form
- The prefixLengthType property may be specified in attribute or short form

It is a schema definition error if the same property is specified in more than one form at the same annotation point.

7.1.3.1 Property Binding Syntax: Attribute Form

Within the format annotation elements are bindings for properties of the form:

Property='Value'

For example:

```
<xs:annotation>
```

```
    <xs:appinfo source="http://www.ogf.org/dfdl/">
        <dfdl:format
          encoding="utf-8"
          separator="%NL;"
                    />
    </xs:appinfo>
     </xs:annotation>
```

The *Property* is the name of the property. The *Value* is an XML string literal corresponding to a value of the appropriate type.

7.1.3.2 Property Binding Syntax: Element Form

The representation properties can sometimes have complex syntax, so an element form for representation property bindings is provided as element content within the format element. This is provided to ease syntactic expression difficulties:
Element form looks like this:

```
  <xs:annotation>
    <xs:appinfo source="http://www.ogf.org/dfdl/">
        <dfdl:format>
          <dfdl:property name='encoding'>utf-8</dfdl:property>
          <dfdl:property name='separator'>%NL;</dfdl:property>
        </dfdl:format>
    </xs:appinfo>
</xs:annotation>
```

Element form is mostly used for properties that themselves contain the quotation mark characters and escape characters so that they can be expressed without concerns about confusion with the XSDL syntax use of these same characters. CDATA encapsulation can be used so as to allow malformed XML and mismatched quotes to be easily used as representation property values:

```
<dfdl:property name='initiator'><[CDATA[<!-- ]]></dfdl:property>
```

7.1.3.3 Property Binding Syntax:Short Form

To save textual clutter, short-form syntax for format annotations is also allowed. Attributes which are in the namespace "dfdl" and whose local name matches one of the DFDL representation properties are assumed to be equivalent to specific DFDL long-form annotations.
For example the two forms below are equivalent in that they describe the same data format. The first is a short-form of the second:

```
<xs:element name="foo">
  <xs:complexType>
     <xs:sequence dfdl:separator="%HT;" >
      ...
     </xs:sequence>
  </xs:complexType>
</xs:element>

<xs:element name="foo">
  <xs:complexType>
    <xs:sequence>
      <xs:annotation><xs:appinfo source="http://www.ogf.org/dfdl/">
        <dfdl:sequence separator="%HT;" />
      </xs:appinfo></xs:annotation>
      ...
```

```
    </xs:sequence>
  </xs:complexType>
</xs:element>
```

Another example:

```
<xs:sequence dfdl:separator=",">

 <xs:element name="foo" type="xs:int" maxOccurs="unbounded"
                       dfdl:representation="text"
                       dfdl:textNumberRep="standard"
                       dfdl:initiator="["
                       dfdl:terminator="]"/>

 <xs:element name="foo" type="xs:int" maxOccurs="unbounded">
      <xs:annotation><xs:appinfo source="http://www.ogf.org/dfdl/">
        <dfdl:element representation="text"
                     textNumberRep="standard"
                     initiator="["
                     terminator="]"/>
      </xs:appinfo></xs:annotation>
</xs:element>
</xs:sequence>
```

7.1.4 Empty String as a Property Value

DFDL provides no mechanism to un-set a property. Setting a representation property's value to the empty string doesn't remove the value for that property, but sets it to the empty string value. This may not be appropriate as a value for certain properties.
For example, in delimited text representations, it is sensible for the separator to be defined to be the empty string. This turns off use of separator delimiters. For many other string-valued properties, it is a schema definition error to assign them the empty string value. For example, the character set encoding property cannot be set to the empty string.

7.2 dfdl:defineFormat - Reusable Data Format Definitions

One or more dfdl:defineFormat annotation elements can appear within the annotation children of the xs:schema element. The dfdl:defineFormat elements may only appear as annotation children of the xs:schema element.
The order of their appearance does not matter, nor does their position relative to other non-annotation children of the xs:schema.
Each dfdl:defineFormat has a required name attribute.
The construct creates a named data format definition. The value of the name attribute is of XML type NCName. The format name will become a member of the schema's target namespace. These names must be unique within the namespace.
If multiple format definitions have the same 'name' attribute, in the same namespace, then it is a schema definition error.
Here is an example of a format definition:

```
<xs:schema ...>
  <xs:annotation>
    <xs:appinfo source="http://www.ogf.org/dfdl/">
      <dfdl:defineFormat name="myConfig" >
        <dfdl:format representation="text"
                     ref="textSpecialFormat1" />
      </dfdl:defineFormat>
    </xs:appinfo>
```

```
</xs:annotation>
...
</xs:schema>
```

A dfdl:defineFormat serves only to supply a named definition for a format for reuse from other places. It does not cause any use of the representation properties it contains to describe any actual data.

7.2.1 Inheritance for dfdl:defineFormat

A dfdl:defineFormat declaration can inherit from another named format definition by use of the ref attribute of the dfdl:format annotation. This allows a single-inheritance hierarchy that reuses definitions. When one definition extends another in this way, any property definitions contained in its direct elements override those in any inherited definition.
Conceptually, the 'ref' inheritance chains can be *flattened* and removed by copying all inherited property bindings and then superseding those for which there is a local binding. Throughout this document we will assume inheritance is fully flattened. That is, all 'ref' inheritance is first removed by flattening before any other examination of properties occurs.

7.2.2 Using/Referencing a Named Format Definition

See section 7.1.2 Ref Property

7.3 The dfdl:assert Annotation Element

The dfdl:assert annotation element is used to assert truths about a DFDL model that are used only when parsing to ensure that the data are well-formed. These checks are separate from validation checking and are performed even when validation is off. This distinction is needed to ensure that switching validation off does not affect parsing.

Examples of dfdl:assert elements are below:

```
<dfdl:assert message="Value is not zero." test="{ ../x ne 0}" />

<dfdl:assert message="Precondition violation." >
        <[CDATA[ {../x le 0 and ../y ne "-->" and ..y ne "<!–" }]]>
</dfdl:assert>


<dfdl:assert message="Postcondition violation."  testKind='expression'>
     {../x ne "’"}
</dfdl:assert>
```

7.3.1 Properties for dfdl:assert

DFDL asserts can be placed on components within a DFDL model. These dfdl:asserts contain a test expression or a test pattern. The dfdl:assert is said to be successful if the test expression evaluates to true or the test pattern returns a non-zero length match, and unsuccessful if the test expression evaluates to false or the test pattern returns a zero length match. An unsuccessful dfdl:assert causes a processing error.

The dfdl:testKind attribute specifies whether an expression or pattern is used by the dfdl:assert. The expression or pattern can be expressed as an attribute or as a value.

```
<dfdl:assert  test="{test expression}" />

<dfdl:assert >
            {test expression}
```

```
</dfdl:assert>
```

It is a schema definition error if a property is specified in more than one form.
It is a schema definition error if both a test expression and a test pattern are specified.

A dfdl:assert can be an annotation on:

- a local xs:element declaration,
- an xs:element reference,
- an xs:group reference,
- an xs:sequence
- an xs:choice.

More than one dfdl:assert may be used at an annotation point. The dfdl:asserts will be evaluated in the order defined in the schema.

Property Name	Description
testKind	Enum (optional) Valid values are 'expression', 'pattern' Default value is 'expression' Specifies whether a DFDL expression or DFDL regular expression is used in the dfdl:assert. Annotation: dfdl:assert
test	DFDL Expression Applies when dfdl:testKind is 'expression' A DFDL expression that evaluates to true or false. If the expression evaluates to true then parsing continues. If the expression evaluates to false then a processing error is raised. Any element referred to by the expression must have already been processed or is a descendent of this element. The expression must have been evaluated by the time this element and it descendents have been processed. If a processing error occurs during the evaluation of the test expression then the dfdl:assert also fails. It is a schema definition error if dfdl:test is the empty string and the value is not specified and dfdl:testKind is 'expression' or not specified . Annotation: dfdl:assert
testPattern	DFDL Regular Expression Applies when dfdl:testKind is 'pattern' A DFDL regular expression that is executed against the data stream starting at the start of the component on which the dfdl:assert is positioned. If the length of the match is zero then the dfdl:assert evaluates to false and a processing error is raised. If the length of the match is non-zero then the dfdl:assert evaluates to true.

	If a processing error occurs during the evaluation of the test regular expression then the dfdl:assert also fails. It is a schema definition error if dfdl:testPattern is the empty string and the value is not specified and dfdl:testKind is 'pattern'. Annotation: dfdl:assert
message	String Defines text to be used as a diagnostic code or for use in an error message. The DFDL specification does not specify how a DFDL processor uses this message text. Annotation: dfdl:assert

Table 9 dfdl:assert properties

7.4 The dfdl:discriminator Annotation Element

DFDL discriminators are used to resolve points of uncertainty that cannot be resolved by speculative parsing. They can also be used to force a resolution earlier during the parsing of a group so that subsequent parsing errors are treated as processing errors of a known component rather than a failure to find a component.

A discriminator determines the existence or non-existence of a component. If the discriminator is successful then the component is known to exist and any subsequent errors will not cause backtracking at points of uncertainty. If a discriminator is unsuccessful then the component is known not to exist and backtracking occurs immediately.

If the complex type of an element contains a sequence group as its content then if the sequence group is known not to exist, then the element is known not to exist.

Examples of dfdl:discriminator annotation are below :

```
<dfdl:discriminator >
        {../recType eq 0}
</dfdl:discriminator>


<dfdl:discriminator test="{ ../recType eq 0}" />
```

When the discriminator's expression evaluates to "false", then it causes a processing error, and the discriminator is said to fail.

.

7.4.1 Properties for dfdl:discriminator

A DFDL discriminator contains a test expression that is an expression that evaluates to true or false. The discriminator is said to be successful if the test evaluates to true and unsuccessful (or fails) if the test evaluates to false.

The dfdl:testKind attribute specifies whether an expression or pattern is used by the dfdl:discriminator. The expression or pattern can be expressed as an attribute or as a value.

```
<dfdl:discriminator  test="{test expression}" />

<dfdl:discriminator >
       {test expression}
</dfdl:discriminator>
```

It is a schema definition error if a property is specified in more than one form.
It is a schema definition error if both a test expression and a test pattern are specified.

A dfdl:discriminator can be an annotation on

- a local xs:element declaration
- an xs:element reference
- an xs:group reference (when the top level of a choice branch)
- an xs:sequence (when the top level of a choice branch)
- an xs:choice (when the top level of a choice branch)

Any one annotation point can contain only a single dfd:discriminator or one or more dfdl:asserts, but not both. It is a schema definition error otherwise

Property Name	*Description*
testKind	Enum Valid values are 'expression', 'pattern' Default value is 'expression' Specifies whether a DFDL expression or DFDL regular expression is used in the dfdl:discriminator . Annotation: dfdl:discriminator
test	DFDL Expression Applies when dfdl:testKind is 'expression' A DFDL expression that evaluates to true or false. If the expression evaluates to true then the discriminator succeeds and parsing continues. If the expression evaluates to false then the discriminator fails and a processing error is raised. If a processing error occurs during the evaluation of the test expression then the discriminator also fails. Any element referred to by the expression must have already been processed or is a descendent of this element. The expression must have been evaluated by the time this element and it descendents have been processed or when a processing error occurs when processing this element or its descendents. It is a schema definition error if dfdl:test is the empty string and the value is not specified and dfdl:testKind is 'expression' or not specified Annotation: dfdl:discriminator
testPattern	DFDL Regular Expression Applies when dfdl:testKind is 'pattern' A DFDL regular expression that is executed against the data stream starting at the start of the component on which the dfdl:discriminator is positioned. If the length of the match is zero then the dfdl:discriminator evaluates to false and a processing error is raised. If the length of the match is non-zero then the dfdl:discriminator evaluates to

	true. It is a schema definition error if dfdl:testPattern is the empty string and the value is not specified and dfdl:testKind is 'pattern'. Annotation: dfdl:discriminator
message	String Defines text to be used as a diagnostic code or for use in an error message. The DFDL specification does not specify how a DFDL processor uses this message text. Annotation: dfdl:discriminator

Table 10 dfdl:discriminator properties

```
<xs:sequence>

<xs:choice>

   <xs:element  name='branchSimple' >
    <xs:annotation>
      <xs:appinfo source="http://www.ogf.org/dfdl/">
         <dfdl:discriminator test='{. eq "a"}'       />
       </xs:appinfo>
     </xs:annotation>
    </xs:element>

   <xs:element name='branchComplex' >
    <xs:annotation>
      <xs:appinfo source="http://www.ogf.org/dfdl/">
     <dfdl:discriminator test='{./identifier eq "b"}' />
     </xs:appinfo>
    </xs:annotation>
        <xs:complexType >
            <xs:element name='identifier'  />
         …..
         </xs:complexType>
    </xs:element>

   <xs:element name='branchNestedComplex' >
  <xs:annotation>
    <xs:appinfo source="http://www.ogf.org/dfdl/">
      <dfdl:discriminator test='{./Header/identifier eq "c"}'/>
    </xs:appinfo>
   </xs:annotation>
       <xs:complexType >
         <xs:sequence>
           <xs:element name='Header'  />
             <xs:complexType >
                <xs:sequence>
                  <xs:element name='identifier'  />
                   …..
               </xs:sequence>
             </xs:complexType>
         </xs:sequence>
        </xs:complexType>
    </xs:element>
```

```
</xs:choice>
</xs:sequence>
```

7.5 The dfdl:defineEscapeScheme Annotation Element

One or more dfdl:defineEscapeScheme annotation elements can appear within the annotation children of the xs:schema. The dfdl:defineEscapeScheme elements may only appear as annotation children of the xs:schema.
The order of their appearance does not matter, nor does their position relative to other annotation or non-annotation children of the xs:schema.
Each dfdl:defineEscapeScheme has a required name attribute and a required dfdl:escapeScheme child element.
The construct creates a named escape scheme definition. The value of the name attribute is of XML type NCName. The name will become a member of the schema's target namespace. These names must be unique within the namespace among escape schemes.
If multiple dfdl:defineEscapeScheme definitions have the same 'name' attribute, in the same namespace, then it is a schema definition error.
Each dfdl:defineEscapeScheme annotation element contains a dfdl:defineEscapeScheme annotation element as detailed below.
Here is an example of an escapeScheme definition:

```
<xs:schema ...>
  <xs:annotation>
    <xs:appinfo source="http://www.ogf.org/dfdl/">
      <dfdl:defineEscapeScheme name="myEscapeScheme">
        ...
        <dfdl:escapeScheme escapeCharacter='/' />
        ...
      </dfdl:defineEscapeScheme>
    </xs:appinfo>
  </xs:annotation>
...
</xs:schema>
```

A dfdl:defineEscapeScheme serves only to supply a named definition for an escapeScheme for reuse from other places. It does not cause any use of the representation properties it contains to describe any actual data.

7.5.1 Using/Referencing a Named escapeScheme Definition

A named, reusable, escape scheme is used by referring to its name from an escapeSchemeRef property on an element. For example:

```
<xs:element name="foo" type="xs:string" >
  <xs:annotation><xs:appinfo source="http://www.ogf.org/dfdl/">

        <dfdl:element representation="text"
              escapeSchemeRef="myEscapeScheme"/>

  </xs:appinfo></xs:annotation>
</xs:element>
```

7.6 The dfdl:escapeScheme Annotation Element

The escapeScheme annotation is used within a dfdl:defineEscapeScheme annotation to group the properties of an escape scheme and allows a common set of attributes to be defined that can be reused.
An escape scheme defines the properties that describe the text escaping rules in force when data such as text delimiters are present in the data. There are two variants on such schemes,

- The use of a single escape character to cause the next character to be interpreted literally. The escape character itself is escaped by the escape escape character.
- The use of a pair of escape strings to cause the enclosed group of characters to be interpreted literally. The ending escape string is escaped by the escape escape character.

On parsing, the escape scheme is applied after padding characters are trimmed and on unparsing before padding characters are added.
DFDL does not provide a substitution mechanism similar to XML which would replace a character entity such as < with its literal value <.
The syntax of escapeScheme is defined in Section 13.2.1
The dfdl:escapeScheme Properties

7.7 The dfdl:defineVariable Annotation Element

Variables provide a means for communication within a DFDL schema. They are defined as top-level elements in a schema and therefore have global scope. .
A new variable is introduced using dfdl:defineVariable:

```
<dfdl:defineVariable
      name = NCName
      type? = qname
defaultValue? = logical value or dfdl expression
external? = 'false' | 'true' >
<!-- Content: logical value or dfdl expression (default value) -->
</dfdl:defineVariable>
```

The name of a newly defined variable is placed into the target namespace of the schema containing the annotation. Variable names are distinct from format, escape scheme and number format names and so cannot conflict with them. A variable can have any simple type.
The defaultValue is optional. This is a literal value or an expression which evaluates to a constant, and it can be specified as an attribute or as the element value. The expression must not contain forward references to elements which have not yet been processed nor to the current component. If specified the default value must match the type of the variable (otherwise it is a schema definition error).
Note that the syntax supports both a dfdl:defaultValue attribute and the 'defaultValue' being specified by the element value. Only one or the other may be present. (Schema definition error otherwise.)
Note the value of the name attribute is an NCName. The name of a variable is defined in the target namespace of the schema containing the definition. If multiple dfdl:defineVariable definitions have the same 'name' attribute in the same namespace then it is a schema definition error.
The scope of a variable *name* covers the entire schema in which it is defined. A default *instance* of the variable is created (with global scope) at the point of definition. Further instances of the variable may subsequently be created on schema elements. If the variable has a default value, this will used as the default value for any *instances* of the variable (unless overridden when the instance is created).
The **external** attribute is optional. If not specified it takes the default value 'false'. If true the value may be provided by the DFDL processor and this external value will be used as the global default

value (overriding any dfdl:defaultValue specified on the dfdl:defineVariable). The mechanism by which the processor provides this value is unspecified and implementation specific.
There is no required order between dfdl:defineVariable and other schema level annotations that may refer to the variable. For example, dfdl:defineFormat.

7.7.1 Examples

```
<dfdl:defineVariable name="EDIFACT_DS" type="xs:string"
                     defaultValue="," />

<dfdl:defineVariable name="codepage" type="xs:string"
                     external=”true”>utf-8</dfdl:defineVariable>
```

7.7.2 Predefined Variables

The following variables are predefined

Name	*Namespace URI*	*Type*	*Default value*	*External*
encoding	http://www.ogf.org/dfdl/dfdl-1.0/	xs:string	'UTF-8'	true
byteOrder	http://www.ogf.org/dfdl/dfdl-1.0/	xs:string	'bigEndian’	true
binaryFloatRep	http://www.ogf.org/dfdl/dfdl-1.0/	xs:string	'ieee’	true
outputNewLine	http://www.ogf.org/dfdl/dfdl-1.0/	xs:string	'%LF;'	true

Table 11 Pre-defined variables

These variables are expected to be commonly set externally so are predefined for convenience.

```
      <xs:element name=”title” type=”xs:string”>
        <xs:annotation>
          <xs:appinfo source=”http://www.ogf.org/dfdl/”>
            <dfdl:element encoding="{$dfdl:encoding}" />
          </xs:appinfo>
        </xs:annotation>
      </xs:element>
```

7.8 The dfdl:newVariableInstance Annotation Element

Scoped instances of defined variables are created using dfdl:newVariableInstance:

```
<dfdl:newVariableInstance
      ref = qname
defaultValue? = logical value or dfdl expression
<!-- Content: logical value or dfdl expression (value) -->
</dfdl:newVariableInstance>
```

Since an initial instance is created when the variable is defined, the use of dfdl:newVariableInstance is optional. It would be used if an instance with restricted scope is required.
The dfdl:newVariableInstance annotation can be used on any element, element reference, group reference, sequence or choice.
The scope of the instance of variable *name* is the *dynamic scope* of the schema component and its contents and so is inherited by any contained constructs or construct references.
The **ref** attribute is a QName. That is, it may be qualified with a namespace prefix.
An optional dfdl:**defaultValue** *for the instance* may be specified. It can be specified as an attribute or as the element value. The expression must not contain forward references to elements which have not yet been processed nor to the current component. If specified the default value must match the type of the variable as specified by dfdl:defineVariable. If the instance is not assigned a new

default value then it will inherit the default value specified by dfdl:defineVariable or externally provided by the DFDL processor. If a default value is not specified (and has not been specified by dfdl:defineVariable) then the value of this instance is undefined until explicitly set (using dfdl:setVariable).
If a default value is specified this initial value of the instance will be set when the instance is created. The value will override any (global) default value which was specified by dfdl:defineVariable or which was provided externally to the DFDL processor. A variable instance with a valid value (specified or default) can be referenced anywhere within the scope of the element on which the instance was created.
Note that the syntax supports both a dfdl:defaultValue attribute and the 'defaultValue' being specified by the element value. Only one or the other may be present. (Schema definition error otherwise.)
It is a schema definition error to have more than one newVariableInstances for the same variable at any given point in the document.
There is no short form syntax for creating variable instances.

7.8.1 Examples

```
<dfdl:newVariableInstance ref="EDIFACT_DS" defaultValue=","/>

<dfdl:newVariableInstance ref="lengthUnitBits">
    { if dfdl:property("lengthUnits")eq "bits" then 1 else 8 }
</dfdl:newVariableInstance>
```

7.9 The dfdl:setVariable Annotation Element

Variable instances get their values either by default, by assignment when instantiated or by subsequent assignment using the dfdl:setVariable annotation.

```
<dfdl:setVariable
      ref = qname
      value? = logical value or dfdl expression
<!-- Content: logical value or dfdl expression (value) -->
</dfdl:setVariable>
```

The dfdl:setVariable annotation can be used on an element, simpleType, element reference, group reference, sequence or choice.

The **ref** attribute is a QName. That is, it may be qualified with a namespace prefix.
The syntax supports both a dfdl:value attribute and the 'value' being specified by the element value. Only one or the other may be present. (Schema definition error otherwise.)
The value must match the type of the variable as specified by dfdl:defineVariable.
A dfdl:setVariable value expression may refer to the value of this element using a relative path value "." . Use of relative path expressions is recommended wherever possible as this will allow the behavior of the parser to be more effectively scoped. However this practice is not enforced and there may be situations in which use of an absolute path is in fact required.
The declaration of a variable must be in scope at the point of the assignment, and at the point of reference.
In normal processing, the value of an instance can only be set once using dfdl:setVariable. Attempting to set the value of the variable instance for a second time is a schema definition error. In addition, if a reference to the variable's value has already occurred and returned a default value, then no assignment (even a first one) can occur. An exception to this behavior occurs whenever the DFDL processor backtracks because it is processing multiple arms of a choice or as a result of speculative parsing. In this case the variable state is also rewound.

A dfdl:setVariable will override any default value specified on either dfdl:defineVariable or dfdl:newVariableInstance, or externally.
It is a schema definition error to have more than one dfdl:setVariable for the same variable at any given point in the document.
There is no short form syntax for variable assignment.

7.9.1 Examples

```
<xs:element name="ds" type="xs:string">
   <xs:annotation>< xs:appinfo source=”http://www.ogf.org/dfdl/”>
      <dfdl:setVariable ref="EDI:EDIFACT_DS" value="{.}" />
      <dfdl:setVariable ref="delta"> {.} </dfdl:setVariable>
   </xs:appinfo></xs:annotation>
</xs:element>
```

In the above example, the element named "ds" contains the string to be used as the EDI:EDIFACT_DS delimiter at other places in the data, so the above defines the value of the EDI:EDIFACT_DS variable to take on the value of this element.

8. Property Scoping Rules

This section describes the rules that govern the scope over which DFDL representation properties apply
The scope of the representational properties on each of the component format annotations is give in **Table 12 DFDL annotation scoping**

Annotation Point	*Property Scope*
Schema declaration	dfdl:format representation properties apply *lexically* over all components in the schema
Element declaration	dfdl:element properties apply locally
Element reference	dfdl:element properties apply locally
Simple type definition	dfdl:simpleType properties apply locally
Sequence	dfdl:sequence properties apply locally
Choice	dfdl:choice properties apply locally
Group reference	dfdl:group properties apply locally

Table 12 DFDL annotation scoping

Note: This table lists DFDL annotations on schema components. DFDL annotations can also be placed on other DFDL annotations, such as a dfdl:format on a dfdl:defineFormat, to provide a named reusable resource. In this case the annotation applies only where the named format is referenced.
DFDL representation properties explicitly defined on annotations, other than a dfdl:format on an xs:schema declaration, apply locally to that component only. The explicitly defined properties are the combination of any defined locally on the annotation and any defined on the dfdl:defineFormat annotation referenced by a local dfdl:ref property. When a property is defined both locally and on the dfdl:defineFormat, the locally defined property takes precedence.
The dfdl:format annotation on the top level xs:schema declaration provides defaults for the DFDL representation properties at every DFDL-annotatable component contained in the schema document. They do not apply to any components in any included or imported schema document (these may have their own defaults).

8.1 Providing Defaults for DFDL properties

A dfdl:format annotation on the top level xs:schema declaration may provide defaults for some or all the DFDL representation properties at every annotation point within the schema document. The default properties may be specified in short, attribute or element form.
The dfdl:ref property is not a representation property so no default can be set.
The dfdl:escapeSchemeRef property provides a default reference to a dfdl:defineEscapeScheme, the properties of dfdl:escapeScheme are not defaulted individually.
DFDL representation properties defined explicitly on a component apply only to that component and override the default value of that property provided by an xs:schema dfdl:format annotation. The example below demonstrates the overriding of a format encoding property. The `'ASCII'` dfdl:format encoding is the default value for the `title` element, but then it is overridden by the locally defined `utf-8` format encoding, which takes precedence.

```
<xs:schema>
      <xs:annotation>
        <xs:appinfo source="http://www.ogf.org/dfdl/">
          <dfdl:format encoding="ASCII" />
        </xs:appinfo>
      </xs:annotation>

<xs:element name="book">
  <xs:complexType>
```

```
    <xs:sequence>
      <xs:element name=”title” type=”xs:string”>
        <xs:annotation>
          <xs:appinfo source=”http://www.ogf.org/dfdl/”>
            <dfdl:element encoding="utf-8" />
          </xs:appinfo>
        </xs:annotation>
      </xs:element>
      <xs:element name=”pages” type=”xs:int”/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
</xs:schema>
```

8.2 Combining DFDL Representation Properties from a dfdl:defineFormat

The DFDL representation properties contained in a referenced dfdl:defineFormat are combined with any DFDL representation properties defined locally on a construct as if they had been defined locally. If the same property is defined locally in and in the referenced dfdl:defineFormat then the local property takes precedence. The combined set of explicit DFDL properties has precedence over any defaults set by a dfdl:format on the xs:schema.

```
<xs:schema>
      <xs:annotation>
        <xs:appinfo source=”http://www.ogf.org/dfdl/”>
          <dfdl:defineFormat name='myFormat'>
            <dfdl:format encoding="ASCII" />
          </dfdl:defineFormat>
        </xs:appinfo>
      </xs:annotation>

<xs:element name=”book”>
  <xs:complexType>
    <xs:sequence>
      <xs:element name=”title” type=”xs:string”>
        <xs:annotation>
          <xs:appinfo source=”http://www.ogf.org/dfdl/”>
            <dfdl:element ref='myFormat' encoding="UTF-8" />
          </xs:appinfo>
        </xs:annotation>
      </xs:element>
      <xs:element name=”pages” type=”xs:int”/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
</xs:schema>
```

The example above demonstrates the overriding of an encoding property. The 'ASCII' format encoding from the 'myFormat' is overridden by the UTF-8 format encoding, which as a locally defined property takes precedence.

8.3 Combining DFDL Properties from References

The DFDL properties from the following types of reference are combined using the rules below:

- An xs:element and its referenced xs:simpleType restriction,
- An xs:element reference and its referenced global xs:element
- An xs:group reference and an xs:sequence or xs:choice in its referenced global xs:group

- An xs:simpleType restriction and its base xs:simpleType restriction

Rules

1. Create an empty working set of "explicit" properties. Create an empty working set of "default" properties.
2. Move to the innermost schema component in the chain of references.
3. a) Assemble its applicable "explicit" properties from its local dfdl:ref (if present) and its local properties (if present), the latter overriding the former (that is, local wins).

   Combine these with the current working set of "explicit" properties.
   It is a schema definition error if there is the same property appears twice.
   The result is a new working set of "explicit" properties

   b) Obtain applicable "default" properties from dfdl:format annotation on the xs:schema that contains the component (if present). Combine these with the current working set of "default" properties, the latter overriding the former (that is, inner wins). Result is a new working set of "default" properties.
4. Move to the schema component that references the current component, and repeat step 3. If there is no referencing component, move to step 5.
5. Combine the resultant sets of properties. The "explicit" properties take priority, "defaults" only used when no "explicit" is present. It is a schema definition error if a required property is in neither the "explicit" nor the "default" working sets.

"Applicable" properties are all the DFDL properties that apply to that type of schema component. For example all the DFDL properties that apply to an xs:simpleType.

```
<xs:simpleType name="newType">
      <xs:annotation>
            < xs:appinfo source=”http://www.ogf.org/dfdl/”>
                  <dfdl:simpleType alignment="16"/>
            </xs:appinfo>
      </xs:annotation>
      <xs:restriction base="xs:integer">
            <xs:maxInclusive value="10"/>
      </xs:restriction>
</xs:simpleType>

<xs:element name="testElement1" type="newType">
     <xs:annotation>
            < xs:appinfo source=”http://www.ogf.org/dfdl/”>
                  <dfdl:element representation="binary"/>
          </xs:appinfo>
       </xs:annotation>
</xs:element>
```

The locally defined dfdl:alignment property with value '16' from the xs:simpleType 'newType' is combined with the locally defined dfdl:representation property with value 'binary' and applied to element 'testElement1',

```
<xs:simpleType name="otherNewType">
      <xs:annotation>
            <xs:appinfo source=”http://www.ogf.org/dfdl/”>
                  <dfdl:simpleType alignment="64"/>
            </xs:appinfo>
```

```
      </xs:annotation>
      <xs:restriction base="newType">
            <xs:maxInclusive value="5"/>
      </xs:restriction>
</xs:simpleType>

<xs:simpleType name="newType">
      <xs:annotation>
            <xs:appinfo source="http://www.ogf.org/dfdl/">
                  <dfdl:simpleType representation='binary'/>
            </xs:appinfo>
      </xs:annotation>
      <xs:restriction base="xs:int">
            <xs:maxInclusive value="10"/>
      </xs:restriction>
</xs:simpleType>
```

The locally defined dfdl:representation property with value 'binary' is combined with the locally defined dfdl:alignment property with value '64' from the xs:simpleType restriction 'otherNewType'

```
<xs:sequence>
  <xs:element ref="testElement1">
     <xs:annotation>
            <xs:appinfo source="http://www.ogf.org/dfdl/">
                  <dfdl:element
                      binaryNumberRep ="binary"/>
          </xs:appinfo>
       </xs:annotation>
  </xs:element>
</xs:sequence>


<xs:element name="testElement1" type="newType">
     <xs:annotation>
            <xs:appinfo source="http://www.ogf.org/dfdl/">
                  <dfdl:element representation="binary"/>
          </xs:appinfo>
       </xs:annotation>
</xs:element>

<xs:simpleType name="newType">
      <xs:annotation>
            <xs:appinfo source="http://www.ogf.org/dfdl/">
                  <dfdl:simpleType alignment="16"/>
            </xs:appinfo>
      </xs:annotation>
      <xs:restriction base="xs:int">
            <xs:maxInclusive value="10"/>
      </xs:restriction>
</xs:simpleType>
```

The locally defined dfdl:alignment property with value '16' from the xs:simpleType 'newType' is combined with the locally defined dfdl:representation property with value 'binary' and locally defined dfdl:binaryNumberRep with a value of 'binary'

```
<!-- SCHEMA1 -->
<xs:schema targetNamespace="" xmlns:tns1="http://tns1">

      <xs:annotation>
        <xs:appinfo source="http://www.ogf.org/dfdl/">
          <dfdl:format encoding="ASCII" byteOrder="littleEndian"
                inputValueCalc="" outputValueCalc=""
                initiator="" terminator=""
                sequenceKind="ordered"  />
        </xs:appinfo>
      </xs:annotation>
<xsd:import namespace="http://tns2" schemaLocation="SCHEMA2.xsd"/>


  <xs:element name="book">
    <xs:complexType>
      <xs:group ref="tns2:ggrp1" dfdl:separator=","></xs:group>
    </xs:complexType>
  </xs:element>
</xs:schema>
```

```
<!-- SCHEMA2 -->
<xs:schema targetNamespace="" xmlns:tns2="http://tns2">
   <xs:annotation>
      <xs:appinfo source="http://www.ogf.org/dfdl/">
          <dfdl:format encoding="UTF-8" byteOrder="littleEndian"
                inputValueCalc="" outputValueCalc=""
                initiator=""
                sequenceKind="ordered"  />
      </xs:appinfo>
   </xs:annotation>

 <xs:group name="ggrp1" >
    <xs:sequence dfdl:separatorPosition="infix" >
         <xs:element name="customer" type="xs:string"
              dfdl:length="8" dfdl:lengthKind="explicit"
              />
      </xs:sequence>
   </xs:group>
</xs:schema>
```

The DFDL properties applied to the xs:sequence in xs:group "ggrp1" in SCHEMA2 when referenced from the group reference in SCHEMA1 are

1. dfdl:separator="," from the group reference in SCHEMA1
2. dfdl:separatorPosition="infix" from the group declaration in SCHEMA2
3. dfdl:encoding="UTF-8", dfdl:inputValueCalc="", dfdl:outputValueCalc="" , dfdl:initiator="" from the default dfdl:format annotation in SCHEMA2

4. dfdl:terminator ="" from the default dfdl:format annotation in SCHEMA1

9. DFDL Processing Introduction

A *DFDL Parser* is an application or code library that can take as input:

- A DFDL schema
- A data stream.

It is able to use the DFDL description to interpret the data stream and realize the DFDL Information Model. This information set could then be written out (for example it could be realized as an XML text string) or it could be accessed by an application through an API (for example, a DOM-like tree could be created in memory for access by applications).

Symmetrically, there is a notion of a *DFDL Unparser.* The unparser works from an instance of the DFDL Information Model, a DFDL annotated schema and writes out to a target data stream in the appropriate representation formats.
Often both parser and unparser would be implemented in the same body of software and so we do not always distinguish them. Collectively they are called the DFDL *Processor*. The parser and unparser may, of course, be different bodies of software. Conforming DFDL processors may optionally implement an unparser.

9.1 Parser Overview

The DFDL logical parser is a recursive-descent parser [RDP] having guided, but potentially unbounded look ahead that is used to resolve points of *uncertainty*. (See 9.1.1 Resolving Points of Uncertainty.). A DFDL parser reads a specification (the DFDL schema) and it recursively walks down and up the schema as it processes the data. This is done in a manner consistent with the scoping of properties and variables described in Section 8 Property Scoping Rules.
The unbounded look ahead means that there are situations where the parser must speculatively attempt to parse data where the occurrence of a processing error causes the parser to suppress the error, back out and make another attempt.
Implementations of DFDL may provide control mechanisms for limiting the speculative search behavior of DFDL parsers. The nature of these mechanisms is beyond the scope of the DFDL specification which defines the behavior of conforming parsers only on correct data. That is, data that can be parsed without any effective processing errors.
The logical parser recursively descends the DFDL schema beginning with the element declaration specified (in an implementation specific manner, see Section 18) of the *distinguished root node* of the schema passed to the DFDL processor. Depending on the kind of schema construct encountered and the DFDL annotations on it, and the pre-existing context, the parser performs specific parsing operations on the data stream. These parsing operations typically recognize and consume data from the stream and construct values in the logical model. For values of complex types and for arrays, these logical model values may incorporate values created by recursive parsing.
DFDL Implementations are free to use whatever techniques for parsing they wish so long as the semantics are equivalent to that of the speculative recursive-descent logical parser described in this specification. It is required that implementations distinguish the various kinds of errors (schema definition error, processing error, etc.) no matter what time they are detected. Some implementations may not detect certain schema definition errors until data are being parsed; however, they must still distinguish schema definition errors (which indicate that the schema itself is not meaningful), from parsing errors (which indicate that the input data doesn't satisfy the requirements of the schema), or unparsing errors (which indicate that the infoset does not satisfy the requirements of the schema).

9.1.1 Resolving Points of Uncertainty.

A point of uncertainty occurs in the data stream when there is more than one schema component that might occur at that point. Points of uncertainty can be nested.
A point of uncertainty is caused when one of the following constructs is used in a DFDL schema

1. An xs:choice
2. An unordered xs:sequence (dfdl:sequenceKind='unordered')
3. An xs:element which is optional (xs:minOccurs = 0, xs:maxOccurs=1)
4. An xs:element is an array with a variable number of occurrences (xs:minOccurs not equal to xs:maxOccurs, and xs:maxOccurs > 1)
5. An xs:sequence containing one or more floating elements.

An xs:choice point of uncertainty is resolved by parsing each choice branch in schema definition order until one is known to exist. It is a processing error if none of the choice branches are known to exist.

An unordered xs:sequence point of uncertainty is resolved by parsing for the child components of the sequence in schema definition order at each point in the data stream where a component can exist until the required number of each child components is known to exist or the sequence is terminated by delimiters or specified length.

An optional element point of uncertainty is resolved by parsing the element until it is either known to exist or known not to exist.

For an array element with a variable number of occurrences. the point of uncertainty is resolved for each occurrence separately. The array is known to exist if one of its occurrences exists.

A sequence with a floating child element point of uncertainty is resolved by parsing for the expected ordered component at that point in the data stream. If the expected component is known not to exist then an instance of each floating component is parsed in schema definition order.

A component is known to exist when

1. All the syntax and content (initiator if defined, content and terminator if defined) of the component are successfully parsed and any dfdl:assert if defined evaluates to true.
2. A dfdl:discriminator on the component evaluates to true.
3. A xs:sequence or xs:choice with dfdl:initiatedContent 'yes' and initiator for the component is found

A component known not to exist when

1. A dfdl:assert on the component evaluates to false or a processing error occurs while evaluating the expression.
2. A dfdl:discriminator on the component evaluates to false or a processing error occurs while evaluating the expression.
3. An xs:sequence or xs:choice with dfdl:initiatedContent 'yes' and initiator is not found.
4. A processing error occurs when parsing the component. Processing errors include, but are not limited to, failure to convert the data to the built-in logical type. Validation errors do not cause a component to be known not to exist.

DFDL discriminators are described in section: 7.4 The dfdl:discriminator Annotation Element

9.2 DFDL Data Syntax Grammar

Data in a format describable via a DFDL schema obeys the grammar given here. A given DFDL schema is read by the DFDL processor to provide specific meaning to the terminals and decisions in this grammar.
The bits of the data are divided into two broad categories:
1 Content
2 Framing

The content is the bits of data that are interpreted to compute a logical value.
Framing is the term we use to describe the delimiters, length fields, and other parts of the data stream which are present, and may be necessary to determine the length or position of the content of DFDL Infoset items.
Note that sometimes the framing is not strictly necessary for parsing, but adds useful redundancy to the data format, allowing corrupt data to be more robustly detected, and sometimes the framing adds human readability to the data format.
In our grammar tables below primitive content is in italic font. The primitive content is one subset of the grammar's terminal symbols. The terminal symbols that are framing are shown in bold italic font.

Productions
Document = Element
Element = SimpleElement | ComplexElement SimpleElement = ElementLeftFraming SimpleContent RightFraming ComplexElement = ElementLeftFraming ComplexContent RightFraming ElementLeftFraming = LeftFraming PrefixLength PrefixLength = SimpleContent
LeftFraming = LeadingAlignment ***Initiator*** RightFraming = ***Terminator*** TrailingAlignment LeadingAlignment = ***LeadingSkip AlignmentFill*** TrailingAlignment = ***TrailingSkip***
SimpleContent = ***LeftPadding SimpleRepresentation RightPadOrFill*** ComplexContent = Sequence | Choice
Sequence = LeftFraming SequenceContent RightFraming SequenceContent = [***PrefixSeparator*** SequenceItem [***Separator*** SequenceItem]* ***PostfixSeparator***] ***FinalUnusedRegion*** SequenceItem = Element | Array | ComplexContent
Choice = LeftFraming ChoiceContent RightFraming ChoiceContent = [Element | Array | ComplexContent] ***FinalUnusedRegion***
Array = [Element [***Separator*** Element]* [***Separator*** StopValue]] StopValue = SimpleElement

Table 13 DFDL Grammar Productions

10. Core Representation Properties and their Format Semantics

The next sections specify the core set of DFDL v1.0 properties that may be used in DFDL annotations in DFDL Schemas to describe data formats.
It is a schema definition error when a DFDL schema does *not* contain a definition for a representation property that is needed to interpret the data. For example, a DFDL schema containing any textual data must provide a definition of the character set 'encoding' property for that textual data, and if it is not part of the format properties context for that data, then it is a schema definition error.
Furthermore, no default values are provided for representation properties as built-in definitions by any DFDL processor. This requires DFDL schemas to be explicit about the representation properties of the data they describe, and avoids any possibility of DFDL schemas that are meaningful for some DFDL processors but not others.
The properties are organized as follows:

- Common to both Content and Framing (see 11)
- Common Framing, Position, and Length (see 12)
- Simple Type Content (see 13)
- Sequence Groups (see 14)
- Choice Groups (see 15)
- Arrays and optional elements (see 16)
- Calculated Values (see 17)

Where properties are specific to a physical representation, the property name may choose to reflect this. Where properties are related to a specific logical type grouping (defined below), the property name may choose to reflect this.

A limited number of properties can take a DFDL expression which must return a value of the type required for the property. Those properties that take an expression explicitly state in the description. Other properties do not take an expression.

The property description defines which schema component that the property may be specified on. In addition all the DFDL properties may be specified on a dfdl:format annotation.

11. Properties Common to both Content and Framing

Property Name	Description
byteOrder	Enum or DFDL Expression Valid values ‘bigEndian’, ‘littleEndian’. This property can be computed by way of an expression which returns the string 'bigEndian' or 'littleEndian'. The expression must not contain forward references to elements which have not yet been processed. Note that there is, intentionally, no such thing as 'native' endian[5]. This also applies to character data for multi-byte character sets when the encoding is not specific. E.g., UTF-16 and UTF-32. Note that when the character set encoding is specific about the byte order (e.g., UTF-16BE), then the byteOrder property is ignored when processing text/strings having that encoding. Note: The Unicode byte order mark is treated as a normal character and does not affect encoding. Annotation: dfdl:element, dfdl:simpleType, dfdl:sequence, dfdl:choice, dfdl:group
encoding	Enum or DFDL Expression Values are IANA charsets or CCSID[6]s. This property can be computed by way of an expression which returns the appropriate string. The expression must not contain forward references to elements which have not yet been processed. Note that there is, deliberately, no concept of 'native' encoding[7]. Conforming DFDL v1.0 processors must accept at least 'UTF-8'', 'UTF-16', 'UTF-16BE', 'UTF-16LE', 'ASCII', and 'ISO-8859-1' as encoding names. Encoding names are case-insensitive, so 'utf-8' and 'UTF-8' are equivalent. The 'UTF-16' encoding requires that dfdl:byteOrder is defined. Annotation: dfdl:element, dfdl:simpleType, dfdl:sequence, dfdl:choice, dfdl:group
utf16Width	Enum Valid values are 'fixed', variable'. Applies only when encoding is 'UTF-16', 'UTF-16BE', UTF16-LE' or their CCSID equivalents. Specifies whether the encoding 'UTF-16' should be treated as a fixed or

[5] The concept of native-endian is avoided in DFDL since a DFDL schema containing such a property binding does not contain a complete description of data, but rather an incomplete one which is parameterized by characteristics of the machine and implementation where the DFDL processor is executed. In DFDL this same behavior is achieved using variables or, for example, by use of external setting of pre-defined variables to set dfdl:byteOrder.

[6] CCSID stands for Coded Character Set ID, a decimal number representation for a codepage specifier..[CCSID].

[7] The concept of native character encoding is avoided in DFDL since a DFDL schema containing such a property binding does not contain a complete description of data, but rather an incomplete one which is parameterized by characteristics of the operating environment where the DFDL processor executes. In DFDL this same behavior is achieved through use of true parameterization using variables or, for example, by use of external setting of pre-defined variables to set dfdl:encoding.

	variable width encoding. 'UTF-16' is a variable width encoding and 'UCS-2' is the fixed width subset. However it is common for users to specify 'UTF-16' when they mean when they should be specifying 'UCS-2' This property effectively converts 'UTF-16' to 'UCS-2'. Annotation: dfdl:element, dfdl:simpleType, dfdl:sequence, dfdl:choice, dfdl:group
ignoreCase	Enum Valid values are 'yes', 'no'. Whether mixed case data is accepted when matching delimiters and data values, such as dfdl:textBooleanTrue, on input. On unparsing always use the delimiters or value as specified. Annotation: dfdl:element, dfdl:simpleType, dfdl:sequence, dfdl:choice, dfdl:group

12. Framing

Several properties are common across the various framing styles or are used to distinguish them. Generally these have to do with position and length for text, bit fields, or opaque data.

12.1 Aligned Data

Alignment properties control the leading alignment and trailing alignment regions.
The following properties are used to define alignment rules.

Property Name	*Description*
alignment	Non-negative Integer or 'implicit' A non-negative number that gives the alignment required for the beginning of the item. If alignment is required then the size of the ***AlignmentFill*** grammar region will be non-zero if the item must be aligned to a boundary. The alignment of a child component must be less than or equal the alignment of its parent element, sequence or choice. 'implicit' specifies that the natural alignment for the representation type is used. See the table of implicit alignments Table 14 Implicit Alignment in bits for simple elements. The 'implicit' alignment of complex elements and groups is the alignment of its child with the greatest alignment. If alignment is 'implicit' then alignmentUnits is ignored. Annotation: dfdl:element, dfdl:simpleType, dfdl:sequence, dfdl:choice, dfdl:group
alignmentUnits	Enum Valid values are 'bits' or 'bytes' Scales the alignment so alignment can be specified in either units of bits or units of bytes. Only used when dfdl:alignment not 'implicit' Annotation: dfdl:element, dfdl:simpleType, dfdl:sequence, dfdl:choice, dfdl:group
fillByte	DFDL String Literal A single byte specified as a DFDL byte value entity or a single character. If a character is specified, it must be a single-byte character in the applicable encoding. Used on unparsing to fill empty space such as between two aligned elements. Used to fill these regions specified in the grammar: **RightPadOrFill, FinalUnusedRegion, LeadingSkip, AlignmentFill, and TrailingSkip.** Annotation: dfdl:element, dfdl:simpleType, dfdl:sequence, dfdl:choice, dfdl:group
leadingSkip	Non-negative Integer A non-negative number of bytes or bits, depending on dfdl:alignmentUnits, to skip before alignment is applied. Gives the size of the grammar region having the same name. Annotation: dfdl:element, dfdl:simpleType, dfdl:sequence, dfdl:choice, dfdl:group
trailingSkip	Non-negative Integer A non-negative number of bytes or bits, depending on dfdl:alignmentUnits, to skip after the element, but before considering the alignment of the next

	element. Gives the size of the grammar region having the same name. If dfdl:trailingSkip is specified when dfdl:lengthKind is 'delimited' or 'endOfParent' then a dfdl:terminator must be specified. Annotation: dfdl:element, dfdl:simpleType, dfdl:sequence, dfdl:choice, dfdl:group

There are two properties which control the data alignment by controlling the length of the Alignment Fill Region

- alignment - an integer 1 or greater
- alignmentUnits - bits or bytes

An element's representation is aligned to N units if P is the first position in the representation and P mod N = 1. When parsing, the position of the first unit of the data stream is 1.

For example, if alignment=4, and alignmentUnits='bytes', then the element's representation must begin at 1 or 1 plus a multiple of a 4 bytes. I.e., 1, 5, 9, 13, 17 and so on.

The length of the alignment fill region is measured in bits. If alignmentUnits is 'bytes' then we multiply the alignment value by 8 to get the *bit alignment*, B. If the current position (first position after the end of the previous element) value is bit position N, then the length of the alignment fill region is the smallest non-negative integer L such that (L + N) mod B = 1. The position of the first bit of the aligned element is P = L + N.

To avoid ambiguity when parsing, optional elements and variable-occurrence arrays where the minimum number of occurrences is zero cannot have alignment properties different from the items that follow them. It is a schema definition error otherwise. This avoids the possibility that the following item is incorrectly parsed as if it were a valid optional element or variable-occurrence array element.
The leading skip and trailing skip regions length are controlled by two properties of corresponding names and the dfdl:alignmentUnits property..

12.1.1 Implicit Alignment

When dfdl:alignment is 'implicit' the following alignment values are applied for each logical type.

	Representation		
	text	*binary*	
String	8	Not applicable	
Float	8	32	
Double	8	64	
Decimal, Integer, nonNegativeInteger	8	packed/bcd :8	binary: 8
Long, UnsignedLong	8	packed/bcd : 8	binary: 64
Int, UnsignedInt	8	packed/bcd : 8	binary: 32
Short, UnsignedShort	8	packed/bcd : 8	binary: 16
Byte, UnsignedByte	8	packed/bcd : 8	binary: 8
DateTime	8	packed/bcd: 8	binarySeconds: 32, binaryMilliseconds:64
Date	8	packed/bcd : 8	binarySeconds: 32, binaryMilliseconds:64
Time	8	packed/bcd : 8	binarySeconds: 32, binaryMilliseconds:64
Boolean	8	32	

HexBinary	Not applicable	8

Table 14 Implicit Alignment in bits

Note: Specifying the implicit alignment in bits does not imply that dfdl:lengthUnits 'bits' can be specified for all simple types.

12.2 Properties for Specifying Delimiters

The following properties apply to all elements (and sequence and choice groups as shown later) that use text delimiters to delimit, that is, to initiate and/or terminate data. Delimiters can apply to binary data; however it is often called 'text' delimiters because it is much more commonly used for textual data formats.

Property Name	Description
initiator	List of DFDL String Literals or DFDL Expression Specifies a whitespace separated list of alternative literal strings one of which marks the beginning of the element or group of elements. This property can be computed by way of an expression which returns a string containing a whitespace separated list of DFDL String Literals. The expression must not contain forward references to elements which have not yet been processed. The ***Initiator*** region contains one of the initiator strings defined by dfdl:initiator. When an initiator is specified, it is a processing error if the component is required and if one of the values is not found. If dfdl:initiator is "" (the empty string), then the initiator region is of length zero, and no initiator is expected. On unparsing the first initiator in the list is automatically inserted into the ***Initiator*** region. If dfdl:ignoreCase is 'yes' then the case of the string is ignored by the parser. Annotation: dfdl:element, dfdl:simpleType, dfdl:sequence, dfdl:choice, dfdl:group

terminator	List of DFDL String Literals or DFDL Expression Specifies a whitespace separated list of alternative text strings that one of which marks the end of an element or group of elements. The strings MUST be searched for in the longest first order. This property can be computed by way of an expression which returns a string of whitespace separated list of values. The expression must not contain forward references to elements which have not yet been processed. The *Terminator* region contains the terminator string. If dfdl:terminator is "" (the empty string), then the terminator region is of length zero, and no terminator is expected. When a terminator is expected it is a processing error if one of the values is not found. However, if dfdl:documentFinalTerminatorCanBeMissing is specified then it is not an error if the last terminator in the data stream is not found. On unparsing the first terminator in the list is automatically inserted in the ***Terminator*** region. If dfdl:ignoreCase is 'yes' then the case of the string is ignored by the parser. Annotation: dfdl:element, dfdl:simpleType, dfdl:sequence, dfdl:choice, dfdl:group

emptyValueDelimiterPolicy	Enum Valid values are 'none', 'initiator', 'terminator' or 'both' Indicates that when an element in the data stream is empty, an initiator (if one is defined), a terminator (if one is defined), both an initiator and a terminator (if defined) or neither must be present. Ignored if both dfdl:initiator and dfdl:terminator are "" (empty string). 'initiator' indicates that, on parsing, if the content region is empty then the dfdl:initiator must be present. It also indicates that on unparsing when the content region is empty that the dfdl:initiator will be output. 'terminator' indicates that, on parsing, if the content region is empty then the dfdl:terminator must be present. It also indicates that on unparsing when the content region is empty the dfdl:terminator will be output. 'both' indicates that, on parsing, if the content region is empty both the dfdl:initiator and dfdl:terminator must be present. On unparsing when the content region is empty the dfdl:initiator followed by the dfdl:terminator will be output. 'none' indicates that if the content region is empty neither the dfdl:initiator or dfdl:terminator must be present. On unparsing when the content region is empty nothing will be output. It is a schema definition error if emptyValueDelimiterPolicy set to 'none' or 'terminator' when the parent xs:sequence has dfdl:initiatedContent 'yes'. Annotation: dfdl:element, dfdl:simpleType
documentFinalTerminatorCanBeMissing	Enum Valid values are 'yes', 'no' When the documentFinalTerminatorCanBeMissing property is true, then when an element is the last element in the data stream, then on parsing, it is not an error if the terminator is not found. For example, if the data are in a file, and the format specifies lines terminated by the newline character (typically LF or CRLF), then if the last line is missing its newline, then this would normally be an error, but if documentFinalTerminatorCanBeMissing is true, then this is not a processing error. On unparsing the terminator is always written out regardless of the state of this property. Annotation: dfdl:format (on xs:schema only)

outputNewLine	DFDL String Literal or DFDL Expression Specifies the character or characters that will be used to replace the %NL; character class entity during unparse It is a schema definition error if any of the characters are not in the set of characters allowed by the DFDL entity %NL; It is a schema definition error if the DFDL entity %NL; is specified This property can be computed by way of an expression which returns DFDL string literal. The expression must not contain forward references to elements which have not yet been processed. Annotation: dfdl:element, dfdl:simpleType, dfdl:sequence, dfdl:choice, dfdl:group

12.3 Properties for Specifying Lengths

These properties are used to determine the representation length of an element and apply to elements of all types (simple and complex).

Property Name	Description
lengthKind	Enum Controls how the representation length of the component is determined. Valid values are: 'explicit', 'delimited', 'prefixed', 'implicit', 'pattern', 'endOfParent' A full description of each enumeration is given in the later sections. 'explicit' means the length of the item is given by the dfdl:length property 'delimited' means the item is delimited by a terminator or separator 'prefixed' means the length of the item is given by an immediately preceding prefix field specified using prefixLengthType. 'implicit means the length is to be determined in terms of the type of the element and its schema-specified properties if any. 'pattern' means the length of the item is given by a regular expression specified using the dfdl:lengthPattern property. 'endOfParent' means that the item is terminated by the termination of the containing construct. Annotation: dfdl:element, dfdl:simpleType
lengthUnits	Enum Valid values 'bytes', 'characters', ''bits'. Specifies the units to be used whenever a length is being used to extract or write data. Applicable when lengthKind is 'explicit', 'implicit' (for xs:string and xs:hexBinary) or 'prefixed'. 'characters' may only be used for simple elements with representation 'text' and complex elements where all the simple child elements must be dfdl:representation 'text', dfdl:lengthUnits 'characters' and the same dfdl:encoding as the parent. 'bits' may only be used for xs:boolean, xs:unsignedByte, xs:unsignedShort, xs:unsignedInt, and xs:unsignedLong simple types with representation 'binary'. Annotation: dfdl:element, dfdl:simpleType

12.3.1 dfdl:lengthKind 'explicit'

When lengthKind='explicit' the length of the item is given by the dfdl:length property, and is measured in units given by dfdl:lengthUnits. Used on parsing and unparsing.

Property Name	Description
length	Non-negative Integer or DFDL Expression. Only used when lengthKind is 'explicit'. Specifies the length of this element in units specified by dfdl:lengthUnits. This property can be computed by way of an expression which returns a non-negative integer. The expression must not contain forward references to elements which have not yet been processed. Annotation: dfdl:element, dfdl:simpleType

When dfdl:lengthKind 'explicit', the method of extracting data that is described in section: 12.3.7 Elements of Specified Length

12.3.2 dfdl:lengthKind 'delimited'

On parsing, the length of an element with dfdl:lengthKind 'delimited' is determined by scanning the datastream for any of

- the element's terminator (if specified)
- an enclosing construct's separator or terminator
- the end of an enclosing element designated by its known length
- the end of the data stream

dfdl:lengthKind 'delimited' may be specified for

- elements of xs:simpleTypes with dfdl:representation 'text'
- elements of number or calendar xs:simpleTypes with representation 'binary' and binaryNumberRep or binaryCalendarRep 'packed' or 'bcd'
- element of xs:complexType.

The rules for resolving ambiguity between delimiters are:

1. When two delimiters have a common prefix, the longest delimiter has precedence.
2. When two delimiters have exactly the same value, the innermost (most deeply nested) delimiter has precedence.
3. When the separator and terminator on a group have the same value, the separator has precedence.

On unparsing the length of an element in the data stream is the representation length of the value, padded to dfdl:textOutputMinLength or xs:minLength if dfdl:textPadKind is 'padChar'

12.3.2.1 Simple Elements of Specified Length within Delimited Constructs

When a simple element has a specified length then delimiter scanning is suspended for the duration of the processing of the specified-length element.
This allows formats to be parsed which are not scanable in that they contain non-character data.

12.3.3 dfdl:lengthKind 'implicit'

When dfdl:lengthKind is 'implicit', the length is determined in terms of the type of the element and its schema-specified properties.

For complex elements, 'implicit' means the length is determined by the combined lengths of the contained children, that is the **ComplexContent** region.

For simple elements the length is fixed and is given in Table 15 Length in bits for simpleTypes when dfdl:lengthKind='implicit' .

	Representation		
	text	*binary*	
String	maxlength	Not applicable	
Float	Not allowed	32	
Double	Not allowed	64	
Decimal, Integer, nonNegativeInteger	Not allowed	packed/bcd : Not allowed	binary: Not allowed
Long, UnsignedLong	Not allowed	packed/bcd : Not allowed	binary: 64
Int, UnsignedInt	Not allowed	packed/bcd : Not allowed	binary: 32
Short, UnsignedShort	Not allowed	packed/bcd : Not allowed	binary: 16
Byte, UnsignedByte	Not allowed	packed/bcd : Not allowed	binary: 8
DateTime	Not allowed	packed/bcd: Not allowed	binarySeconds: 32, binaryMilliseconds:64
Date	Not allowed	packed/bcd : Not allowed	binarySeconds: 32, binaryMilliseconds:64
Time	Not allowed	packed/bcd : Not allowed	binarySeconds: 32, binaryMilliseconds:64
Boolean	Length of longest of textBooleanTrue and textBooleanFalse	32	
HexBinary	Not applicable	maxlength	

Table 15 Length in bits for simpleTypes when dfdl:lengthKind='implicit'

- 'Not Allowed' means that there is no implicit length for the combination of simple type and representation and it is a schema definition error if dfdl:lengthKind='implicit' is specified.
- Packed/bcd means binaryNumberRep is 'packed' or 'bcd'
- Binary means binaryNumberRep is 'binary'
- binarySeconds means binaryCalendarRep is 'binarySeconds'
- binaryMilliseconds means binaryCalendarRep is 'binaryMilliseconds'
- maxLength means xs:maxlength

Note: Specifying the implicit length in bits does not imply that dfdl:lengthUnits 'bits' can be specified for all simple types.

When dfdl:lengthKind is 'implicit', the method of extracting data that is described in section: 12.3.7 Elements of Specified Length

12.3.4 dfdl:lengthKind 'prefixed'

When dfdl:lengthKind is ‘prefixed’ the length of the element is given by the **PrefixLength** region specified using prefixLengthType. The property prefixIncludesPrefixLength also can be used to adjust the length appropriately.

When dfdl:lengthKind is 'prefixed' the method of extracting data that is described in section: 12.3.7 Elements of Specified Length

Property Name	Description
prefixIncludesPrefixLength	Enum Valid values are 'yes', 'no' Whether the length given by a prefix includes the length of the prefix as well as the length of the content region. Used only when lengthKind=’prefix’. Annotation: dfdl:element, dfdl:simpleType
prefixLengthType	QName Name of a simple type derived from xs:integer or any subtype of it. This type, with its DFDL annotations specifies the representation of the length prefix, which is in the **PrefixLength** region. It is a schema definition error if the xs:simpleType specifies dfdl:lengthKind 'delimited' or 'endOfParent' or a dfdl:outputValueCalc Annotation: dfdl:element, dfdl:simpleType

The representation of the element is in two parts.

1. The 'length prefix' is an integer which specifies the length of the element's content. The representation of the length prefix is described by a simple type which is identified using the dfdl:prefixLengthType property.
2. The content of the element.

When parsing, the length of the element’s content is obtained by parsing the simple type specified by dfdl:prefixLengthType to obtain an integer value. Note that all required properties must be present on the specified simple type or defaulted because there is no element declaration to supply any missing required properties.

If the dfdl:prefixIncludesPrefixLength property is 'yes' then the length of the element's content is the value of the length prefix minus the length of the representation of the length prefix.

When unparsing, the length of the element’s content must be determined first. The length of a simple element in the data stream is the representation length of the value, padded to dfdl:textOutputMinLength or xs:minLength if dfdl:textPadKind is 'padChar'. The length of a complex element is the combined length of its children including their initiators, separators and terminators.
Then the value of the prefix length must be calculated using dfdl:prefixIncludesPrefixLength. Then the prefix length can be written to the data stream using the properties on the dfdl:prefixLengthType, and finally the element's content can be written to the data stream.

. Consider this example:

```
<xs:element name="myString" type="xs:string"
```

```
                    dfdl:lengthKind="prefixed"
                    dfdl:prefixIncludesPrefixLength="false"
                    dfdl:prefixLengthType="packed3"/>

<xs:simpleType name="packed3"
            dfdl:representation="binary"
            dfdl:binaryNumberRep ="packed"
            dfdl:lengthKind="explicit"
            dfdl:length="2" >
       <xs:restriction base="integer" />
</xs:simpleType>
```

In the above, the string has a prefix element of type 'packed3' containing 3 packed decimal digits. The property dfdl:prefixIncludesPrefixLength is an enumeration which allows the length computation to be varied to include or exclude the length of the prefix element itself.
The prefix element's value contains the length measured in units given by dfdl:lengthUnits.
When unparsing data, the value of the prefix is computed automatically and inserted into the data before the element.

12.3.5 dfdl:lengthKind 'pattern'

The dfdl:lengthKind ‘pattern’ means the length of the element is given by a regular expression specified using the dfdl:lengthPattern property. The DFDL processor scans the data stream to determine a string value that is the longest match to a regular expression. The pattern is only used on parsing,

Property Name	Description
lengthPattern	DFDL Regular Expression. Only used when lengthKind is ’pattern’. Specifies a regular expression that, on parsing, is executed against the datastream to determine the length of the element. The data stream beginning at the starting offset of the content region of the element is interpreted as a stream of characters in the encoding of the element, and the regular expression contained in the dfdl:lengthPattern property is executed against that stream of characters. When the element is complex this is the dfdl:encoding of the complex element itself. Child content contained within the element must be scannable (see below). Escape schemes are not applied when executing the regular expression. If the regular expression returns a matched length of zero (i.e. no match) then the element has a zero-length representation. If the element is not allowed to have a zero-length representation then the appropriate processing error is reported. Otherwise, normal processing of nils and default values occurs. It is a processing error if conversion of data into a string based on the character set encoding causes an error due to illegal bit patterns that are not legal for the encoding. Annotation: dfdl:element, dfdl:simpleType

On unparsing if the element is complex then the length of the element is the length of its children. If the element is simple then the length is given in Table 16 Unparse lengths (in bits) for dfdl:lengthKind 'pattern'.

	Representation		
	text	***binary***	
String	unpadded length	Not applicable	
Float	unpadded length	32	
Double	unpadded length	64	
Decimal, Integer, nonNegativeInteger	unpadded length	Minimum number of bytes to represent significant digits and sign	
Long, UnsignedLong	unpadded length	packed/bcd : as decimal	binary: 64
Int, UnsignedInt	unpadded length	packed/bcd : as decimal	binary: 32
Short, UnsignedShort	unpadded length	packed/bcd : as decimal	binary: 16
Byte, UnsignedByte	unpadded length	packed/bcd : as decimal	binary: 8
DateTime	unpadded length	packed/bcd : as decimal	binarySeconds: 32, binaryMilliseconds:64
Date	unpadded length	packed/bcd : as decimal	binarySeconds: 32, binaryMilliseconds:64
Time	unpadded length	packed/bcd : as decimal	binarySeconds: 32, binaryMilliseconds:64
Boolean	Length of textBooleanTrue or textBooleanFalse	32	
HexBinary	Not applicable	Length of infoset value	

Table 16 Unparse lengths (in bits) for dfdl:lengthKind 'pattern'

12.3.5.1 Pattern-Based Lengths - Scanability

Any element (complex, simple text, simple binary) may have a dfdl:lengthKind 'pattern' as long as the bytes in the content region of the element are legal in the stated encoding of that element. Where a complex element has children with binary representation in practice this means an 8-bit ASCII encoding.

Binary data can be handled by way of treating it as text with encoding='iso-8859-1'. In this case the text is interpreted as in the iso-8859-1 character encoding, and the correspondence of byte values in the data to a string in the DFDL infoset is one to one. That is, byte with value N, produces an infoset character with character code N.

12.3.6 dfdl:lengthKind 'endOfParent'

The dfdl:lengthKind ‘endOfParent’ means that the element is terminated by the end of the data stream or the end of an enclosing complex element, sequence or choice. The enclosing component must have an identifiable end point, such as a known length, a delimiter, or end of data stream. The enclosing component does not have to be the immediate parent of the element, but there must be no other elements defined between the element specifying 'endOfParent' and the end of the enclosing component.

A dfdl:lengthKind of 'endOfParent' can only be used on simple elements in the following locations:

- When the immediate parent is a sequence, on the final element in the sequence
- When the immediate parent is a choice, on any element that is a branch of the choice
- A global element declaration that is the document root.
- A simple type or global element declaration referenced by one of the above.

It is a schema definition error if the element has a terminator.
It is a schema definition error if the element has dfdl:trailingSkip not equal to 0.
It is a schema definition error if the element has maxOccurs > 1.
It is a schema definition error if any other element is defined between this element and the end of the enclosing component.

The dfdl:lengthKind 'endOfParent' is used when the length of an element is defined by an enclosing element . For example, the parent is a fixed length element then an element with dfdl:lengthKind 'endOfParent' will consume all the remaining data up to the length of the parent. A dfdl:lengthKind 'endOfParent' can also be used to allow the last element to consume the data up to the end of the data stream.
This is distinct from situation where the lengths of the elements of a sequence are known but are not sufficient to fill the fixed length parent. In that case the remaining data are ignored on parsing and filled with dfdl:fillByte on unparsing.

12.3.7 Elements of Specified Length

An element has a specified length when dfdl:lengthKind is 'explicit', 'implicit' or 'prefixed'. The units that the length represents are specified by the dfdl:lengthUnits property, expect when dfdl:lengthKind is 'implicit' and the simpleType is not xs:string or xs:hexBinary.
If dfdl:lengthUnits='bytes' then the value of the length property gives the exact length in bytes.
If dfdl:lengthUnits='characters' then the length in bytes will depend on the encoding of the characters. If the encoding property specifies a fixed-width encoding then the length in bytes is (character width*length). If the encoding property specifies a variable-width encoding then the length in bytes will depend on the actual characters in the element's value. The dfdl:lengthUnits 'characters' may only be used when dfdl:representation is 'text'.
If dfdl:lengthUnits='bits' then the value of the length property gives the exact length in bits. 'Bits' may only be used for a limited set of schema types. See section: 12.3.7.2 Length of Bit Fields

Using specified length, it is possible for an element to have representation length longer than needed to represent just the data. For example, a simple text element may be padded in the ***RightPadOrFill region*** if the data is not long enough.

12.3.7.1 Length of Simple Elements with dfdl:representation 'text'

Textual data is defined to mean either data of type string (independent of representation), or data where the representation property is 'text'.
.

12.3.7.1.1 Character Width

The *width* of a character is the length of its representation in bytes and depends on the dfdl:encoding property.
Character encodings are themselves either intrinsically fixed or variable width, but this is modified by additional properties.

fixed, 1 byte (e.g., ASCII)	*fixed, 2 byte (e.g., UCS-2)*	*fixed, 4 byte (e.g., UTF-32)*	*variable (e.g., Shift_JIS, UTF-8, UTF-16)*
1	2	4	Variable width. Min = 1, Max = encoding dependent, 2

Table 17 Character Widths

We define the term *fixed width encoding* to mean an encoding and associated other representation properties where the value in the bottom row of the above table is a fixed integer. The term *variable width encoding* is the opposite. In a variable width encoding, the characters have a minimum and a maximum length. The maximum depends on the encoding, but is typically either 3 (Shift-JIS), or 4 (UTF-8).

UTF-16, UTF16LE and UTF16BE are a variable width encodings, however when dfdl:utf16Width is 'fixed' they are treated as a 2 byte fixed width encoding.

12.3.7.1.2 Text Length in Characters when Specified in Bytes

If a simple element has dfdl:representation='text' but dfdl:lengthUnits='bytes' then the following rules apply:

- The length of the simple content region is the length in bytes, the length being calculated using the normal rules.
- When parsing, as many characters as possible are extracted from the bytes of the simple content region. Any left over bytes are skipped.
- When unparsing, if the simple content region is larger than the encoded length of the element then the remaining bytes are filled with dfdl:fillByte (This is the grammar ***RightPadOrFill*** region.).

12.3.7.1.3 Byte Order Mark

If a byte-order mark codepoint appears at the start of a UTF-8, UTF-16 or UTF-32 encoded string then the byte-order mark will be included as part of the string payload[8]. That is, for the UTF-8, UTF-16 and UTF-32 character encodings, a byte-order-mark codepoint is treated as a character of the string in DFDL and contributes to the length.
A way of eliminating the byte-order mark so that it does not end up in the infoset is that the byte-order mark can be modeled as a separate element before the string. This BOM element can be either required or optional depending on whether one is expected or optional at the beginning of the string.

[8] Byte-order marks are explicitly stated to be "not characters" in the Unicode standard.

12.3.7.2 Length of Bit Fields

A bit field is an element of integer type where the lengthUnits='bits'.
It is a schema definition error if the length of a bit field is too large for the corresponding integer type, and the length can be statically determined (from the schema only).
It is a runtime schema definition error if the length of a bit field can only be determined dynamically (for example because it is stored in the data), and the resulting length is too large for the integer type.

Definition: Bit position
The data stream is assumed to be a collection of consecutively numbered unsigned bytes. Each byte is a numeric value, and bit position within an individual byte is given by numeric behavior. The bits within each byte are numbered, with the most significant bit having position 1, and the least significant bit having position 8.
This gives every bit in the data stream a specific bit position. Furthermore, the bit position of the least significant bit of byte N is numerically adjacent to the bit position of the most significant bit of byte N+1.

Definition: Bit string
For types xs:boolean, xs:unsignedByte, xs:unsignedShort, xs:unsignedInt, and xs:unsignedLong, it is possible to specify dfdl:lengthUnits='bits', dfdl:lengthKind='explicit', and then provide a dfdl:length expression. This expression must be a literal integer, the value of which is between (inclusively) 1 and 32, 8, 16, 32, and 64 respectively for these types. Such an element is called a bit string for brevity.

If the dfdl:length expression contains a value out of range then it is a schema definition error.
When parsing, if the data stream ends without enough bits to parse a bit string, that is, N bits are required based on the dfdl:length, but only M < N bits are available, then it is a processing error. (Note: This is not specific to bit strings. Any binary type whose length cannot be satisfied from the data will cause a processing error.

Bit strings, Alignment, and dfdl:fillByte
The dfdl:alignmentUnits='bits', and dfdl:alignment='1' can be used to position a bit string anywhere in the data stream without regard for any other grouping of bits into bytes.
The numeric value of the unsigned integer represented by a bit string is unaffected by alignment.
When unparsing a bit string, alignment may cause the bits of the bit string to occupy only some of the bits within a byte of the data stream. The bits of data in the alignment fill region are unspecified by the elements of the DFDL schema, and are not found in the DFDL infoset. Such unspecified bits are filled in using the value of the dfdl:fillByte property. Corresponding bits from the dfdl:fillByte value are used to fill in unspecified bits of the data stream. That is, if bit K (K will be 1 or greater, but less than or equal to 8) of a data stream byte is unspecified, its value will be taken from bit K of the dfdl:fillByte property value.
Since the value of any bit string element is unaffected by alignment, the logical integer value for a bit-string is always computed as if the first bit were at position 1 of the bit stream. If the dfdl:length for the bit-string evaluates to M, then the bit-string conceptually occupies bits 1 to M of a data stream for purposes of computing its value.
Bits within Bit Strings of Length <= 8
Any time the length in bits is < 8, then when set, the bit at position Z supplies value 2^(M-Z), and the value of the bit string as an integer is the sum of these values for each of its bits.

Bits within Bit Strings of Length > 8
Call M the length of the bit string element in bits. In general, when M > 8 the contribution of a bit in position i to the numeric value of a bit string is given by a formula specific to the dfdl:byteOrder.
For dfdl:byteOrder='bigEndian' the value of bit i is given by 2^(M - i).
For dfdl:byteOrder='littleEndian' the value of bit i is given by a more complex formula. The following pseudo code computes the value of a bit in a littleEndian bit string. It is just a very big

expression, but is spread out over many local variables to illustrate the various sub-calculations clearly. DFDL implementations may use any way of converting bit strings to the corresponding integer values that is consistent with this:
In the pseudo code below:

- '%' is modular division (division where remainder is returned)
- '/' is regular division (quotient is returned)
- the expression 'a ? b : c' means 'if a is true, then the value is b, otherwise the value is c'

```
    littleEndianBitValue(bitPosition, bitStringLength)
        assert bitPosition >= 1;
        assert bitStringLength >= 1;
        assert bitStringLength >= bitPosition;
        numBitsInFinalPartialByte = bitStringLength % 8;
        numBitsInWholeBytes = bitStringLength -
                              numBitsInFinalPartialByte;
        bitPosInByte = ((bitPosition - 1) % 8) + 1;
        widthOfActiveBitsInByte = (bitPosition <= numBitsInWholeBytes)
             ? 8 : numBitsInFinalPartialByte;
        placeValueExponentOfBitInByte = widthOfActiveBitsInByte -
                                        bitPosInByte;
        bitValueInByte = 2^placeValueExponentOfBitInByte;
        byteNumZeroBased = (bitPosition - 1)/8;
        scaleFactorForBytePosition = 2^(8 * byteNumZeroBased);
        bitValue = bitValueInByte * scaleFactorForBytePosition;
        return bitValue;
```

Figure 4 Little Endian bit position and value

Examples

Example: consider the first three bytes of the data stream. Imagine their numeric values as 0x5A 0x92 0x00.

```
Positions:
00000000 01111111 11122222
12345678 90123456 78901234
Bits:
01011010 10010010 00000000
Hex values
   5   A    9   2    0   0
```

Beginning at bit position 1, (the very first bit) if we consider the first two bytes as a bigEndian short, the value will be 0x5A92.

```
  < xs:element name="num" type="unsignedShort"
        dfdl:alignment="1"
        dfdl:alignmentUnits="bytes"
        dfdl:byteOrder="bigEndian"
        dfdl:representation="binary"/>
```

As a littleEndian short, the value will be 0x925A.

```
  < xs:element name="num" type="unsignedShort"
        dfdl:alignment="1"
        dfdl:alignmentUnits="bytes"
        dfdl:byteOrder="littleEndian"
        dfdl:representation="binary"/>
```

Now let us examine a bit string of length 13, beginning at position 2.

```
< xs:sequence>
  < xs:element name="ignored" type="unsignedByte"
        dfdl:alignment="1"
        dfdl:alignmentUnits="bits"
        dfdl:lengthUnits="bits"
        dfdl:length="1"
        dfdl:representation="binary"/>
  < xs:element name="x" type="unsignedShort"
        dfdl:alignment="1"
        dfdl:alignmentUnits="bits"
        dfdl:byteOrder="bigEndian"
        dfdl:lengthUnits="bits"
        dfdl:length="13"
        dfdl:representation="binary"/>
   ...
< /xs:sequence>
```

Let's examine the same data stream and consider the bit positions that make up element 'x', which are the bits at positions 2 through 14 inclusive.

```
Positions:
00000000 01111111 11122222
12345678 90123456 78901234
Bits:
 1011010 100100
```

Since alignment does not affect logical value, we will obtain the same logical value as if we realigned the bits. That is, the value is the same as if we began the bits of the element's representation with bit position 1.

```
Realigned Positions:
00000000 01111111 11122222
12345678 90123456 78901234
Bits:
10110101 00100
```

The DFDL schema fragment above gives element ‘x’ the dfdl:byteOrder='bigEndian' property. In this case the place value of each position is given by 2^(M – i)

PlaceValue positions 2^(M - i)

```
...11110 00000000
...21098 76543210
Bit values
...10110 10100100
Hex values
   1   6    A   4
```

The value of element 'x' is 0x16A4. Notice how it is the most-significant byte -- which is the first byte when big endian -- that becomes the partial byte (having fewer than 8 bits) in the case where the length of the bit string is not a multiple of 8 bits.

For dfdl:byteOrder='littleEndian'. The place values of the individual bits are not as easily visualized. However there is still a basic formula (given in the pseudo code in Figure 4 Little Endian bit position and value.

Looking again at our realigned positions:

```
Realigned Positions:
00000000 01111111 11122222
12345678 90123456 78901234
Bits:
10110101 00100
```

The place values of each of these bits, for little endian byte order can be seen to be:

```
PlaceValue positions
00000000 ...11100
76543210 ...21098
Bit values
10110101 ...00100
Hex values
   B   5    0   4
```

We must reorder the bytes for little endian byte order. The value of element 'x' is 0x04B5. In little endian form, the first 8 bits make up the first byte, and that contains the least-significant byte of the logical numeric unsignedShort value. The additional bits of the partial byte are once again the most significant byte; however, for little endian form, this is the second byte. The second byte contains only 5 bits, those make up the least significant 5 bits of that byte, but that logical 5-bit value makes up the most-significant byte of the unsignedShort integer.

Booleans

The properties dfdl:binaryBooleanTrueRep and dfdl:binaryBooleanFalseRep are unsigned integers. Specifically, their numeric ranges are restricted as if of type xs:unsignedInt, with additional restriction in range when the dfdl:lengthUnits='bits' and dfdl:length are used to specify fewer than the maximum of 32 bits.

12.3.7.3 Length of Complex Element of Specified Length

A complex element of known length is defining a 'box' in which its child element exist. For example a fixed length record with a variable number of children that may not fill the full length of the record.

For example, an element of complex type may have explicit length of 100 bytes, but contain a sequence of child elements that use up less than 100 bytes of data. In this case the remaining unused data is called the ***FinalUnusedRegion.*** It is skipped when parsing, and is filled with the dfdl:fillByte on unparsing.

When the dfdl:lengthUnits is 'characters' on a complex element of specified length then the dfdl:lengthUnits of all its children must be characters also.

12.3.8 Length of Simple Types with Binary Representations

Elements with dfdl:representation 'binary' and dfdl:binaryNumberRep or dfdl:binaryCalendarRep 'packed' or 'bcd' may be delimited or known length. All other elements with dfdl:representation 'binary' must be of known length and it is a schema definition error if dfdl:lengthKind 'delimited' or 'endOfParent', where the parent dfdl:lengthKind is 'delimited'.

13. Simple Types

The 'representation' property identifies the physical representation of the element. The DFDL logical types are grouped to illustrate which physical representations apply to each logical type. These properties provide the correct interpretation of the data found in the ***SimpleContent*** grammar region.
The allowable physical representations for each logical type grouping are also shown, where the logical type groupings are defined as:

Logical type group	types
Number	xs:double, xs:float, xs:decimal, xs:integer and its restrictions (xs:int, xs:unsignedLong, etc.)
String	xs:string
Calendar	xs:dateTime, xs:date, xs:time
Opaque	xs:hexBinary
Boolean	xs:Boolean

Table 18 Logical type groups

13.1 Properties Common to All Simple Types

Property Name	Description
representation	Enum Valid values are dependent on logical type. **Number:** 'text, 'binary' **String:** representation is assumed to be 'text' and the representation property is not examined **Calendar:** 'text, 'binary' **Boolean:** 'text, 'binary' **Opaque:** representation is assumed to be 'binary' and the representation property is not examined. Annotation: dfdl:element, dfdl:simpleType

The permitted representation properties for each logical type are shown in Table 19: Logical Type to Representation properties

Logical type	*dfdl:representation*	*Additional representation property*
String	Assumed to be text	
Float, Double	text	**textNumberRep:** standard
	binary	**binaryFloatRep**: ieee, ibm390Hex
Decimal, Integer, nonNegativeInteger	text	**textNumberRep:** standard, zoned
	binary	**binaryNumberRep:** packed, bcd, binary
Long, Int, Short, Byte, UnsignedLong,	text	**textNumberRep:** standard, zoned

Unsignedint, Unsignedshort, UnsignedByte	binary	**binaryNumberRep:** packed, bcd, binary
DateTime, Date, Time	text	
	binary	**binaryCalendarRep:** packed, bcd, binarySeconds, binaryMilliseconds
Boolean	text	
	binary	
HexBinary	Assumed to be binary	

Table 19: Logical Type to Representation properties

13.2 Properties Common to All Simple Types with Text representation

Property Name	Description
textPadKind	Enum Valid values 'none', 'padChar'. Indicates whether to pad the representation text on unparsing. 'none': No padding occurs. When lengthKind is 'implicit' or 'explicit' the representation text must match the expected length otherwise it is a processing error. 'padChar': The element is padded using the dfdl:textStringPadCharacter, dfdl:textNumberPadCharacter, dfdl:textBooleanPadCharacter or dfdl:textCalendarPadCharacter depending on the type of the element When lengthKind is 'implicit' the element is padded to the implicit length for the type. When lengthKind is 'explicit' the element is padded to the length given by the dfdl:length property. When lengthKind is 'delimited', 'prefixed', 'pattern' or 'endOfParent' the element is padded to the length given by the xs:minLength facet for type 'xs:string' or dfdl:textOutputMinLength property for other types. Annotation: dfdl:element, dfdl:simpleType
textTrimKind	Enum Valid values 'none', 'padChar' Indicates whether to trim data on parsing. When 'none' no trimming takes place When 'padChar' the element is trimmed of the dfdl:textStringPadCharacter, dfdl:textNumberPadCharacter, dfdl:textBooleanPadCharacter or dfdl:textCalendarPadCharacter depending on the type of the element.. Annotation: dfdl:element , dfdl:simpleType
textOutputMinLength	Non-negative Integer. Only used when dfdl:textPadKind is 'padChar' and dfdl:lengthKind is 'delimited', 'prefixed', 'pattern' or 'endOfParent', and type is not xs:string

	Specifies the minimum representation length during unparsing for simple types that do not allow the xs:minlength facet to be specified. The units are specified by the dfdl:lengthUnits property. If dfdl:textOutputMinLength is zero or less than the length of the representation text then no padding occurs. Annotation: dfdl:element, dfdl:simpleType
escapeSchemeRef	Qname or empty String The name of the dfdl:defineEscapeScheme annotation that provides the additional properties used to describe the escape scheme. If the value is the empty string then escaping is explicitly turned off. See The dfdl:defineEscapeScheme Annotation Element and The dfdl:escapeScheme Annotation Element Annotation: dfdl:element, dfdl:simpleType

13.2.1 The dfdl:escapeScheme Properties

The dfdl:escapeScheme annotation is used within a dfdl:defineEscapeScheme annotation to group the properties of an escape scheme and allows a common set of attributes to be defined that can be reused.
An escape scheme is needed when the contents of a text element contains sequences of characters that are the same as an in-scope separator or terminator. If the characters are not escaped, a parser scanning for a separator or terminator would erroneously find the character sequence in the contents.
An escape scheme defines the properties that describe the text escaping rules. There are two variants on such schemes:

- The use of a single escape character to cause the next character to be interpreted literally. The escape character itself is escaped by the escape escape character.
- The use of a pair of escape strings to cause the enclosed group of characters to be interpreted literally. The ending escape string is escaped by the escape escape character.

On parsing, the escape scheme is applied after padding characters are trimmed and on unparsing before padding characters are added.
DFDL does not provide a substitution mechanism similar to XML that would replace a character entity such as < with its literal value <.

Property Name	*Description*
escapeKind	Enum Valid values ‘escapeCharacter', 'escapeBlock' The type of escape mechanism defined in the escape scheme When ‘escapeCharacter’: On unparsing a single character of the data is escaped by adding an dfdl:escapeCharacter before it. The following are escaped if they are in the data - Any in-scope terminating delimiter by escaping its first character. - dfdl:escapeCharacter (escaped by dfdl:escapeEscapeCharacter) - any dfdl:extraEscapedCharacters On parsing the dfdl:escapeCharacter and dfdl:escapeEscapeCharacter' are removed from the data, unless the dfdl:escapeCharacter is preceded by the dfdl:escapeEscapeCharacter, or the dfdl:escapeEscapeCharacter does not proceed the dfdl:escapeCharacter.

	When 'escapeBlock': On unparsing the entire data are escaped by adding dfdl:escapeBlockStart to the beginning and dfdl:escapeBlockEnd to the end of the data. The data is either always escaped or escaped when needed as specified by dfdl:generateEscapeBlock. If the data is escaped and contains the dfdl:escapeBlockEnd then first character of each appearance of the dfdl:escapeBlockEnd is escaped by the dfdl:escapeEscapeCharacter. On parsing the dfdl:escapeBlockStart is removed from the beginning of the data and dfdl:escapeBlockEnd is removed from end of the data and any dfdl:escapeEscapeCharacters are removed when they precede a dfdl:escapeBlockEnd. Annotation: dfdl:escapeScheme
escapeCharacter	DFDL String Literal or DFDL Expression Specifies one character that escapes the subsequent character. Used when dfdl:escapeKind = 'escapeCharacter' It is a schema definition error if dfdl:escapeCharacter is empty when dfdl:escapeKind is 'escapeCharacter' This property can be computed by way of an expression which returns a character. The expression must not contain forward references to elements which have not yet been processed. Escape characters contribute to the representation length of the field Annotation: dfdl:escapeScheme
escapeBlockStart	DFDL String Literal The string of characters that denotes the beginning of a sequence of characters escaped by a pair of escape strings. Used when dfdl:escapeKind = 'escapeBlock' It is a schema definition error if escapeBlockStart is empty when dfdl:escapeKind is 'escapeBlock' An dfdl:escapeBlockStart string contributes to the representation length of the field Annotation: dfdl:escapeScheme
escapeBlockEnd	DFDL String Literal The string of characters that denotes the end of a sequence of characters escaped by a pair of escape strings. Used when dfdl:escapeKind = 'escapeBlock' . It is a schema definition error if dfdl:escapeBlockEnd is empty when dfdl:escapeKind is 'escapeBlock' A dfdl:escapeBlockEnd string contributes to the representation length of the field Annotation: dfdl:escapeScheme
escapeEscapeCharacter	DFDL String Literal or DFDL Expression Specifies one character that escapes the subsequent escape character or first character of dfdl:escapeBlockEnd. Used when dfdl:escapeKind = 'escapeCharacter' or 'escapeBlock'. This property can be computed by way of an expression which returns a

	character. The expression must not contain forward references to elements which have not yet been processed. If the empty string is specified then no escaping of escape characters occurs. It is explicitly allowed for both the dfdl:escapeCharacter and the dfdl:escapeEscapeCharacter to be the same character. In that case processing functions as if the dfdl:escapeCharacter escapes itself. Annotation: dfdl:escapeScheme
extraEscapedCharacters	List of DFDL String Literals A space separated list of single characters that must be escaped in addition to the in-scope delimiters. This property only applies on unparsing Annotation: dfdl:escapeScheme
generateEscapeBlock	Enum Valid values 'always', 'whenNeeded' Controls when escaping is used on unparsing when dfdl:escapeKind is 'escapeBlock'. If 'always' then escaping is always occurs as described in dfdl:escapeKind. If 'whenNeeded' then escaping occurs as described in dfdl:escapeKind when the data contains any of the following : any in-scope terminating delimiter dfdl:escapeBlockStart at the start of the data any dfdl:extraEscapedCharacters Annotation: dfdl:escapeScheme

13.3 Properties for Bidirectional support for All Simple Types with Text representation

Bidirectional text consists of mainly right-to-left text with some left-to-right nested segments (such as an Arabic text with some information in English), or vice versa (such as an English letter with a Hebrew address nested within it.)
Note: the bidirectional properties apply to the value of the element and not to the initiator, terminator or separator if defined.

textBidi	Enum Valid values are 'yes', 'no' Indicates the text value of the element is bidirectional. Annotation: dfdl:element, dfdl:simpleType (representation text)
textBidiTextOrdering	Enum Valid values ‘implicit’, ‘visual’. Defines how bidirectional text is stored in memory. 'Implicit' means that the characters are stored in the order they are read or typed. That is with the first character in the first position in the data. (This is also called logical). 'Visual means that the characters are stored in the order they would be printed or displayed. That is, the last character of a right to left sequence is in the first position in the data and the first character of a left to right sequence is in the first position in the data. Annotation: dfdl:element , dfdl:simpleType (representation text) ,
textBidiOrientation	Enum Valid values ‘LTR’, ‘RTL’, ‘contextual_LTR’, ‘contextual_RTL’. Indicates how the text should be displayed. 'LTR' means left-to-right 'RTL' mean right to left. 'contextual_LTR' and 'contextual_RTL' means that the orientation should be taken from the context of the data. The data may contain 'strong' characters that are either orientation left or orientation right. The term following contextual (LTR or RTL) specifies what should be the default orientation when the data are orientation-neutral (i.e. there are no strong characters). Annotation: dfdl:element, dfdl:simpleType (representation text)
textBidiSymmetric	Enum Valid values are 'yes', 'no' Defines whether characters such as < ([{ that have a symmetric character with an opposite directional meaning: >)] } should be swapped Annotation: dfdl:element, dfdl:simpleType (representation text)
textBidiTextShaped	Enum Valid values are 'yes', 'no' Defines whether characters should be shaped on unparsing. Character shaping occurs when the shape of a character is dependent on its position in a word. Annotation: dfdl:element, dfdl:simpleType (representation text)

textBidiNumeralShapes	Enum Valid values ‘nominal’, ‘national’. Defines on unparsing whether logical numbers with text representation should have Arabic shapes (0123456789) or Arabic-Indic (٠١٢٣٤٥٦٧٨٩) When 'nominal': All numbers are presented using Arabic shapes When 'national': All numbers are presented using Arabic-Indic shapes. Annotation: dfdl:element, dfdl:simpleType (number with representation text)

13.4 Properties Specific to Strings with Text representation

Property Name	Description
textStringJustification	Enum Valid values ‘left’, ‘right’, ‘center’ Unparsing: 'left': Justifies to the left and adds padding chars to the string contents if the string is too short, to the length determined by the dfdl:textPadKind property. 'right': Justifies to the right and adds padding chars to the string contents if the string is too short, to the length determined by the dfdl:textPadKind property. ‘center’: Adds equal padding chars left and right of the string contents if the string is too short, to the length determined by the dfdl:textPadKind property. It adds one extra padding char on the left if needed. Parsing: 'left': Trims any padding characters from the right of the string, according to dfdl:textTrimKind property. 'right': Trims any padding characters from the left of the string, according to dfdl:textTrimKind property. ‘center’ Trims any padding characters from the left and right of the string, according to dfdl:textTrimKind property. Annotation: dfdl:element, dfdl:simpleType
textStringPadCharacter	DFDL String Literal The value that is used when padding or trimming string elements. The value can be a single character or a single byte. If a character, then it can be specified using a literal character or using DFDL entities. If a byte, then it must be specified using a single byte value entity otherwise it is a schema definition error If a pad character is specified when dfdl:lengthUnits='bytes' then the pad character must be a single-byte character. If a pad byte is specified when dfdl:lengthUnits='characters' then - the encoding must be a fixed-width encoding

	- padding and trimming must be applied using a sequence of N pad bytes, where N is the width of a character in the fixed-width encoding. Annotation: dfdl:element, dfdl:simpleType
truncateSpecifiedLengthString	Enum Valid values are 'yes', 'no' Used on unparsing only 'yes' means if the item is a string (that is, the logical type is xs:string) that is longer than the specified length, the string is truncated to this length. (See section 12.3.7 Elements of Specified Length) No exception is raised on unparsing, unless validation (see Validating messages) is active. The position from which data is truncated is determined by the value of the dfdl:textStringJustification property. If the value of the dfdl:textStringJustification property is 'left', data is truncated from the right; if the value of the dfdl:textStringJustification property is 'right', data is truncated from the left. However if the value of the dfdl:textStringJustification property is 'center' or 'none', truncation does not occur and a processing error occurs if the string is too long. Annotation: dfdl:element, dfdl:simpleType (string simple type)

13.5 Properties Specific to Number with Text or Binary representation

Property Name	Description
decimalSigned	Enum Valid values are 'yes', 'no' Indicates whether an xs:decimal element is signed. See 13.6.2 Converting logical numbers to/from text representation and 13.7.1 Converting logical numbers to/from binary representation to see how this affects the presence of the sign in the data stream. 'yes' means that the xs:decimal element is signed 'no' means that the xs:decimal element is not signed Annotation: dfdl:element, dfdl:simpleType

13.6 Properties Specific to Number with Text representation

Property Name	Description
textNumberRep	Enum Valid values are 'standard', 'zoned', 'standard' means represented as characters in the 'encoding' code page 'zoned' means represented as a zoned decimal in the 'encoding' code page. Zoned is not supported for float and double numbers Annotation: dfdl:element, dfdl:simpleType
textNumberJustification	Enum Valid values 'left', 'right', 'center' Controls how the data is padded or trimmed on parsing and unparsing. Behavior as for dfdl:textStringJustification. Annotation: dfdl:element, dfdl:simpleType

textNumberPadCharacter	DFDL String Literal The value that is used when padding or trimming number elements. The value can be a single character or a single byte. If a character, then it can be specified using a literal character or using DFDL entities. If a byte, then it must be specified using a single byte value entity If a pad character is specified when dfdl:lengthUnits='bytes' then the pad character must be a single-byte character. If a pad byte is specified when dfdl:lengthUnits='characters' then - the encoding must be a fixed-width encoding - padding and trimming must be applied using a sequence of N pad bytes, where N is the width of a character in the fixed-width encoding. Annotation: dfdl:element, dfdl:simpleType
textNumberPattern	String Defines the ICU-like pattern that describes the format of the text number. The pattern defines where grouping separators, decimal separators, implied decimal points, exponents, positive signs and negative signs appear. It permits definition by either digits/fractions or significant digits. Allows rounding. When dfdl:textNumberRep is 'standard' this property only applies when dfdl:textStandardBase is 10. When dfdl:textNumberRep is 'standard' and dfdl:textStandardBase is not 10 the number is represented as the minimum number of characters to represent the digits. There is no sign or virtual decimal point. The syntax of dfdl:textNumberPattern is described in section 13.6.1 The textNumberPattern Property Annotation: dfdl:element, dfdl:simpleType
textNumberRounding	Enum Specifies how rounding is controlled during unparsing. Valid values ‘pattern' 'explicit' When dfdl:textNumberRep is 'standard' this property only applies when dfdl:textStandardBase is 10. If 'pattern' then the rounding increment is specified in the dfdl:textNumberPattern using digits '1' though '9'. The rounding mode is always 'roundHalfEven'. To switch off rounding, do not use digits '1' through '9'. If 'explicit' then the rounding increment is specified by the dfdl:textNumberRoundingIncrement property, and any digits '1' through '9' in the dfdl:textNumberPattern are treated as digit '0'. The rounding mode is specified by the dfdl:textRoundingMode property. To switch off rounding, use 0.0 for the dfdl:textNumberRoundingIncrement. Annotation: dfdl:element, dfdl:simpleType

textNumberRoundingMode	Enum Specifies how rounding occurs during unparsing, when dfdl:textNumberRounding is 'explicit'. When dfdl:textNumberRep is 'standard' this property only applies when dfdl:textStandardBase is 10. Valid values ‘roundCeiling’, ‘roundFloor’, ‘roundDown’, ‘roundUp’, ‘roundHalfEven’, ‘roundHalfDown’, ‘roundHalfUp' Annotation: dfdl:element, dfdl:simpleType
textNumberRoundingIncrement	Double Specifies the rounding increment to use during unparsing, when dfdl:textNumberRounding is 'explicit'. When dfdl:textNumberRep is 'standard' this property only applies when dfdl:textStandardBase is 10. To switch off rounding, use 0.0. A negative value is a schema definition error. Annotation: dfdl:element, dfdl:simpleType
textNumberCheckPolicy	Enum Values are 'strict' and 'lax'. Indicates how lenient to be when parsing against the pattern. When dfdl:textNumberRep is 'standard' this property only applies when dfdl:textStandardBase is 10. If ‘lax' and dfdl:textNumberRep is 'standard' then grouping separators can be omitted, decimal separator can be either ‘.’ or ‘,’ (as long as this is unambiguous), leading positive sign can be omitted, all whitespace is treated as zero, and leading and trailing whitespace is ignored. Also the exponent is also optional and assumed to be '1' if not supplied If 'lax' and dfdl:textNumberRep is 'zoned' then positive punched data is accepted when parsing an unsigned type, and unpunched data is accepted when parsing a signed type On unparsing the pattern is always followed and follow the rules in 13.6.2 Converting logical numbers to/from text representation. Annotation: dfdl:element, dfdl:simpleType
textStandardDecimalSeparator	DFDL String Literal or DFDL Expression Defines the single character that will appear in the data as the decimal separator. This property is applicable when dfdl:textNumberRep is 'standard' and dfdl:textStandardBase is 10. This property can be computed by way of an expression which returns a character. The expression must not contain forward references to elements which have not yet been processed. Annotation: dfdl:element, dfdl:simpleType

textStandardGroupingSeparator	DFDL String Literal or DFDL Expression Defines the single character that will appear in the data as the grouping separator. This property is applicable when dfdl:textNumberRep is 'standard' and dfdl:textStandardBase is 10. This property can be computed by way of an expression which returns a character. The expression must not contain forward references to elements which have not yet been processed. Annotation: dfdl:element, dfdl:simpleType
textStandardExponentCharacter	DFDL String Literal or DFDL Expression Defines the actual character that will appear in the data as the exponent indicator. If the empty string is specified then no exponent character will be used. This property is applicable when dfdl:textNumberRep is 'standard' and dfdl:textStandardBase is 10. This property can be computed by way of an expression which returns a character. The expression must not contain forward references to elements which have not yet been processed. If dfdl:ignoreCase is 'yes' then the case of the string is ignored by the parser. Annotation: dfdl:element, dfdl:simpleType
textStandardInfinityRep	DFDL String Literal The value used to represent infinity. Infinity is represented as a string with the positive or negative prefixes and suffixes from the dfdl:textNumberPattern applied This property is applicable when dfdl:textNumberRep is 'standard', dfdl:textStandardBase is 10 and the simple type is float or double If dfdl:ignoreCase is 'yes' then the case of the string is ignored by the parser. Annotation: dfdl:element, dfdl:simpleType
textStandardNanRep	DFDL String Literal The value used to represent NaN. NaN is represented as string and the positive or negative prefixes and suffixes from the dfdl:textNumberPattern are not used This property is applicable when dfdl:textNumberRep is 'standard', dfdl:textStandardBase is 10 and the simple type is float or double If dfdl:ignoreCase is 'yes' then the case of the string is ignored by the parser. Annotation: dfdl:element, dfdl:simpleType

textStandardZeroRep	List of DFDL String Literals Valid values: empty string, any character string The whitespace separated list of alternative literal strings that are equivalent to zero, for example the characters ‘zero’. On unparsing the first value is used. If dfdl:ignoreCase is 'yes' then the case of the string is ignored by the parser. The empty string means that there is no special literal string for zero This property is applicable when dfdl:textNumberRep is 'standard' and dfdl:textStandardBase is 10. Annotation: dfdl:element, dfdl:simpleType
textStandardBase	Non-negative Integer Valid Values 2, 8, 10, 16 Indicates the number base. Only used when dfdl:textNumberRep is 'standard'. When base is not 10, xs:decimal, xs:float and xs:double are not supported. When dfdl:textNumberRep is 'zoned' dfdl:textNumberBase 10 is assumed Annotation: dfdl:element, dfdl:simpleType
textZonedSignStyle	Enum Specifies the characters that are used to overpunch the sign nibble when the encoding is an ASCII character set. The location of this sign nibble is indicated in the dfdl:textNumberPattern. This property is applicable when dfdl:textNumberRep is 'zoned' Used only when encoding specifies an ASCII-derived character set. That is printable character codepoints 0x20 - 0x7E are the same as US-ASCII. This includes all the Unicode character sets, and all variations of ASCII and ISO-8859. Valid values 'asciiStandard', ‘asciiTranslatedEBCDIC', ‘asciiCARealiaModified' Which characters are used to represent ‘overpunched’ (included) positive and negative signs, varies by encoding, Cobol compiler and system. It is fixed for EBCDIC systems but not for ASCII. In EBCDIC-based encodings, characters ‘{ABCDEFGHI’ or '0123456789' represent a positive sign and digits 0 to 9. (Character codes 0xC0 to 0xC9 or 0xF0 to 0xF9). The characters ‘}JKLMNOPQR’ or '^£¥·©§¶¼½¾ 'represent a negative sign and digits 0 to 9. (character codes 0xD0 to 0xD9 or 0xB0 to 0xB9) On parsing both ranges of characters will be accepted. On unparsing the range 0xC0 to 0xC9 will be produced for positive signs and 0xD0 to 0xD9 will be produced for negative signs. asciiStandard: ASCII characters ‘0123456789’ represent a

	positive sign and the corresponding digit. (Sign nibble for '+' is 0x3, which is the high nibble of these character codes unmodified.) ASCII characters 'pqrstuvwxy' represent negative sign and digits 0 to 9. (Character codes 0x70 to 0x79) asciiTranslatedEBCDIC: The overpunched character is the ASCII equivalent of the EBCDIC above. So the characters '{ABCDEFGHI' still represent a positive sign and digits 0 to 9. (These are character codes 0x7B, 0x41 through 0x49). The characters '}JKLMNOPQR' still represent negative sign and digits 0 to 9. (These are character codes 0x7D, 0x4A through 0x52). This case comes up if ebcdic zoned decimal data is translated to ASCII as if it were textual data. asciiCARealiaModified[9]: In this style, the ASCII characters '0123456789' represent positive sign and digits 0 to 9 as in standard. However, ASCII characters from code 0x20 to 0x29 are used for negative sign and the corresponding decimal digit. This doesn't translate well into printing characters. These characters include the space (' ') for zero, characters '!"#$%&' for 1 through 6, the single quote character "'" for 7, and the parenthesis '()' for 8 and 9. Annotation: dfdl:element, dfdl:simpleType

13.6.1 The textNumberPattern Property

The dfdl:textNumberPattern describes how to parse and unparse text representations of number logical types with base 10.
The length of the representation of the number is determined first, and the number pattern is used only for conversion of the text to and from a numeric logical infoset value.
The pattern described below is derived from the ICU DecimalFormat class described here: [ICUDecForm]

The pattern is an ICU-like syntax that defines where grouping separators, decimal separators, implied decimal points, exponents, positive signs and negative signs appear. It permits definition by either digits/fractions or significant digits.
If the pattern uses digits/fractions then these must match any XML schema facets. If not it is a schema definition error.

13.6.1.1 dfdl:textNumberPattern for dfdl:textNumberRep 'standard'

When dfdl:textNumberRep is 'standard' this property only applies when dfdl:textStandardBase is 10
The pattern comes in two parts separated by a semi-colon. The first is mandatory and applies to positive numbers, the second is optional and applies to negative numbers.

[9] Reference for this CA Realia 0x20 overpunch for negative sign is the article: "EBCDIC to ASCII Conversion of Signed Fields" at http://www.discinterchange.com/TechTalk_signed_fields_.html, where it says:
COBOL compilers that run on ASCII platforms have a "signed" data type that operates in a similar manner to the EBCDIC Signed field -- that is, they over punch the sign on the LSD. However, this is not standardized in ASCII, and different compilers use different overpunch codes. For example, Computer Associates' Realia compiler uses a 30 hex for positive values and a 20 hex for negative values, but Micro Focus® and Microsoft® use 30 hex for positive values and 70 hex for negative values.

Examples: The first shows digits/fractions and positive/negative signs, the second shows exponent, the third shows significant digits.
+###,##0.00;(###,##0.00)
##0.0#E0
+###V#0

Note that 'V' is used to indicate the location of an implied decimal point for fixed point number representations. (This is an extension to the ICU pattern language.)
The actual grouping separator, decimal separator and exponent characters are defined independently of the pattern.
The actual positive sign and negative sign are defined within the pattern itself.

Many characters in a pattern are taken literally; they are matched during parsing and output unchanged during formatting. Special characters, on the other hand, stand for other characters, strings, or classes of characters. For example, the '#' character is replaced by a digit.

To insert a special character in a pattern as a literal, that is, without any special meaning, the character must be quoted. There are some exceptions to this which are noted below.

Symbol	Location	Meaning
0	Number	Digit
1-9	Number	'1' through '9' indicates rounding.
#	Number	Digit, zero shows as absent
.	Number	Decimal separator or monetary decimal separator
-	Number	Minus sign
,	Number	Grouping separator
E	Number	Separates mantissa and exponent in scientific notation. Need not be quoted in prefix or suffix.
+	Exponent	Prefix positive exponents with plus sign. Need not be quoted in prefix or suffix.
;	Subpattern boundary	Separates positive and negative subpatterns
'	Prefix or suffix	Used to quote special characters in a prefix or suffix, for example, "'#'#" formats 123 to "#123". To create a single quote itself, use two in a row: "# o''clock".
*	Prefix or suffix boundary	Pad escape, precedes pad character
V	Number	Virtual decimal point marker. Only used with decimal, float and double simple types.
P	Number	Decimal scaling position. Only used with decimal, float and double simple types.

Table 20 dfdl:textNumberPattern special characters

A pattern contains a positive and negative subpattern, for example, "#,##0.00;(#,##0.00)". Each subpattern has a prefix, a numeric part, and a suffix. If there is no explicit negative subpattern, the negative subpattern is the minus sign prefixed to the positive subpattern. That is, "0.00" alone is equivalent to "0.00;-0.00". If there is an explicit negative subpattern, it serves only to specify the negative prefix and suffix; the number of digits, minimal digits, and other characteristics are

ignored in the negative subpattern. That means that "#,##0.0#;(#)" has precisely the same result as "#,##0.0#;(#,##0.0#)".

The prefixes, suffixes, and various symbols used for infinity, digits, grouping separators, decimal separators, etc. may be set to arbitrary values, and they will appear properly during formatting. However, care must be taken that the symbols and strings do not conflict, or parsing will be unreliable. For example, either the positive and negative prefixes or the suffixes must be distinct for parse to be able to distinguish positive from negative values. Another example is that the decimal separator and grouping separator should be distinct characters, or parsing will be impossible.

The *grouping separator* is a character that separates clusters of integer digits to make large numbers more legible. It commonly used for thousands, but in some locales it separates ten-thousands. The *grouping size* is the number of digits between the grouping separators, such as 3 for "100,000,000" or 4 for "1 0000 0000". There are actually two different grouping sizes: One used for the least significant integer digits, the *primary grouping size*, and one used for all others, the *secondary grouping size*. In most locales these are the same, but sometimes they are different. For example, if the primary grouping interval is 3, and the secondary is 2, then this corresponds to the pattern "#,##,##0", and the number 123456789 is formatted as "12,34,56,789". If a pattern contains multiple grouping separators, the interval between the last one and the end of the integer defines the primary grouping size, and the interval between the last two defines the secondary grouping size. All others are ignored, so "#,##,###,####" == "###,###,####" == "##,#,###,####".

The P symbol is used to specify the location of an assumed decimal point when the point is not within the number that appears in the data.
The symbol P can be specified only as a continuous string of Ps in the leftmost or rightmost digit positions in the number region of the pattern. The decimal point symbol V is assumed as either the leftmost or rightmost character of the number region.

It is a schema definition error if any symbols other than "0", "1"-"9" or # are used in the same number region of the pattern as V or P.

Examples

Data representation	Pattern	Value
123	PP000	0.00123
123	000PP	12300

Pattern BNF

```
pattern    := subpattern (';' subpattern)?
subpattern := prefix? ((number exponent?)|(vpinteger) suffix?
number     := (integer ('.' fraction)?)

vpinteger  := (pinteger | vinteger)
pinteger   := ('P'* integer) | (integer 'P'* )
vinteger   := ('V'? integer) |
              ('#'* 'V'? integer)|
              ('#'* '0'* 'V'? '0'* '0')|
              (integer 'V'?)

prefix     := '\u0000'..'\uFFFD' - specialCharacters
suffix     := '\u0000'..'\uFFFD' - specialCharacters
integer    := '#'* '0'* '0'
fraction   := '0'* '#'*
```

```
exponent    := 'E' '+'? '0'* '0'
padSpec     := '*' padChar
padChar     := '\u0000'..'\uFFFD' - quote

Notation:
  X*        0 or more instances of X
  X?        0 or 1 instances of X
  X|Y       either X or Y
  C..D      any character from C up to D, inclusive
  S-T       characters in S, except those in T
```

Figure 5 dfdl:numberPattern syntax

The first subpattern is for positive numbers. The second (optional) subpattern is for negative numbers.
Not indicated in the BNF syntax above:

- The grouping separator ',' can occur inside the integer elements, between any two pattern characters of that element, as long as the integer or sigDigits element is not followed by the exponent element.
- Two grouping intervals are recognized: That between the decimal point and the first grouping symbol, and that between the first and second grouping symbols. These intervals are identical in most locales, but in some locales they differ. For example, the pattern "#,##,###" formats the number 123456789 as "12,34,56,789".
- The pad specifier `padSpec` may appear before the prefix, after the prefix, before the suffix, after the suffix, or not at all.
- In place of '0', the digits '1' through '9' may be used to indicate a rounding increment.

Parsing
During parsing, grouping separators are removed from the data.

Formatting

Formatting is guided by several parameters all of which can be specified using a pattern. The following description applies to formats that do not use scientific notation.

- If the number of actual integer digits exceeds the *maximum integer digits*, then only the least significant digits are shown. For example, 1997 is formatted as "97" if the maximum integer digits is set to 2.
- If the number of actual integer digits is less than the *minimum integer digits*, then leading zeros are added. For example, 1997 is formatted as "01997" if the minimum integer digits is set to 5.
- If the number of actual fraction digits exceeds the *maximum fraction digits*, then half-even rounding it performed to the maximum fraction digits. For example, 0.125 is formatted as "0.12" if the maximum fraction digits is 2. This behavior can be changed by specifying a rounding increment and a rounding mode.
- If the number of actual fraction digits is less than the *minimum fraction digits*, then trailing zeros are added. For example, 0.125 is formatted as "0.1250" if the minimum fraction digits is set to 4.
- Trailing fractional zeros are not displayed if they occur *j* positions after the decimal, where *j* is less than the maximum fraction digits. For example, 0.10004 is formatted as "0.1" if the maximum fraction digits is four or less.

Special Values
`NaN` is represented as a string determined by the dfdl:textStandardNanRep property. This is the only value for which the prefixes and suffixes are not used.
Infinity is represented as a string with the positive or negative prefixes and suffixes applied. The infinity string is determined by the dfdl:textStandardInfinityRep property.

Scientific Notation
Numbers in scientific notation are expressed as the product of a mantissa and a power of ten, for example, 1234 can be expressed as 1.234 x 10^3. The mantissa is typically in the half-open interval [1.0, 10.0) or sometimes [0.0, 1.0), but it need not be. In a pattern, the exponent character immediately followed by one or more digit characters indicates scientific notation. Example: "0.###E0" formats the number 1234 as "1.234E3".

- The number of digit characters after the exponent character gives the minimum exponent digit count. There is no maximum. Negative exponents are formatted using the minus sign, *not* the prefix and suffix from the pattern. This allows patterns such as "0.###E0 m/s". To prefix positive exponents with a plus sign, specify '+' between the exponent and the digits: "0.###E+0" will produce formats "1E+1", "1E+0", "1E-1", etc.

- The minimum number of integer digits is achieved by adjusting the exponent. Example: 0.00123 formatted with "00.###E0" yields "12.3E-4". This only happens if there is no maximum number of integer digits. If there is a maximum, then the minimum number of integer digits is fixed at one.

- The maximum number of integer digits, if present, specifies the exponent grouping. The most common use of this is to generate *engineering notation*, in which the exponent is a multiple of three, e.g., "##0.###E0". The number 12345 is formatted using "##0.####E0" as "12.345E3".

- When using scientific notation, the formatter controls the digit counts using significant digits logic. The maximum number of significant digits limits the total number of integer and fraction digits that will be shown in the mantissa; it does not affect parsing. For example, 12345 formatted with "##0.##E0" is "12.3E3". .

- Exponential patterns may not contain grouping separators.

Padding
Padding may be specified through the pattern syntax. In a pattern the pad escape character, followed by a single pad character, causes padding to be parsed and formatted. The pad escape character is '*'. For example, `"*x#,##0.00"` formats 123 to `"xx123.00"`, and 1234 to `"1,234.00"`.

- When padding is in effect, the width of the positive subpattern, including prefix and suffix, determines the format width. For example, in the pattern `"* #0 o''clock"`, the format width is 10.

- The width is counted in 16-bit code units.

- Some parameters which usually do not matter have meaning when padding is used, because the pattern width is significant with padding. In the pattern "* ##,##,#,##0.##", the format width is 14. The initial characters "##,##," do not affect the grouping size or maximum integer digits, but they do affect the format width.

- Padding may be inserted at one of four locations: before the prefix, after the prefix, before the suffix, or after the suffix. If there is no prefix, before the prefix and after the prefix are equivalent, likewise for the suffix.

- When specified in a pattern, the 32-bit code point immediately following the pad escape is the pad character. This may be any character, including a special pattern character. That is, the pad escape *escapes* the following character. If there is no character after the pad escape, then the pattern is illegal.

Note: This padding is in addition to the normal DFDL text padding.

Rounding

How rounding is controlled is given by dfdl:textNumberRounding. The rounding increment may be specified in the dfdl:textNumberPattern itself using digits '1' through '9' or using an explicit increment in dfdl:textNumberRoundingIncrement. For example, 1230 rounded to the nearest 50 is 1250. 1.234 rounded to the nearest 0.65 is 1.3.

- Rounding only affects the string produced by formatting. It does not affect parsing or change any numerical values.

- In a pattern, digits '1' through '9' specify rounding, but otherwise behave identically to digit '0'. For example, "#,#50" specifies a rounding increment of 50.

- Using digits in a pattern, rounding is always 'half even', meaning rounds towards the nearest integer, or towards the nearest even integer if equidistant.

Using an explicit rounding increment, dfdl:textNumberRoundingMode determines how values are rounded.

13.6.1.2 dfdl:textNumberPattern for dfdl:textNumberRep 'zoned'

When dfdl:textNumberRep is ‘zoned’ only the pattern for positive numbers is used. It is a schema definition error if the negative pattern is specified.

Only the following pattern characters may be used:

- '+' MUST BE present at the beginning or end of the pattern to indicate whether the leading or trailing digit carries the overpunched sign, if the logical type is signed
- '+' MAY BE present at the beginning or end of the pattern to indicate whether the leading or trailing digit carries the overpunched sign, if the logical type is unsigned. If logical type is unsigned and dfdl:textNumberPolicy = 'lax' specified it is a schema definition error if no '+' is present.
- 'V' MAY BE used to indicate the location of an implied decimal point
- 'P' MAY BE used to indicate the decimal scaling
- '0-9' indicates the number of required digits (including overpunched).
- '#' indicates the number optional digits.

Rounding occurs as described under Rounding in 13.6.1.1 dfdl:textNumberPattern for dfdl:textNumberRep 'standard'

13.6.2 Converting logical numbers to/from text representation

- Signed numbers with dfdl:textNumberRep 'standard' and dfdl:textStandardBase 10 are mapped using the dfdl:textNumberPattern.
- Signed numbers with dfdl:textNumberRep 'standard' and dfdl:textStandardBase not 10 are mapped to an unsigned representation. On unparsing the minimum number of characters to represent the digits is output and it is a processing error if the value is negative.
- Signed numbers with dfdl:textNumberRep 'zoned' are mapped using the dfdl:textNumberPattern to indicate the position of the sign and virtual decimal point. On parsing if the sign is not overpunched, that is it does not have a sign, it is treated as positive. On unparsing the sign is always overpunched.
- Unsigned numbers with dfdl:textNumberRep 'standard' and dfdl:textStandardBase 10 are mapped using the dfdl:textNumberPattern. On parsing it is a processing error if the data are negative.
- Unsigned numbers with dfdl:textNumberRep 'standard' and dfdl:textStandardBase not 10 are mapped to an unsigned representation. On unparsing the minimum number of characters to represent the digits is output. .
- Unsigned numbers with dfdl:textNumberRep 'zoned' are mapped using the dfdl:textNumberPattern to indicate the position of the sign and virtual decimal point. On parsing it is a processing error if the data are negative. On unparsing the data are not overpunched with a sign.

13.7 Properties Specific to Numbers with Binary representation

These properties are applicable to decimals types and its derived types. These properties are not applicable to types float and double. See section 13.8 Properties Specific to Float/Double with Binary representation

Property Name	Description

<table>
<tr><td>binaryNumberRep</td><td>Enum

Valid values are ‘packed’, ‘bcd’, 'binary'

Allowable values for each number type are

<table>
<tr><th>type</th><th>Permitted value</th></tr>
<tr><td>Decimal, Integer, nonNegativeInteger</td><td>packed, bcd, binary</td></tr>
<tr><td>Long, Int, Short, Byte,</td><td>packed, binary</td></tr>
<tr><td>UnsignedLong, Unsignedint, UnsignedShort, UnsignedByte</td><td>packed, bcd, binary</td></tr>
</table>

‘packed’ means represented as a packed decimal. In the packed decimal format, each byte contains two decimal digits, except for the least significant byte, which contains a sign in the least significant nibble.
‘bcd’ means represented as a binary coded decimal with two digits per byte.
‘binary’ means represented as twos complement for signed types and unsigned binary for unsigned types.
Annotation: dfdl:element, dfdl:simpleType</td></tr>
<tr><td>binaryDecimalVirtualPoint</td><td>Integer.
Used when base simpleType is xs:decimal.
An integer that represents the position of an implied decimal point within a number, or specify 0.
If you specify 0 then there is no virtual decimal point
If you specify a positive integer, the position of the decimal point is moved left from the right side of the number. For example, if you specify 3, the decimal value 1234 represents 1.234
If you specify a negative integer, the position of the decimal point is moved right from the right side of the number. For example, if you specify -3, the decimal value 1234 represents 1 234 000
Annotation: dfdl:element, dfdl:simpleType</td></tr>
</table>

binaryPackedSignCodes	List of Character Used only when dfdl:binaryNumberRep or dfdl:binaryCalendarRep is 'packed' A space separated string giving the hex sign nibbles to use for a positive value, a negative value, an unsigned value, and zero. Valid values for positive nibble: A, C, E, F Valid values for negative nibble: B, D Valid values for unsigned nibble: F Valid values for zero sign: A C E F 0 Example: 'C D F C' – typical S/390 usage Example: 'C D F 0' – handle special case for zero On parsing, whether to accept all valid values for a positive, negative or unsigned number, and for zero, is governed by the dfdl:binaryNumberCheckPolicy property. On unparsing, the specified values are always used. Annotation: dfdl:element, dfdl:simpleType
binaryNumberCheckPolicy	Enum Values are 'strict' and 'lax'. Indicates how lenient to be when parsing binary numbers. If 'lax' then the parser tolerates all valid alternatives where such alternatives exist. Specifically, for dfdl:binaryNumberRep = 'packed' the sign nibble for positive, negative, unsigned and zero is allowed to be any of the valid respective values. On unparsing, the specified value is always used Annotation: dfdl:element, dfdl:simpleType

13.7.1 Converting logical numbers to/from binary representation

- Signed numbers with dfdl:binaryNumberRep 'packed' are mapped using sign nibble to indicate the sign. The unsigned nibble is treated as positive. On unparsing the sign nibble is written according to dfdl:binaryPackedSignCodes. The unsigned nibble is never used.
- Signed numbers with dfdl:binaryNumberRep 'bcd' are always positive. On unparsing it is a processing error if the data is negative.
- Unsigned numbers with dfdl:binaryNumberRep 'packed' are mapped if the nibble is positive or unsigned. It is a processing error if the data are negative. On unparsing the unsigned nibble is used
- Unsigned numbers with dfdl:binaryNumberRep 'bcd' are mapped as BCD data is always positive

13.8 Properties Specific to Float/Double with Binary representation

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Property Name	Description
binaryFloatRep	Enum or DFDL Expression This specifies the encoding method for the float and double. Valid values are 'ieee', 'ibm390Hex', This property can be computed by way of an expression which returns the string of 'ieee' or ' ibm390Hex' . The expression must not contain forward

	references to elements which have not yet been processed. Annotation: dfdl:element, dfdl:simpleType

13.9 Properties Specific to Boolean with Text representation

Property Name	Description
textBooleanTrueRep	List of DFDL String Literals or DFDL Expression A whitespace separated list of representation values to be used for 'true' This property can be computed by way of an expression which returns a string of whitespace separated list of values. The expression must not contain forward references to elements which have not yet been processed. On unparsing the first value is used If dfdl:ignoreCase is 'yes' then the case of the string is ignored by the parser. Annotation: dfdl:element, dfdl:simpleType
textBooleanFalseRep	List of DFDL String Literals or DFDL Expression A whitespace separated list of representation value to be used for 'false' This property can be computed by way of an expression which returns a string of whitespace separated list of values. The expression must not contain forward references to elements which have not yet been processed. On unparsing the first value is used If dfdl:ignoreCase is 'yes' then the case of the string is ignored by the parser. Annotation: dfdl:element, dfdl:simpleType
textBooleanJustification	Enum Valid values 'left', 'right', 'center' Controls how the data is padded or trimmed on parsing and unparsing. Behavior as for dfdl:textStringJustification. Annotation: dfdl:element, dfdl:simpleType
textBooleanPadCharacter	DFDL String Literal The value that is used when padding or trimming boolean elements. The value can be a single character or a single byte. If a character, then it can be specified using a literal character or using DFDL entities. If a byte, then it must be specified using a single byte value entity If a pad character is specified when lengthUnits='bytes' then the pad character must be a single-byte character.

	If a pad byte is specified when lengthUnits='characters' then - the encoding must be a fixed-width encoding - padding and trimming must be applied using a sequence of N pad bytes, where N is the width of a character in the fixed-width encoding. Annotation: dfdl:element, dfdl:simpleType

13.10 Properties Specific to Boolean with Binary representation

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Property Name	Description
binaryBooleanTrueRep	Non-negative Integer Representation value to be used for 'true' The empty string means dfdl:binaryBooleanTrueRep is any value other than dfdl:binaryBooleanFalseRep. The value must be consistent with the representation as an xs:unsignedInt, including that it must be within the range allowed by the number of bits, when dfdl:lengthUnits='bits' is specified, and the dfdl:length is less than 32. Annotation: dfdl:element, dfdl:simpleType
binaryBooleanFalseRep	Non-negative Integer Representation value to be used for 'false' The value must be consistent with the representation as an xs:unsignedInt, including that it must be within the range allowed by the number of bits, when dfdl:lengthUnits='bits' is specified, and the dfdl:length is less than 32. Annotation: dfdl:element, dfdl:simpleType

13.11 Properties specific to calendar with Text or Binary representation

The properties describe how a calendar is to be interpreted including a formatting pattern property plus properties that qualify the pattern.
These properties can be used when a calendar has a representation of 'text' or a representation of 'binary' and a dfdl:binaryCalendarRep of 'packed' or 'bcd'.

Property Name	*Description*
calendarPattern	String Defines the ICU pattern that describes the format of the calendar. The pattern defines where the year, month, day, hour, minute, second, fractional second and time zone components appear. See calendarPattern property section below. When the dfdl:representation is 'binary' and dfdl:binaryCalendarRep is 'packed' or 'bcd' then the pattern can contain only characters that result in a presentation of number.

<table>
<tr><td></td><td>Annotation: dfdl:element, dfdl:simpleType</td></tr>
<tr><td>calendarPatternKind</td><td>Enum
Valid values ‘explicit’, ‘implicit’
‘explicit’ means the pattern is given by dfdl:calendarPattern,
‘implicit’ means the pattern is derived from the XML schema date/time type.
<table>
<tr><td>Logical Type</td><td>Default Pattern</td></tr>
<tr><td>xs:date</td><td>yyyy-MM-dd</td></tr>
<tr><td>xs:dateTime</td><td>yyyy-MM-dd'T'HH:mm:ss</td></tr>
<tr><td>xs:time</td><td>HH:mm:ssZZZ</td></tr>
</table>
Annotation: dfdl:element, dfdl:simpleType</td></tr>
<tr><td>calendarCheckPolicy</td><td>Enum
Valid values are 'strict', 'lax'
Indicates how lenient to be when parsing against the pattern.
If 'lax' then the parser will convert invalid date/time values to the appropriate in-band value. For example, a date of 2005-05-32 will be converted to 2005-06-01.
Annotation: dfdl:element, dfdl:simpleType</td></tr>
<tr><td>calendarTimeZone</td><td>Enum
Valid values are the list of time zone designations in the form UTC±n where n is the offset in hours. The offset can be expressed as the hours or hours and minutes. Examples UTC-1, UTC+4:30,
The time zone that will be assumed if no time zone explicitly occurs in the data.
Annotation: dfdl:element, dfdl:simpleType</td></tr>
<tr><td>calendarObserveDST</td><td>Enum
Valid values are 'yes', 'no'
Whether the time zone given in dfdl:calendarTimeZone observes daylight savings time.
Annotation: dfdl:element, dfdl:simpleType</td></tr>
<tr><td>calendarFirstDayOfWeek</td><td>Enum
Valid values ‘Monday’ … ‘Sunday’
The day of the week upon which a new week is considered to start.
Annotation: dfdl:element, dfdl:simpleType</td></tr>
<tr><td>calendarDaysInFirstWeek</td><td>Non-negative Integer
Valid values 1 to 7
Specify the number of days of the new year that must fall within the first week.
The start of a year usually falls in the middle of a week. If the number of days in that week is less than the value specified here, the week is considered to be the last week of the previous year; hence week 1 starts some days into the new year. Otherwise it is considered to be the first week of the new year; hence week 1 starts some days before the new</td></tr>
</table>

	year. Annotation: dfdl:element, dfdl:simpleType
calendarCenturyStart	Non-negative Integer Valid values 0 to 99. This property determines on parsing how two-digit years are interpreted. Specify the two digits that start a 100-year window that contains the current year. For example, if you specify `89`, and the current year is 2006, all two-digit dates are interpreted as being in the range 1989 to 2088. A two-digit year less than 89 will be interpreted as 20nn and a two-digit year more than or equal to 89 will be treated as 19nn. Annotation: dfdl:element, dfdl:simpleType
calendarLanguage	Enum The language that is used when the pattern produces a presentation in text. For example 'Monday' The valid values are as defined by [IETF RFC 3066], Tags for the Identification of Languages, or its successors. For example 'en-GB' Annotation: dfdl:element, dfdl:simpleType

13.11.1 The dfdl:calendarPattern property

The dfdl:calendarPattern describes how to parse and unparse text and binary representations of dateTime, date and time logical types. The pattern is primarily used on unparsing to define the format but is also used to aid parsing.
When parsing and unparsing the Pattern is derived from the ICU SimpleDatetimeFormat class described here: http://icu.sourceforge.net/apiref/icu4c/classSimpleDateFormat.html
Extensions are two formatting symbols I and T, which mean accept a subset of ISO 8601 compliant xs:dateTime and xs:time, respectively, and the acceptance of the 'Z' character to mean UTC.

Symbol	Meaning	Presentation	Example
G	era designator	(Text)	AD
y	year	(Number)	1996
Y	year (week of year)	(Number)	1997
M	month in year	(Text & Number)	July & 07
d	day in month	(Number)	10
h	hour in am/pm (1~12)	(Number)	12
H	hour in day (0~23)	(Number)	0
m	minute in hour	(Number)	30
s	second in minute	(Number)	55
S	fractional second (see note 1)	(Number)	978
E	day of week	(Text)	Tuesday
e	day of week (local 1~7)	(Text & Number)	Tues & 2
D	day in year	(Number)	189
F	day of week in month	(Number)	2 (2nd Wed in July)
w	week in year	(Number)	27
W	week in month	(Number)	2
a	am/pm marker	(Text)	PM
k	hour in day (0~24[10])	(Number)	24
K	hour in am/pm (0~11)	(Number)	0
z	time zone	(Text)	Pacific Standard Time

[10] For pattern character k, 24 is equivalent to 0 and allowed only if minutes is 00.

Z	time zone (RFC 822)	(Number)	-0800
ZU	time zone (RFC 822) with output "Z" if the time zone is +00:00)	(Text)	Z
v	time zone (generic)	(Text)	Pacific Time
V	time zone (location)	(Text)	United States (Los Angeles)
I	ISO8601 Date/Time	(Text)	2006-10-07T12:06:56.568+01:00
IU	ISO8601 Date/Time with output "Z" if the time zone is +00:00)	(Text)	2006-10-07T12:06:56.568Z
T	ISO8601 Time (up to HH:mm:ss.SSSZZ)	(Text)	12:06:56.568+01:00
TU	ISO8601 Time (similar to T, but a time zone of +00:00 is replaced with 'Z')	(Text)	12:06:56.568Z
'	escape for text	(Delimiter)	'Date='
''	single quote	(Literal)	'o''clock'

Note 1: Any number of fractional seconds "S" may by specified in the pattern and accepted by implementations, but an implementation is free to represent a limited number of fractional seconds internally. Round up rounding must occur when converting between external and internal representations. At least millisecond accuracy must be implemented..

The count of pattern letters determine the format.

(Text): 4 or more, use full form, < 4, use short or abbreviated form if it exists. (e.g., "EEEE" produces "Monday", "EEE" produces "Mon")

(Number): the minimum number of digits. Shorter numbers are zero-padded to this amount (e.g. if "m" produces "6", "mm" produces "06"). Year is handled specially; that is, if the count of 'y' is 2, the Year will be truncated to 2 digits. (e.g., if "yyyy" produces "1997", "yy" produces "97".) Unlike other fields, fractional seconds are padded on the right with zero.

(Text & Number): 3 or over, use text, otherwise use number. (e.g., "M" produces "1", "MM" produces "01", "MMM" produces "Jan", and "MMMM" produces "January".)

Any characters in the pattern that are not in the ranges of ['a'..'z'] and ['A'..'Z'] will be treated as quoted text. For instance, characters like ':', '.', ' ', '#' and '@' will appear in the resulting time text even if they are not embraced within single quotes.

The 'I' and 'T' pattern characters should be used on their own to format dates and times which match the following subset of the ISO8601 standard.

- The restricted profile as proposed by the W3C at http://www.w3.org/TR/NOTE-datetime
- Truncated representations of calendar dates, as specified in section 5.2.1.3 of ISO8601:2000
    - Basic format (subsections c, e, and f)
    - Extended format (subsections a, b, and d)

13.12 Properties specific to calendar with Text representation

Property Name	Description
textCalendarJustification	Enum Valid values 'left', 'right', 'center' Controls how the data is padded or trimmed on parsing and unparsing. Behavior as for dfdl:textStringJustification. Annotation: dfdl:element, dfdl:simpleType
textCalendarPadCharacter	DFDL String Literal The value that is used when padding or trimming calendar elements. The value can be a single character or a single byte. If a character, then it can be specified using a literal character or using DFDL entities. If a byte, then it must be specified using a single byte value entity If a pad character is specified when dfdl:lengthUnits='bytes' then the pad character must be a single-byte character. If a pad byte is specified when dfdl:lengthUnits='characters' then - the encoding must be a fixed-width encoding - padding and trimming must be applied using a sequence of N pad bytes, where N is the width of a character in the fixed-width encoding. Annotation: dfdl:element, dfdl:simpleType

13.13 Properties specific to calendar with Binary representation

Binary integers are considered to be a binary representation.

Property Name	Description
binaryCalendarRep	Enum Valid values are 'packed', 'bcd', 'binarySeconds', 'binaryMilliseconds' 'packed' means represented as a packed decimal. In the packed decimal format, each byte contains two decimal digits, except for the rightmost byte, which contains a sign to the right of a decimal digit. 'bcd' means represented as a binary coded decimal with two digits per byte.. For 'packed' and 'bcd' the following properties are also applicable dfdl:binaryPackedSignCodes (packed only) dfdl:binaryNumberCheckPolicy dfdl:binaryDecimalVirtualPoint is assumed to be 0,

	See Properties specific to numbers with binary representation section : 13.7 Properties Specific to Numbers with Binary representation 'binarySeconds' means represented as a 4 byte integer that is the number of seconds since the epoch. 'binaryMilliseconds' means represented as an 8 byte integer that is the number of seconds since the epoch. Annotation: dfdl:element, dfdl:simpleType
binaryCalendarEpoch	DateTime Used when dfdl:binaryCalendarRep is 'binarySeconds' or 'binaryMilliseconds' The epoch from which to calculate dates and times. Annotation: dfdl:element, dfdl:simpleType

13.14 Properties Specific to Opaque Types (hexBinary)

There are no properties specific to opaque types

13.15 Nils and Default processing

This section describes the processing for nil and default.

Sometimes it is desirable to represent an unshipped element, unknown information, or inapplicable information *explicitly* with an element, rather than by an absent element. For example, it may be desirable to represent a "null" value being sent to or from a relational database with an element that is present. Such cases can be represented using the DFDL nil mechanism which is based on the XML Schema's nil mechanism and allows "out of band" nil values. Nil processing is used when the XSDL 'nillable' attribute of an element is true.

Default processing provides a value for an element that is missing from the data stream on parsing or the infoset on unparsing. Default processing applies to both simple and complex elements.

Definition 'has default'

A simple element has a default if any of these are true:

1. The xs:default attribute exists. The default value is the attribute's value.
2. The xs:fixed attribute exists. The default value is the attribute's value.
3. The element has xs:nillable='true' and dfdl:useNilForDefault is specified. The default value is nil.

A complex element has a default if either:

1. The content is a sequence and all the required children of a complex element have a default.
2. The content is a choice and one of the choice branches has a default. The default is the first choice branch in schema definition order to have a default.

Otherwise the element has no default.

Definition: 'required parent context'

A required element (defined below) is only required when its enclosing parent element is one of the following

- The document root
- A required element within a sequence.
- An optional element that is not missing within a sequence
- The selected branch of a xs:choice

Definition: 'required element'

When an element is in a 'required parent context', we define the term 'required element' to be :

- A scalar element
- An element of a fixed-occurrence array
- An element of a variable-occurrence array if its index is less than or equal to the value of minOccurs.

On parsing, a required element in a required parent context must produce a value in the infoset otherwise it is a processing error.
On unparsing a required element in a required parent context must produce a value in the augmented infoset otherwise it is a processing error.

Definition 'missing element'

On parsing, an element is missing

- IF an intiator is defined AND dfdl:emptyValueDelimiterPolicy is 'initiator' or 'both' but the initiator is not found in the data stream.
- OR the content region in the data stream is empty.

.

On unparsing, an element is missing if it is not in the infoset.

Definition 'is nil'

On parsing an element is nil if xs:nillable is 'true' AND one of the following:

1. dfdl:nilKind is 'logicalValue' and the ***SimpleRepresentation*** region of the data stream, converted to its logical type, matches any of the dfdl:nilValue values.
2. dfdl:nilKind is 'literalValue' and the ***SimpleRepresentation*** region of the data stream matches any of the dfdl:nilValue values
3. dfdl:nilKind is 'literalCharacter' and all characters in the ***SimpleRepresentation*** region of the data stream match the dfdl:nilValue character.

On unparsing an element is nil if xs:nillable is 'true' AND the element value is nil in the infoset.

Definition 'nil output representation'

The 'nil output representation' is one of the following:

1. When dfdl:nilKind is 'logicalValue' then the representation value is the first value of dfdl:nilValue converted to the physical representation.
2. When dfdl:nilKind is 'literalValue' then the representation value is the first value of dfdl:nilValue
3. When dfdl:nilKind is 'literalCharacter' then the representation value is the character from dfdl:nilValue repeated to the required length

13.15.1 Nils and Defaults on Parsing

For simple elements the following applies:

- If 'missing element':
  1. If both dfdl:initiator and dfdl:terminator are not specified
     a. If 'is nil' then the infoset value is nil
     b. Else if 'required element', and 'has a default' then the infoset value is the value provided by the default
     c. Else If 'required element', it is a processing error
     d. Otherwise nothing is added to the infoset
  2. Otherwise
     a. If 'is nil' and the initiator and/or terminator comply with dfdl:nilValueDelimiterPolicy then the infoset value is nil
     b. Else if 'required element', and 'has a default' and the initiator and/or terminator comply with dfdl:emptyValueDelimiterPolicy then the infoset value is the value provided by the default
     c. Else If 'required element', it is a processing error
     d. Otherwise nothing is added to the infoset
- Otherwise
  1. If both dfdl:initiator and dfdl:terminator are not specified
     a. If 'is nil' then the infoset value is nil
     b. Otherwise the infoset value is the parsed value from the data stream
  2. Otherwise
     a. If 'is nil' and the initiator and/or terminator comply with dfdl:nilValueDelimiterPolicy then the infoset value is nil
     b. Otherwise the infoset value is the parsed value from the data stream

For complex elements the following applies:

- If 'missing element':
  1. If both dfdl:initiator and dfdl:terminator are not specified
     a. If 'required element', and 'has a default' then the element is added to the Infoset and 'missing element' processing is applied to all child elements.
     b. Else if 'required element' it is a processing error
     c. Otherwise nothing is added to the infoset

2. Otherwise
    a. If 'required element', and 'has a default' and the initiator and/or terminator comply with dfdl:emptyValueDelimiterPolicy then the element is added to the infoset and 'missing element' processing is applied to all child elements.
    b. Else if 'required element' it is a processing error
    c. Otherwise nothing is added to the infoset

- Otherwise the element is added to the infoset.

13.15.2 Nils and Defaults on Unparsing

For simple elements the following applies:

- If 'missing element'
    1. If both dfdl:initiator and dfdl:terminator are not specified
        a. If 'required element' and 'has a default' then the output value is the unparsed value provided by the default.
        b. Else if 'required element' it is a processing error
        c. Otherwise nothing is output
    2. Otherwise
        a. If 'required element' and 'has a default' then the output value is the unparsed value provided by the default, with initiator and/or terminator as controlled by dfdl:emptyValueDelimiterPolicy if the value is the empty string or dfdl:nilValueDelimiterPolicy if dfdl:useNilForDefault' is 'true' .
        b. Else if 'required element' it is a processing error
        c. Otherwise nothing is output
- Otherwise
    1. If xs:nillable is not 'true' and the infoset value is nil it is a processing error.
    2. Else if both dfdl:initiator and dfdl:terminator are not specified
        a. If 'is nil' then the 'nil output representation' is output .
        b. Otherwise the output value is the unparsed value from the infoset..
    3. Otherwise
        a. If 'is nil' then the 'nil output representation' is output with initiator and/or terminator as controlled by dfdl:nilValueDelimiterPolicy.
        b. Otherwise the output value is the unparsed value from the infoset with initiator and/or terminator as controlled by dfdl:emptyValueDelimiterPolicy if the value is the empty string.

For complex elements the following applies:

- If 'missing element'
  1. If both dfdl:initiator and dfdl:terminator are not specified
     a. If 'required element' and 'has a default' then 'missing element' processing is applied to all child elements.
     b. Else if 'required element' it is a processing error
     c. Otherwise nothing is output
  2. Otherwise
     a. If 'required element' and 'has a default' then 'missing element' processing is applied to all child elements, and initiator and/or terminator are output (as controlled by dfdl:emptyValueDelimiterPolicy if the children's total representation is the empty string).
     b. Else if 'required element' it is a processing error
     c. Otherwise nothing is output
- Otherwise
  1. If dfdl:initiator and dfdl:terminator are not specified then nothing is output for this element .
  2. Else if dfdl:initiator and/or dfdl:terminator are specified then the initiator and/or terminator are output as controlled by dfdl:emptyValueDelimiterPolicy if the children's total representation is the empty string

13.16 Properties for Nillable Elements

These properties are used when the XSDL 'nillable' attribute of an element is true, and they control when and how the representation data are interpreted as having the logical meaning 'nil'. They apply only to elements of simple type.

Property Name	Description
nilKind	Enum Valid values 'literalValue', 'logicalValue', 'literalCharacter', Used when xs:nillable is 'true' Specifies how dfdl:nilValue is interpreted to represent the nil value in the data stream.. If 'literalCharacter' then dfdl:nilValue specifies a single character or a single byte that, when repeated to the length of the element, is the nil value. 'literalCharacter' may only be specified for fixed length elements, that is dfdl:lengthKind 'implicit' and 'explicit' when dfdl:length is not a DFDL expression, otherwise it is a schema definition error. If 'literalValue' then dfdl:nilValue specifies a list of DFDL literal strings that are the possible representation values for nil. If 'logicalValue' then dfdl:nilValue specifies a list of logical values that are the possible logical values for nil. Annotation: dfdl:element(simpleType)

nilValue	List of DFDL String Literals, List of Logical Values, DFDL String Literal Specifies the text strings that are the possible literal or logical nil values of the element. If dfdl:nilKind is 'literalValue' then nilValue specifies a white space separated list of DFDL literal strings that are the possible representation values for nil. On parsing the element value is nil if the data matches one of the literal strings in the list. On unparsing if the element value is nil the first nilValue from the list is output. Only applicable when representation is 'text' If dfdl:nilKind is 'logicalValue' then nilValue specifies white space separated list of logical values that are the possible logical values for nil. On parsing the element value is nil if the data, converted to its logical type, matches any of the logical values in the list. On unparsing if the element value is nil, the first nilValue from the list is converted to its physical representation and output. If dfdl:nilKind is 'literalCharacter' then nilValue specifies a single character or byte that, when repeated to the length of the element, is the nil representation value. If a character, then it can be specified using a literal character or using DFDL entities. If a character is specified when dfdl:lengthUnits='bytes' then the nilValue must be a single-byte character. If a byte, then it must be specified using a single %#r entity If a byte is specified when dfdl:lengthUnits='characters' then the encoding must be a fixed-width encoding On parsing the element value is nil if all characters in the data match the nilValue character . On unparsing if the element value is nil the nilValue character is output to the required length. Annotation: dfdl:element(simpleType)
nilValueDelimiterPolicy	Enum Valid values are 'none', 'initiator', 'terminator' or 'both'. Indicates that when a value is nil, an initiator (if one is defined), a terminator (if one is defined), both an initiator and a terminator (if defined) or neither must be present. Ignored if both dfdl:initiator and dfdl:terminator are "" (empty string). 'initiator' indicates that, on parsing, the dfdl:initiator followed by one of the dfdl:nilValue is the required syntax to indicate that a nil value is present. It also indicates that on unparsing when the logical value is nil that the dfdl:initiator will be output followed by the first of the dfdl:nilValue. 'terminator' indicates that, on parsing, by one of the dfdl:nilValue followed by the dfdl:terminator is the required syntax to indicate that a nil value is present. It also indicates that on unparsing when the logical value is nil the first of the dfdl:nilValue followed by the dfdl:terminator will be output. 'both' indicates that, on parsing, both the dfdl:initiator and dfdl:terminator must be present with one of the dfdl:nilValue to indicate that a nil value is present. On unparsing the dfdl:initiator followed by the first dfdl:nilValue, followed by the dfdl:terminator will be output.

	'none' indicates that one of the dfdl:nilValue without any dfdl:initiator or dfdl:terminator triggers creation of a nilvalue. On unparsing the first of the dfdl:nilValue is output without the dfdl:initiator or dfdl:terminator. It is a schema definition error if dfdl:nilValueDelimiterPolicy is set to 'none' or 'terminator' when the parent xs:sequence has dfdl:initiatedContent 'yes'. Annotation: dfdl:element(simpleType)

13.17 Properties for Default Value Control

The DFDL default processing uses xs:default, xs:fixed or dfdl:useNilForDefault to provide a default value. See section 13.15 Nils and Default processing for a full description.

Property Name	Description
useNilForDefault	Enum Valid values are 'yes', 'no' Use nil as the default value This property has precedence over the xs:default and xs:fixed attributes. Defaulting occurs as described above with nil as the default value. The dfdl:nilValue property must specify at least one nil value otherwise a schema definition error occurs. Annotation: dfdl:element (simpleType)

14. Sequence Groups

The following properties are specific to sequences.

Property Name	Description
sequenceKind	Enum Valid values are 'ordered', 'unordered' When 'ordered', this property means that the contained items of the sequence will be encountered in the same order that they appear in the schema, which is called schema-definition-order. When 'unordered', this property means that the items of the sequence will be encountered in any order. Repeating instances of the same element do not need to be contiguous. The children of an unordered sequence MUST be xs:element otherwise it is a schema definition error. Annotation: dfdl:sequence, dfdl:group (sequence)
initiatedContent	Enum Valid values are 'yes', 'no' When 'yes' indicates that all the children of the sequence are initiated. It is a schema definition error if any children have their dfdl:initiator property set to the empty string. If the child is optional then it is deemed to have been found when its initiator has been found. Any subsequent error parsing the child will not cause the parser to backtrack to try other alternatives. When 'no', the children of the sequence may have their dfdl:initiator property set to the empty string. Annotation: dfdl:sequence, dfdl:choice, dfdl:group

A sequence can have an initiator and/or a terminator as described earlier.

14.1 Empty Sequences

A sequence having no children is syntactically legal in DFDL. In the data stream, such a sequence can have non-zero length ***LeftFraming*** and ***RightFraming*** regions, but the ***SequenceContent*** region in between must be empty. It is a processing error if the ***SequenceContent*** region of an empty sequence has non-zero length when parsing.

XML schema does not define an empty sequence that is the content of a complex type as effective content so any DFDL annotations on such a construct would be ignored. It is a schema definition error if the empty sequence is the content of a complex type.

14.2 Sequence Groups with Delimiters

The following additional properties apply to sequence groups that use text delimiters to separate child content.

Property Name	Description
separator	List of DFDL String Literals or DFDL Expression Specifies a whitespace separated list of alternative literal

	strings that are the possible separators between a sequence of elements or multiple occurrences of an element. The ***Separator, PrefixSeparator and PostfixSeparator*** regions contain one of the strings specified by the dfdl:separator property. When this property has "''" (empty string) as its value then the separator region is of length zero. On unparsing the first separator in the list is used as the separator. This property can be computed by way of an expression which returns a string of whitespace separated values. The expression must not contain forward references to elements which have not yet been processed. If a child element uses an escape scheme, then the escape scheme also applies to any separator. If dfdl:ignoreCase is 'yes' then the case of the string is ignored by the parser. Annotation: dfdl:sequence, dfdl:group (sequence)
separatorPosition	Enum Valid values ‘infix’, ‘prefix’, ‘postfix’ ‘infix’ means the separator occurs between the elements in the ***Separator*** grammar region. ‘prefix’ means the separator occurs before each element n both the ***Separator*** grammar region and the ***PrefixSeparator*** grammar region. ‘postfix’ means the separator occurs after each element in the ***Separator*** grammar region and the ***PostfixSeparator*** grammar region. Annotation: dfdl:sequence, dfdl:group (sequence).
separatorPolicy	Enum Valid values ‘required', ‘suppressed', ‘suppressedAtEndStrict’, ‘suppressedAtEndLax’ Specifies whether to expect a separator when an element is missing. Ignored unless dfdl:separator is specified and is not "" (empty string). This property applies when dfdl:sequenceKind is 'ordered' See section 14.214.2.1 Sequence Groups and Separators. 'suppressed' implies it must be possible for speculative parsing to identify which elements are present. 'suppressedAtEndStrict' and 'suppressedAtEndLax' can only be used when there is no clash with delimiters from the containing structure. Annotation: dfdl:sequence, dfdl:group (sequence)
documentFinalSeparatorCanBeMissing	Enum Valid values are 'yes', 'no' When the documentFinalSeparatorCanBeMissing property is true, then when an element is the last element in a sequence or array is also the last element in the data

	stream, then on parsing, it is not an error if the postfix separator is not found. For example, if the data are in a file, and the format specifies lines terminated by the newline character (typically LF or CRLF), then if the last line is missing its newline, then this would normally be an error, but if documentFinalSeparatorCanBeMissing is true, then this is not a processing error. On unparsing the separator is always written out regardless of the state of this property. Annotation: dfdl:format (on xs:schema only)

14.2.1 Sequence Groups and Separators

A number of issues arise in explaining sequence groups having separators.
There are 5 distinct kinds of sequence groups

sequenceKind	***separatorPolicy***	***Implications***
ordered	required	All separators MUST be found in the data. When the last element in the sequence is an array then separators will be output, after the last occurrence, up to xs:maxOccurs if there aren't sufficient occurrences. It is a schema definition error if xs:maxOccurs is 'unbounded'
ordered	suppressedAtEndStrict	Separators MUST be omitted for any 'missing elements' at the end of the sequence. When the last element in the sequence is an array then separators will be output up to the last occurrence.
ordered	suppressedAtEndLax	Separators MAY be omitted for any 'missing elements' at the end of the sequence. When the last element in the sequence is an array then separators will be output up to the last occurrence.
ordered	suppressed	Separators MAY be omitted for 'missing elements'. It must be possible for speculative parsing to identify which elements are present.
unordered	ignored (suppressed behavior implied)	

Table 21 Sequence groups and separators

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14.3 Unordered Sequence Groups

In DFDL, ordered and unordered are characteristics of the representation only. Logically, sequence groups are always in schema order.
The semantics of unordered groups (sequence with dfdl:sequenceKind='unordered' property) are expressed by way of a source-to-source transformation of the declaration, and by a data transformation on the resulting value. An implementation may use any technique consistent with this semantic.
The source to source transformation turns the declaration of an unordered group into an ordered sequence that contains an array element that contains a choice. Each element declaration of the unordered group becomes an alternative element within the choice. The unordered group's separator and terminator become the Separator and Terminator of the surrounding sequence.

The dfdl:sequenceKind property is dropped, but other DFDL annotation properties are preserved. The xs:maxOccurs and xs:minOccurs on any element of the unordered sequence are dropped when the element is placed into the choice.
For example:

```
<xs:sequence dfdl:sequenceKind="unordered">
         <xs:element name=”a” type="xs:string" dfdl:initiator="A:" />
         <xs:element name=”b” type="xs:int" minOccurs="0"
dfdl:initiator="B:" />
         <xs:element name=”c” type="xs:string" minOccurs=”0”
maxOccurs="10"
                           dfdl:initiator="C:" />
</xs:sequence>
```

The above is conceptually rewritten into an element declaration and reference like so:

```
<xs:element name="dummy">
  <xs:complexType>
     <xs:choice>
         <xs:element name=”a” type="xs:string" dfdl:initiator="A:" />
         <xs:element name=”b” type="xs:int" dfdl:initiator="B:" />
         <xs:element name=”c” type="xs:string" dfdl:initiator="C:" />
     </xs:choice>
  </xs:complexType>
</xs:element>

<xs:sequence dfdl:sequenceKind="ordered">
  <xs:element ref="dummy" minOccurs="1" maxOccurs="12"/>
</xs:sequence>
```

Schema definition errors are then detected as for choice group types. Notice how the xs:minOccurs and xs:maxOccurs for the rewritten element reference are computed based on the possible occurrences from the original source.
Processing then constructs this array element by parsing the data.
The post processing then transforms this array back into the original sequence of non-choice elements. That is, the array is then used to populate the infoset corresponding to:

```
<xs:sequence>
         <xs:element name=”a” type="xs:string" />
         <xs:element name=”b” type="xs:int" minOccurs="0" />
         <xs:element name=”c” type="xs:string" minOccurs=”0”
maxOccurs="10" />
</xs:sequence>
```

This is a logical-value to logical value transformation. Ordered and unordered are characteristics of the representation only. The transformation here is the obvious one where all array elements having the first choice alternative as their value are accumulated into the first child element of the logical sequence. If there is either no such value or more than one such value, then the first child element must be an array or optional declaration (appropriate xs:minOccurs and xs:maxOccurs) so that it can accommodate the number of values found. The dimensionality of the first element must accommodate the number of values actually found. It is a processing error if it cannot. This algorithm repeats for the array elements having the 2nd choice alternative as their value, and so on until all the choice alternative values have been moved into their corresponding elements/arrays in the logical sequence group, and all logical sequence elements have been populated in a manner conforming to their xs:minOccurs constraints.
An unordered sequence is of fixed length if the same sequence is fixed length when the unordered property is removed.

On Unparsing, the behavior is exactly as if dfdl:sequenceKind='ordered'. That is, the elements are output in schema declaration order.

14.4 Floating Elements

Elements within an ordered sequence can be designated as floating which means that they can appear in any position within the sequence.[11]

Property Name	Description
floating	Enum Valid values are 'yes', 'no' Whether the occurrences of an element in an ordered sequence can appear out-of-order in the representation. When parsing, and dfdl:floating is 'yes', instances of the element may be encountered in the representation in any position within its containing sequence. If present they are placed into the infoset in schema declaration order. If the element repeats, instances do not need to be contiguous in the representation. When parsing, and dfdl:floating is 'no', instances of the element must be in schema declaration order, and, if present, they are placed into the infoset in schema declaration order. It is a processing error if instances of the element are not encountered in schema declaration order. When unparsing, instances of the element are expected in the infoset in schema declaration order, and are output in the representation in schema declaration order. It is a processing error if instances of the element are not encountered in schema declaration order, It is a schema definition error if an unordered sequence or a choice contains any element with dfdl:floating='yes'. It is a schema definition error if an ordered sequence contains any element with dfdl:floating='yes' and also contains non-element component (such as a choice or sequence model group). Annotation: dfdl:element

An ordered sequence with floating components is similar to an unordered sequence except only the floating elements may be out of order.

An ordered sequence of n element children with either n or n-1 of those children with dfdl:floating='yes' is equivalent to an unordered sequence with the same n element children with dfdl:floating='no'.

A complex element with dfdl:floating='yes' can have as its content model a sequence with elements that also have dfdl:floating='yes'.

[11] . The NTE segment in the X12 EDI standard is an example of a floating element.

This makes every element in a sequence containing one or more floating elements a point of uncertainty, similar to the way every element in an unordered sequence is a point of uncertainty. A parser MUST look for the element defined at that position in the schema first and then look for the floating elements in the order they are defined in the schema.

14.5 Hidden Groups

Some fields in the physical stream provide information about other fields in the stream and are not really part of the data. For example, a field could give the number of repeats in a following array. These fields may not be of interest to an application so may be removed from the Infoset on parsing by marking them as hidden. A hidden sequence group allows fields to be defined that will not be added to the infoset on parsing and will not be expected in the Infoset on unparsing.

```
<xs:element name="root">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="firstElement" type="xs:int"

      <xs:sequence>
              <dfdl:sequence hiddenGroupRef="tns:hiddenRepeatCount">
      </xs:sequence>

      <xs:element name="arrayElement" type="xs:int"
                  minOccurs="0" maxOccurs="unbounded"
                  dfdl:occursCountKind="expression"
                  dfdl:occurCount= "{../repeatCount}" />
    </xs:sequence>
  </xs:complexType>
</xs:element>

<xs:group name="hiddenRepeatCount" >
  <xs:sequence>
    <xs:element name="repeatCount" type=int
       dfdl:outputValueCalc="{count(../arrayElement)}"
       dfdl:representation="binary" dfdl:lengthKind="implicit" />
  </xs:sequence>
</xs:group>
```

Hidden elements within a hidden sequence can be referenced via path expressions using the same DFDL expression that we would have if it were not hidden.
Hidden elements can (typically will) contain the regular DFDL annotations to define their physical properties and on unparsing to set their value. They are processed using the same behavior as non-hidden elements.

When the dfdl:hiddenGroupRef property is specified, all other DFDL properties are ignored. It is a schema definition error if the sequence is not empty.

A hidden sequence may appear within another hidden sequence.

Property Name	Description
hiddenGroupRef	Qname or empty String Reference to a global model group definition that defines the hidden element or elements. The model group within the model group definition may be a xs:sequence or xs:choice If the value is the empty string then there is no hidden group.

	Annotation: dfdl:sequence

Table 22 Hidden properties

15. Choice Groups

The following properties are specific to xs:choice.

Property Name	Description
choiceLengthKind	Enum Valid values are 'implicit', 'explicit' 'implicit' means the branches of the choice are not filled, so the ***ChoiceContent*** region is variable length depending on which branch appears. 'explicit' means that the branches of the choice are always filled to the fixed length specified by dfdl:choiceLength, so the ***ChoiceContent*** region is fixed length regardless of which branch appears. Annotation: dfdl:choice, dfdl:group (choice)
choiceLength	Integer Only used when dfdl:choiceLengthKind is 'explicit'. Specifies the length of the choice in bytes, so the ***ChoiceContent*** region is fixed length regardless of which branch appears. Annotation: dfdl:choice, dfdl:group (choice)
initiatedContent	Enum Valid values are 'yes', 'no' When 'yes' indicates that all the branches of the choice are initiated. It is a schema definition error if any children have their dfdl:initiator property set to the empty string. The branch is deemed to have been found when its initiator has been found. Any subsequent error parsing the branch will not cause the parser to backtrack. When 'no', the branches of the choice may have their dfdl:initiator property set to the empty string. Annotation: dfdl:sequence, dfdl:choice, dfdl:group

A choice can have an initiator and/or a terminator as described earlier.
We will use this terminology:

Branch	A *branch* is one of the available alternatives within a choice. A branch can be an element of simple type or complex type, or it can be an embedded sequence, choice or group reference.
Root of the Branch	Each *branch* conceptually has a single element, sequence, choice or group reference component at its root. This element is known as the *Root of the Branch*.

Table 23 Choice group terminology

The Root of the Branch MUST NOT be optional. That is xs:minOccurs MUST BE greater than 0. When processing a choice group the parser validates any contained path expressions. If a path expression contained inside a choice branch refers to any other branch of the choice, then it is a schema definition error. Note that this rule handles nested choices also. A path that navigates

outward from an inner choice to another alternative of an outer choice is violating this rule with respect to the outer choice.

15.1 Resolving Choices

A choice corresponds to concepts called variant records, multi-format records, discriminated unions, or tagged unions in various programming languages. In some contexts choices are referred to generally as 'unions'. However, this should not be confused with XML schema unions.

When processing a choice, speculative parsing is used. Processing works as follows:

1. Attempt to parse the first branch of the choice.
2. If this fails with a processing error
    a. If we have evaluated a dfdl:discriminator to true earlier on this branch then the parser is 'bound' to this choice and parsing of the entire choice construct fails with a processing error.
    b. If we have not evaluated a dfdl:discriminator to true then we repeat from step 1 for the next branch of the choice.
3. It is a processing error if we exhaust the branches of the choice
4. If we succeed to parse a branch without error, then that branch's value becomes the logical value for the parse of the choice construct.

It is not possible for variable settings to be communicated from the speculative attempt to parse a branch to any other parsing situation. The speculative effort is completely isolated. Whether it succeeds or fails, neither the parse position in the source data, nor anything in the variable memory, nor the infoset is affected.

Nested choices can require unbounded look ahead into the data.

On unparsing the choice branch supplied in the infoset is output. It is a processing error is more than one choice branch is supplied. If no choice branch is supplied in the infoset then each choice branch is tried in schema definition order until one does not result in a processing error. It is a processing error if none of the choice branches unparse successfully.

16. Arrays and Optional Elements: Properties for Repeating and Variable-Occurrence Data Items

These properties are for arrays (xs:maxOccurs >1 or unbounded) or optional elements (xs:minOccurs = 0 and xs:maxOccurs = 1) and apply to local elements and element references.

Property Name	Description
occursCountKind	Enum Specifies how the actual number of occurrences is to be established. Valid values 'fixed', 'expression', 'parsed' ,'stopValue' 'fixed' means use the value of the xs:maxOccurs on the declaration. It is a schema definition error if the value for xs:minOccurs is not equal to xs:maxOccurs. 'expression' means use the value of the dfdl:occursCount property. Applies during parsing only. On unparsing the number of occurrences in the infoset is used, defaulted up to xs:minOccurs if necessary. 'parsed' means that the number of occurrences is determined by normal speculative parsing such as discriminating by the initiator 'stopValue' means look for a logical stop value which signifies the end of the occurrences. Annotation: dfdl:element
occursCount	Non-negative Integer or DFDL Expression Specifies the number of occurrences of the element. This property can be computed by way of an expression which returns an integer. The expression must not contain forward references to elements which have not yet been processed. Annotation: dfdl:element,
occursStopValue	List of DFDL Logical Values A space separated list of logical values that specify the alternative logical stop values for the element. Only used when dfdl:occursCountKind='stopValue'. When parsing then if an occurrence of the element has a logical value that matches one of the values in this list then the parser must not expect any more occurrences of the element. On unparsing the first value will be inserted as the last value in the array after all of the occurrences in the infoset have been output. Annotation: dfdl:element

The above properties handle a logical one-dimensional array of any type.
In some situations arrays of elements and sequence groups of elements seem to be similar; however, there is no notion of the array itself independent of its contained elements. Arrays are distinctly different from sequence groups in this way.
A sequence can have its own initiator, and an element having that sequence as its type can also have its own element initiator, so you could express two different initiators.
Unlike a sequence group, an array does not have its own initiator, terminator, or alignment. Those properties apply to each of the child elements of the array. To give an alignment, initiator,

separator or terminator for an entire array you must enclose the element declaration for the array in a sequence group and specify the alignment, separator, initiator and terminator on the sequence group.

16.1 Repeating and Variable-Occurrence Items and Default Values

Variable-occurrence items include both variable-occurrence arrays and optional elements.
The number of occurrences of a variable-occurrence item may be specified in the data. This can be combined with delimiters for determining the number of occurrences, in which case the number of occurrences obtained by parsing using delimiters and any stored information must be consistent. It is a processing error if they are not.
To determine the logical contents and number of occurrences for an array, we examine the input stream trying to parse elements one by one with separators between them. Parsing for an optional element is similar, except there is only the possibility of one occurrence, so separators don't matter.
If the element is not found then defaulting occurs as described in 13.17 Properties for Default Value Control
It is a processing error if a separator is parsed successfully, but parsing does not find the subsequent element successfully, unless dfdl:separatorPolicy is 'postfix'.
On parsing and unparsing if the number of occurrences of an element is less than xs:minOccurs and the element has a default specified then the element is defaulted up to xs:minOccurs, otherwise it is a processing error.

16.2 Stop Value Delimited Array Number of occurrences

When an array has a stopValue specified, this means that a distinguished logical value must be found to determine the end of the array. As each element is parsed, its value is compared to the stop value, and if it matches, then that ends the array. The stop value itself is not considered to be an element of the array and is not added to the infoset.
This technique can only be used on arrays of simple type elements. It is a schema definition error if stop values are used on arrays with complex type elements.

16.3 Arrays with DFDL Expressions

If the value of a DFDL property of an array element is given by a DFDL Expression, then the expression must be re-evaluated for each instance of the element.

17. Calculated Value Properties.

This section describes properties which allow the creation of calculated elements. When parsing, the value of a calculated element is derived using a DFDL Expression, and not by processing bytes from the data stream. When unparsing, the value of a calculated element is derived using a DFDL Expression, and is not obtained from the infoset in the usual way.

Calculated elements allow a technique that is commonly called layering. In this technique, some elements are said to be in the physical layer, and some in the logical layer. When parsing, the logical layer values are computed from physical layer values. When unparsing the opposite occurs, that is the physical layer values are computed from the logical layer values.

Calculated elements are commonly used with hidden elements so as to hide the physical layer elements so that they do not become part of the infoset.

When a DFDL Schema is used to both parse and unparse data, then a calculated element on parsing will normally have one or more calculated elements on unparsing.

These properties apply to elements of simple type, and to simple types.

Property Name	Description
inputValueCalc	DFDL Expression An expression that calculates the value of the element when parsing. The element having the inputValueCalc property is called a derived element, and the elements referenced from the inputValueCalc expression are called representation elements. An empty string is a valid return value for expression for a string-typed element if minLength allows length 0. An element that specifies an inputValueCalc expression has no representation of its own in the data stream. All other DFDL representation properties are ignored The element must not be optional nor an array The DFDL Expression must not refer to this element nor cause a circular reference to this element. The expression must not contain forward references to elements which have not yet been processed. It is a schema definition error if dfdl:inputValueCalc is specified on an element which has an xs:fixed or xs:default value. It is a schema definition error if dfdl:inputValueCalc and dfdl:outputValueCalc are specified on the same element. Annotation: dfdl:element
outputValueCalc	DFDL Expression An expression that calculates the value of the current element when unparsing. An empty string is a valid return value for expression for a string-typed element if minLength allows length 0. The element must not be optional nor an array The value for the element, is any, in the infoset is ignored. The DFDL expression must not refer to this element nor cause a circular reference to this element. The expression may contain forward references to elements which have not yet been processed.

	It is a schema definition error if dfdl:outputValueCalc is specified on an element which has an xs:fixed or xs:default value. It is a schema definition error if dfdl:inputValueCalc and dfdl:outputValueCalc are specified on the same element. Annotation: dfdl:element

Example: 2d Nested Array

Consider this simple example. The data stream contains two elements giving the number of rows and number of columns of an array of numbers. The contents of the array are stored after these two elements.

```
<xs:complexType name="array">
      <xs:sequence dfdl:initiator="" >

          <xs:sequence dfdl:hiddenGroupRef="tns:hiddenArrayCounts"/>

        <xs:element name="rows" maxOccurs=”unbounded”
                    dfdl:occursCountKind="expression"
                    dfdl:occursCount="{ ../nrows }">
           <xs:complexType>
             <xs:sequence>
               <xs:element name=”cols” type=”xs:float”
maxOccurs=”unbounded”
                    dfdl:occursCountKind=”expression”
                    dfdl:occursCount=” { ../../ncols } “ />
             </xs:sequence>
          </xs:complexType>
        </xs:element>
      </xs:sequence>
</xs:complexType>

<xs:group name="hiddenArrayCounts" >
  <xs:sequence>
     <xs:element name="nrows" type="xs:unsignedInt"
                 dfdl:representation="binary"
                 dfdl:lengthKind="implicit"
                 dfdl:outputValueCalc="{ count(../rows) }"/>
     <xs:element name="ncols" type="xs:unsignedInt"
                 dfdl:representation="binary"
                 dfdl:lengthKind="implicit"
                 dfdl:outputValueCalc=
                 "{  if ( count(../rows) ge 1 )
                    then
                       count(../rows[1]/cols)
                    else
                       0
                  }"/>
  </xs:sequence>
</xs:group>
```

In the example above we see that there are two hidden elements named ‘nrows’ and ‘ncols’. These hidden elements’ values are computed when unparsing from the number of occurrences in

the ‘rows’ and ‘cols’ repeating elements. The ‘rows’ and ‘cols’ repeating elements number of occurrences are computed when parsing from the hidden elements ‘nrows’ and ‘ncols’.

Example: Three-Byte Date

Logically, the data is a date.

```
<xs:element name=“d” type=“date”/>
```

Physically, it is stored as 3 single byte integers.

The format of this data is expressed as this schema:

```
<xs:sequence dfdl:representation="binary”>
              <xs:element name="mm" type="byte" />
              <xs:element name="dd" type="byte” />
              <xs:element name="yy" type="byte"/>
</xs:sequence>
```

This physical representation can be hidden so that it does not become part of the infoset:

```
<xs:sequence>
  <xs:sequence dfdl:hiddenGroupRef="tns:hiddenpDate"/>

  <xs:element name="d" type="date">
    …
  </xs:element>
          …
</xs:sequence>

<xs:group name="hiddenpDate" >
  <xs:sequence>
       <xs:element name="pdate">
          <xs:complexType>
            <xs:sequence dfdl:representation="binary”>
              <xs:element name="mm" type="byte" />
              <xs:element name="dd" type="byte” />
              <xs:element name="yy" type="byte"/>
            </xs:sequence>
          </xs:complexType>
       </xs:element>
  </xs:sequence>
</xs:group>
```

A calculation can be used to compute the logical date element ‘d’ from the physical ‘pdate’ when parsing:

```
<xs:sequence>
   … hidden pdate here …
  <xs:element name="d" type="date">
    <xs:annotation><xs:appinfo source=”http://www.ogf.org/dfdl/”>
      <dfdl:element>
```

```
        <dfdl:property name="inputValueCalc">
         {
           fn:date(fn:concat(if(../pdate/yy gt 50 )then "19" else "20",
                             if ( ../pdate/yy gt 9 )
                                then fn:string(../pdate/yy)
                                else fn:concat("0",
                                       fn:string(../pdate/yy)),
                                       "-",
                                       fn:string(../pdate/mm),
                                       "-",
                                       fn:string(../pdate/dd)))
         }
        </dfdl:property>
      </dfdl:element>
    </xs:appinfo></xs:annotation>
</xs:element>
          …
</xs:sequence>
```

The expression above assembles a string resembling, for example, “2005-12-17” or “1957-3-9” which is the string representation of a date that is acceptable to the fn:date constructor function. The hidden element ‘pdate’ is referenced by relative paths. The expression ‘../pdate/yy’ accesses an element of type ‘int’, and the fn:string constructor function turns it into an integer.

Finally, we must handle the unparse case where the physical layer is computed from the logical layer:

```
<xs:sequence dfdl:representation="binary"
              <xs:element name="mm" type="byte"
                 dfdl:outputValueCalc="{ fn:month-from-date(../d) }" />
              <xs:element name="dd" type="byte"
                 dfdl:outputValueCalc="{ fn:day-from-date(../d) }" />
              <xs:element name="yy" type="byte"
                 dfdl:outputValueCalc="{ fn:year-from-date(../d)
idivmod 100 }"
              />
</xs:sequence>
```

The entire example in one place:

```
<xs:sequence>
  <xs:sequence dfdl:hiddenGroupRef="tns:hiddenpDate"/>

  <xs:element name="d" type="date">
    <xs:annotation><xs:appinfo source=”http://www.ogf.org/dfdl/”>
      <dfdl:element>
        <dfdl:property name="inputValueCalc">
         {
           fn:date(fn:concat(if(../pdate/yy gt 50) then "19" else "20",
                             if ( ../pdate/yy gt 9 )
                                then fn:string(../pdate/yy)
                                else fn:concat("0",
                                       fn:string(../pdate/yy)),
                                       "-",
                                       fn:string(../pdate/mm),
                                       "-",
                                       fn:string(../pdate/dd)))
```

```
          }
         </dfdl:property>
       </dfdl:element>
     </xs:appinfo></xs:annotation>
  </xs:element>
           …
</xs:sequence>

<xs:group name="hiddenpDate" >
  <xs:sequence>
       <xs:element name="pdate">
          <xs:complexType>
            <xs:sequence dfdl:representation="binary”>
              <xs:element name="mm" type="byte"
                 dfdl:outputValueCalc="{ fn:month-from-date(../d) }" />
              <xs:element name="dd" type="byte"
                 dfdl:outputValueCalc="{ fn:day-from-date(../d) }" />
              <xs:element name="yy" type="byte"
                 dfdl:outputValueCalc="{ fn:year-from-date(../d)
idivmod 100 }"
               />
             </xs:sequence>
          </xs:complexType>
       </xs:element>
  </xs:sequence>
</xs:group>
```

The above sequence contains logically only a single date element.

18. External Control of the DFDL Processor

In addition to providing the DFDL schema and data to be parsed or serialized, DFDL Schemas can also be parameterized by external variables,.

DFDL processors can provide means to specify:

1. The data to be processed: a data stream when parsing or an infoset when unparsing.
2. The DFDL schema to be used
3. The *distinguished root node* element declaration to be used (specifying both name of element and namespace of that name)
4. Values for external variables

Notice also that like any XML schema a DFDL schema can have multiple top-level element declarations, so the distinguished root node is necessary to indicate which of these top-level element declarations is to be the starting point for processing data. The distinguished root node may be omitted if the DFDL schema contains only one top-level element declaration.
The mechanism by which a DFDL processor is controlled is not specified by this standard. For example, command line DFDL processors may use command line options, but DFDL processors embedded in other kinds of software systems may need other mechanisms.

19. Built-in Specifications

For convenience, a standard set of named DFDL format definitions may be provided with DFDL processors. These built-in format definitions may be imported by DFDL schema authors.

20. Conformance

DFDL conformance can be claimed for schema documents and for processors

A schema document conforms to this specification if it conforms to the subset of XML Schema 1.0 defined in section 5.1 DFDL Subset of XML Schema and consists of components which individually and collectively satisfy all the relevant constraints specified in this document.

Conformance may be claimed separately for a DFDL parser, a DFDL unparser or a DFDL processor that parses and unparses.

1. A DFDL processor claiming conformance MUST identify the level of conformance and version specification claimed.
2. A minimal conforming DFDL processor conforms to this specification when it implements all the non-optional features defined in this document.
3. A extended conforming DFDL processor conforms to the specification when it implements all the non-optional features and some of the optional features defined in this document.
4. A fully conforming DFDL processor conforms to the specification when it implements all the features defined in this document.

See 21 Optional DFDL Features for the list of optional feature

It is the intention of the DFDL Work Group to provide a conformance test suit to help verify conformance with this specification..

21. Optional DFDL Features

The following table lists the features of the DFDL language that are considered optional for DFDL processor implementations.

Feature	Detection
Validation	External switch
Simple type restrictions	xs:simpleType in xsd
Nils	xs:nillable='true' in xsd
Defaults	xs:default or xs:fixed in xsd
Bi-Directional text.	dfdl:textBiDi='yes'
Lengths in Bits	dfdl:alignmentUnits='bits' or dfdl:lengthUnits='bits'
Delimited lengths and representation binary element	dfdl:representation='binary' (or implied binary) and dfdl:lengthKind='delimited'
Regular expressions	dfdl:lengthKind='pattern', dfdl:assert dfdl:testkind 'pattern' , dfdl:discriminator dfdl:testkind 'pattern'
Zoned numbers	dfdl:textNumberRep='zoned'
Packed numbers	dfdl:binaryNumberRep='packed'
Packed calendars	dfdl:binaryCalendarRep='packed'
S/390 floats	dfdl:binaryFloatRep='ibm390Hex'
Unordered sequences	dfdl:sequenceKind='unordered'
Floating elements	dfdl:floating='yes'
dfdl functions in expression language	dfdl:functions in expression
Hidden groups	dfdl:hiddenRef <> ''
Calculated values	dfdl:inputValueCalc <> '' or dfdl:outputValueCalc <> ''
Escape schemes	dfd:defineEscapeScheme in xsd
Extended encodings	Any dfdl:encoding value beyond the core list
Asserts annotations	dfdl:assert in xsd
Discriminators annotations	dfdl:discriminator in xsd
Prefixed lengths	dfdl:lengthKind='prefixed'
Variables	dfdl:defineVariable, dfdl:newVariableInstances, dfdl:setVariable Variables in DFDL expression language

Table 24 Optional DFDL features

In order to provide portability of a DFDL schema, a minimal or extended conforming processor must ensure that all the required properties, as defined in the property precedence sections, are present in a schema, even when those properties are not implemented. For example if the bi-directional text feature is not implemented, it is still a schema definition error if dfdl:textBiDi is not set to 'no' an xs:string element.
It is a schema definition error if a DFDL schema uses an optional feature that is not supported by a minimal or extended conforming processor.

22. Property Precedence

22.1 Parsing

The following list gives the order in which DFDL properties are examined when the DFDL parser is positioned at a particular component in the DFDL schema, and about to parse the bitstream modeled by that component.

22.1.1 dfdl:element (simple) and dfdl:simpleType

- *Parsing: calculated value*
  - dfdl:inputValueCalc
- *Parsing: common*
  - dfdl:byteOrder
  - dfdl:encoding
    - 'UTF-16' 'UTF-16BE' 'UTF-16LE'
      - dfdl:utf16Width
  - dfdl:ignoreCase
- *Parsing: occurrences (does not apply to simple types or to global elements)*
  - dfdl:floating
  - (xs:maxOccurs > 1 or unbounded) or (xs:minOccurs = 0 and xs:maxOccurs = 1)
    - dfdl:occursCountKind
      - *"expression"*
        - dfdl:occursCount
      - *"fixed"*
        - xs:maxOccurs
      - *"parsed"*
      - *"stopValue"*
        - dfdl:occursStopValue
- *Parsing: identification, framing & extraction*
  - dfdl:leadingSkip
    - dfdl:alignmentUnits
  - dfdl:alignment
    - dfdl:alignmentUnits
  - dfdl:initiator
    - dfdl:nilValueDelimiterPolicy *(does not apply to simple types)*
    - dfdl:emptyValueDelimiterPolicy
  - dfdl:representation *"text" or xs:simpleType is 'string'*
    - dfdl:lengthKind
      - *"implicit"*
        - xs:maxLength *or* dfdl:textBooleanyyyRep
        - dfdl:lengthUnits
      - *"explicit"*
        - dfdl:length
        - dfdl:lengthUnits

                - *"prefixed"*
                    - dfdl:prefixLengthType
                    - dfdl:prefixIncludesPrefixLength
                    - dfdl:lengthUnits
                - *"pattern"*
                    - dfdl:lengthPattern
                - *"delimited", "endOfParent"*
                    - *None*
            - dfdl:textTrimKind
                - dfdl:textStringPadCharacter, dfdl:textNumberPadCharacter, dfdl:textBooleanPadCharacter or dfdl:textCalendarPadCharacter
                - dfdl:textStringJustification, dfdl:textNumberJustification, dfdl:textBooleanJustification or dfdl:textCalendarJustification
            - dfdl:escapeSchemeRef
            - dfdl:textBidi
                - dfdl:textBidiTextOrdering
                - dfdl:textBidiOrientation
        - dfdl:representation *"binary" or xs:simpleType is 'hexBinary'*
            - dfdl:lengthKind
                - *"implicit"*
                    - xs:maxLength *or* xs:simpleType
                    - dfdl:lengthUnits
                - *"explicit"*
                    - dfdl:length
                    - dfdl:lengthUnits
                - *"prefixed"*
                    - dfdl:prefixLengthType
                    - dfdl:prefixIncludesPrefixLength
                    - dfdl:lengthUnits
                - *"pattern"*
                    - dfdl:lengthPattern
                - *"endOfParent"*
                    - *None*
        - dfdl:terminator
            - dfdl:nilValueDelimiterPolicy *(does not apply to simple types)*
            - dfdl:emptyValueDelimiterPolicy
            - dfdl:documentFinalTerminatorCanBeMissing
        - dfdl:trailingSkip
            - dfdl:alignmentUnits
- *Parsing: conversion*
    - xs:nillable *(does not apply to simple types)*
        - dfdl:nilKind
            - *"literalValue", "logicalValue", "literalCharacter"*
                - dfdl:nilValue
    - xs:type

- *"Number"*
  - dfdl: decimalSigned
  - dfdl:representation
    - *"text"*
      - dfdl:textNumberRep
        - *"standard"*
          - dfdl:textNumberPattern
          - dfdl:textStandardDecimalSeparator
          - dfdl:textStandardGroupingSeparator
          - dfdl:textStandardExponentCharacter
          - dfdl:textNumberCheckPolicy
          - dfdl:textStandardInfinityRep
          - dfdl:textStandardNanRep
          - dfdl:textNumberRounding
            - "*explicit*"
              - dfdl:textNumberRoundingMode
              - dfdl:textNumberRoundingIncrement
          - dfdl:textStandardZeroRep
          - dfdl:textStandardBase
        - *"zoned"*
          - dfdl:textNumberPattern
          - dfdl:textNumberCheckPolicy
          - dfdl:textNumberRounding
            - "*explicit*"
              - dfdl:textNumberRoundingMode
              - dfdl:textNumberRoundingIncrement
          - dfdl:textZonedSignStyle
    - *"binary"*
      - *xs:decimal and restrictions*
        - dfdl:binaryNumberRep
          - *“packed”*
            - dfdl:binaryPackedSignCodes
            - dfdl:binaryDecimalVirtualPoint
            - dfdl:binaryNumberCheckPolicy
          - *“bcd”*
            - dfdl:binaryDecimalVirtualPoint

- *"binary"*
  - dfdl:binaryDecimalVirtualPoint
- *xs:float, xs:double*
  - dfdl:binaryFloatRep
- *"String"*
- *"Calendar"*
  - dfdl:representation
    - *"text"*
      - dfdl:calendarPatternKind "*explicit*"
        - dfdl:calendarPattern
      - dfdl:calendarCheckPolicy
      - dfdl:calendarTimeZone
      - dfdl:calendarObserveDST
      - dfdl:calendarFirstDayOfWeek
      - dfdl:calendarDaysInFirstWeek
      - dfdl:calendarCenturyStart
      - dfdl:calendarLanguage
    - *"binary"*
      - dfdl:binaryCalendarRep
        - *"packed"*
          - dfdl:packedDecimalSignCodes
          - dfdl:decimalVirtualPoint
          - dfdl:binaryNumberCheckPolicy
          - dfdl:calendarPatternKind
            - "*explicit*"
              - dfdl:calendarPattern
          - dfdl:calendarCheckPolicy
          - dfdl:calendarTimeZone
          - dfdl:calendarObserveDST
          - dfdl:calendarFirstDayOfWeek
          - dfdl:calendarDaysInFirstWeek
          - dfdl:calendarCenturyStart
        - *"bcd"*
          - dfdl:decimalVirtualPoint
          - dfdl:calendarPatternKind
            - "*explicit*"
              - dfdl:calendarPattern
          - dfdl:calendarCheckPolicy
          - dfdl:calendarTimeZone
          - dfdl:calendarObserveDST
          - dfdl:calendarFirstDayOfWeek
          - dfdl:calendarDaysInFirstWeek
          - dfdl:calendarCenturyStart
        - *"binarySeconds", "binaryMilliseconds"*

                - dfdl:binaryCalendarEpoch
            - *"Opaque"*
            - *"Boolean"*
                - dfdl:representation
                    - *"text"*
                        - dfdl:textBooleanTrueRep
                        - dfdl:textBooleanFalseRep
                    - *"binary"*
                        - dfdl:binaryBooleanTrueRep
                        - dfdl:binaryBooleanFalseRep
    - dfdl:useNilForDefault *(does not apply to simple types)*
        - *“true”*
            - *None*
        - *“false”*
            - xs:default or xs:fixed

22.1.2 dfdl:element (complex)

- *Parsing: common*
    - dfdl:byteOrder
    - dfdl:encoding
        - 'UTF-16' 'UTF-16BE' 'UTF-16LE'
            - dfdl:utf16Width
    - dfdl:ignoreCase
- *Parsing: occurrences (does not apply to global elements)*
    - dfdl:floating
    - (xs:maxOccurs > 1 or unbounded) or (xs:minOccurs = 0 and xs:maxOccurs = 1)
        - dfdl:occursCountKind
            - *"expression"*
                - dfdl:occursCount
            - *"fixed"*
                - xs:maxOccurs
            - *"parsed"*
            - *"stopValue"*
                - dfdl:occursStopValue
- *Parsing: identification, framing & extraction*
    - dfdl:leadingSkip
        - dfdl:alignmentUnits
    - dfdl:alignment
        - not *“implicit”*
            - dfdl:alignmentUnits
    - dfdl:initiator
        - dfdl:emptyValueDelimiterPolicy
    - dfdl:lengthKind

        - *"explicit"*
            - dfdl:length
            - dfdl:lengthUnits
        - *"prefixed"*
            - dfdl:prefixLengthType
            - dfdl:prefixIncludesPrefixLength
            - dfdl:lengthUnits
        - *"pattern"*
            - dfdl:lengthPattern
        - *"implicit", "delimited"*
            - *None*
    - dfdl:terminator
        - dfdl:emptyValueDelimiterPolicy
        - dfdl:documentFinalTerminatorCanBeMissing
    - dfdl:trailingSkip
        - dfdl:alignmentUnits

22.1.3 dfdl:sequence and dfdl:group (when reference is to a sequence)

- *Parsing: hidden (xs:sequence only)*
    - *dfdl:hiddenGroupRef*
- *Parsing: common*
    - dfdl:byteOrder
    - dfdl:encoding
        - 'UTF-16' 'UTF-16BE' 'UTF-16LE'
            - dfdl:utf16Width
    - dfdl:ignoreCase
- *Parsing: identification, framing & extraction*
    - dfdl:leadingSkip
        - dfdl:alignmentUnits
    - dfdl:alignment
        - *not "implicit"*
            - dfdl:alignmentUnits
    - dfdl:initiator
    - dfdl:sequenceKind
    - dfdl:initiatedContent
    - dfdl:separator
        - dfdl:separatorPosition
        - dfdl:separatorPolicy
        - dfdl:documentFinalSeparatorCanBeMissing
    - dfdl:terminator
        - dfdl:documentFinalTerminatorCanBeMissing
    - dfdl:trailingSkip
        - dfdl:alignmentUnits

22.1.4 dfdl:choice and dfdl:group (when reference is to a choice)

- *Parsing: common*
  - dfdl:byteOrder
  - dfdl:encoding
    - 'UTF-16' 'UTF-16BE' 'UTF-16LE'
      - dfdl:utf16Width
  - dfdl:ignoreCase
- *Parsing: identification, framing & extraction*
  - dfdl:leadingSkip
    - dfdl:alignmentUnits
  - dfdl:alignment
    - *not "implicit"*
      - dfdl:alignmentUnits
  - dfdl:initiator
  - dfdl:choiceLengthKind
    - *"explicit"*
      - dfdl:choiceLength
  - dfdl:initiatedContent
  - dfdl:terminator
    - dfdl:documentFinalTerminatorCanBeMissing
  - dfdl:trailingSkip
    - dfdl:alignmentUnits

22.2 Unparsing

The following list gives the order in which DFDL properties are examined when the DFDL unparser is positioned at a particular component in the DFDL Infoset, and about to unparsed and thereby create the bitstream which is the representation of that component.

22.2.1 dfdl:element (simple) and dfdl:simpleType

- *Unparsing: calculated value*
  - dfdl:inputValueCalc (if set them element is ignored)
  - dfdl:outputValueCalc
- *Unparsing: common*
  - dfdl:byteOrder
  - dfdl:outputNewLine
  - dfdl:encoding
    - 'UTF-16' 'UTF-16BE' 'UTF-16LE'
      - dfdl:utf16Width
  - dfdl:fillByte
- *Unparsing: repeats (does not apply to simple types or to global elements)*
  - (xs:maxOccurs > 1 or unbounded) or (xs:minOccurs = 0 and xs:maxOccurs = 1)

        - dfdl:occursCountKind
            - *"expression"*
                - dfdl:occursCount
            - *"fixed"*
                - xs:maxOccurs
            - *"parsed"*
            - *"stopValue"*
                - dfdl:occursStopValue

- *Unparsing: conversion*
    - dfdl:useNilForDefault *(does not apply to simple types)*
        - *“true”*
            - *None*
        - *“false”*
            - xs:default *or* xs:fixed
    - xs:nillable *(does not apply to simple types)*
        - dfdl:nilKind
            - *"literalValue", "logicalValue", "literalCharacter"*
                - dfdl:nilValue
    - xs:type
        - *"Number"*
            - dfdl:decimalSigned
            - dfdl:representation
                - *"text"*
                    - dfdl:textNumberRep
                        - *"standard"*
                            - dfdl:textNumberPattern
                            - dfdl:textStandardBase
                            - dfdl:textStandardDecimalSeparator
                            - dfdl:textStandardGroupingSeparator
                            - dfdl:textStandardExponentCharacter
                            - dfdl:textNumberCheckPolicy
                            - dfdl:textStandardInfinityRep
                            - dfdl:textStandardNanRep
                            - dfdl:textNumberRounding
                                - "*explicit*"
                                    - dfdl:textNumberRoundingMode
                                    - dfdl:textNumberRoundingIncrement
                            - dfdl:textStandardZeroRep
                        - *"zoned"*
                            - *d*fdl:textNumberPattern
                            - dfdl:textNumberCheckPolicy

- dfdl:textNumberRounding
  - "*explicit*"
    - dfdl:textNumberRoundingMode
    - dfdl:textNumberRoundingIncrement
- dfdl:textZonedSignStyle

- dfdl:textBidi
  - dfdl:textBidiTextOrdering
  - dfdl:textBiDiOrientation
  - dfdl:textBidiNumeralShapes

- *"binary"*
  - *xs:decimal and restrictions*
    - dfdl:binaryNumberRep
      - *“packed”*
        - dfdl:binaryPackedSignCodes
        - dfdl:binaryDecimalVirtualPoint
      - *“bcd”*
        - dfdl:binaryDecimalVirtualPoint
      - *“binary”*
        - dfdl:binaryDecimalVirtualPoint
  - *xs:float, xs:double*
    - dfdl:binaryFloatRep

- *"String"*
  - dfdl:textBidi
    - dfdl:textBidiTextOrdering
    - dfdl:textBiDiOrientation
    - dfdl:textBidiSymmetric
    - dfdl:textBidiTextShaped
- *"Calendar"*
  - dfdl:representation
    - *"text"*
      - dfdl:calendarPatternKind "*explicit*"
        - dfdl:calendarPattern
      - dfdl:calendarCheckPolicy
      - dfdl:calendarTimeZone
      - dfdl:calendarObserveDST
      - dfdl:calendarFirstDayOfWeek
      - dfdl:calendarDaysInFirstWeek
      - dfdl:calendarLanguage
      - dfdl:textBidi
        - dfdl:textBidiTextOrdering

- dfdl:textBiDiOrientation
- dfdl:textBidiSymmetric
- dfdl:textBidiTextShaped

- *"binary"*
  - dfdl:binaryCalendarRep
    - *“packed”*
      - dfdl:packedDecimalSignCodes
      - dfdl:decimalVirtualPoint
      - dfdl:binaryNumberCheckPolicy
      - dfdl:calendarPatternKind
        - "*explicit*"
          - dfdl:calendarPattern
      - dfdl:calendarCheckPolicy
      - dfdl:calendarTimeZone
      - dfdl:calendarObserveDST
      - dfdl:calendarFirstDayOfWeek
      - dfdl:calendarDaysInFirstWeek
      - dfdl:calendarCenturyStart
    - *“bcd”*
      - dfdl:decimalVirtualPoint
      - dfdl:calendarPatternKind
        - "*explicit*"
          - dfdl:calendarPattern
      - dfdl:calendarCheckPolicy
      - dfdl:calendarTimeZone
      - dfdl:calendarObserveDST
      - dfdl:calendarFirstDayOfWeek
      - dfdl:calendarDaysInFirstWeek
      - dfdl:calendarCenturyStart
    - *“binarySeconds”, “binaryMilliseconds”*
      - dfdl:binaryCalendarEpoch

- *"Opaque"*
- *"Boolean"*
  - dfdl:representation
    - *"text"*
      - dfdl:textBooleanTrueRep
      - dfdl:textBooleanFalseRep
      - dfdl:textBidi
        - dfdl:textBidiTextOrdering
        - dfdl:textBiDiOrientation
        - dfdl:textBidiSymmetric
        - dfdl:textBidiTextShaped
    - *"binary"*
      - dfdl:binaryBooleanTrueRep
      - dfdl:binaryBooleanFalseRep

- *Unparsing: insertion & framing*
  - dfdl:leadingSkip
    - dfdl:alignmentUnits
  - dfdl:alignment
    - *not "implicit"*
      - dfdl:alignmentUnits
  - dfdl:initiator
    - dfdl:nilValueDelimiterPolicy *(does not apply to simple types)*
    - dfdl:emptyValueDelimiterPolicy
  - dfdl:representation *"text" or xs:simpleType 'string'*
    - dfdl:escapeSchemeRef
    - dfdl:lengthKind
      - *"implicit"*
        - xs:maxLength *or* dfdl:textBooleanyyyRep
        - dfdl:lengthUnits
        - dfdl:textPadKind
          - dfdl:textStringPadCharacter, dfdl:textNumberPadCharacter, dfdl:textBooleanPadCharacter or dfdl:textCalendarPadCharacter
          - dfdl:textStringJustification, dfdl:textNumberJustification, dfdl:textBooleanJustification or dfdl:textCalendarJustification
        - dfdl:truncateSpecifiedLengthString
      - *"explicit"*
        - dfdl:length
        - dfdl:lengthUnits
        - dfdl:textPadKind
          - dfdl:textStringPadCharacter, dfdl:textNumberPadCharacter, dfdl:textBooleanPadCharacter or dfdl:textCalendarPadCharacter
          - dfdl:textStringJustification, dfdl:textNumberJustification, dfdl:textBooleanJustification or dfdl:textCalendarJustification
        - dfdl:truncateSpecifiedLengthString
      - *"prefixed"*
        - dfdl:prefixLengthType
        - dfdl:prefixIncludesPrefixLength
        - dfdl:lengthUnits
        - dfdl:textPadKind
          - dfdl:textStringPadCharacter, dfdl:textNumberPadCharacter, dfdl:textBooleanPadCharacter or dfdl:textCalendarPadCharacter

                - dfdl:textStringJustification, dfdl:textNumberJustification, dfdl:textBooleanJustification or dfdl:textCalendarJustification
                - xs:minLength *or* dfdl:textOutputMinLength
            - *“pattern”, "delimited", "endOfParent"*
                - dfdl:textPadKind
                - dfdl:textStringPadCharacter, dfdl:textNumberPadCharacter, dfdl:textBooleanPadCharacter or dfdl:textCalendarPadCharacter
                - dfdl:textStringJustification, dfdl:textNumberJustification, dfdl:textBooleanJustification or dfdl:textCalendarJustification
                - xs:minLength *or* dfdl:textOutputMinLength
    - dfdl:representation *“binary” or xs:simpleType 'hexBinary'*
        - dfdl:lengthKind
            - *"implicit"*
                - xs:maxLength *or* xs:simpleType
                - dfdl:lengthUnits
            - *“explicit”*
                - dfdl:length
                - dfdl:lengthUnits
            - *"prefixed"*
                - dfdl:prefixLengthType
                - dfdl:prefixIncludesPrefixLength
                - dfdl:lengthUnits
            - *“pattern”, "endOfParent"*
                - *None*
    - dfdl:terminator
        - dfdl:nilValueDelimiterPolicy *(does not apply to simple types)*
        - dfdl:emptyValueDelimiterPolicy
    - dfdl:trailingSkip
        - dfdl:alignmentUnits

22.2.2 dfdl:element (complex)

- *Unparsing: common*
    - dfdl:byteOrder
    - dfdl:outputNewLine
    - dfdl:encoding
        - 'UTF-16' 'UTF-16BE' 'UTF-16LE'
            - dfdl:utf16Width
    - dfdl:fillByte
- *Unparsing: repeats (does not apply to simple types or to global elements)*

- (xs:maxOccurs > 1 or unbounded) or (xs:minOccurs = 0 and xs:maxOccurs = 1)
  - dfdl:occursCountKind
    - *"expression"*
      - dfdl:occursCount
    - *"fixed"*
      - xs:maxOccurs
    - *"parsed"*

- *Unparsing: insertion & framing*
  - dfdl:leadingSkip
    - dfdl:alignmentUnits
  - dfdl:alignment
    - *not "implicit"*
      - dfdl:alignmentUnits
  - dfdl:initiator
    - dfdl:emptyValueDelimiterPolicy
  - dfdl:lengthKind
    - *"explicit"*
      - dfdl:length
      - dfdl:lengthUnits
    - *"prefixed"*
      - dfdl:prefixLengthType
      - dfdl:prefixIncludesPrefixLength
      - dfdl:lengthUnits
    - *"implicit", "pattern", "delimited"*
      - *None*
  - dfdl:terminator
    - dfdl:emptyValueDelimiterPolicy
  - dfdl:trailingSkip
    - dfdl:alignmentUnits

22.2.3 dfdl:sequence and dfdl:group (when reference is a sequence)

- *Parsing: hidden (xs:sequence only)*
  - dfdl:hiddenGroupRef
- *Unparsing: common*
  - dfdl:byteOrder
  - dfdl:outputNewLine
  - dfdl:encoding
    - 'UTF-16' 'UTF-16BE' 'UTF-16LE'
      - dfdl:utf16Width
  - dfdl:fillByte
- *Unparsing: insertion & framing*
  - dfdl:leadingSkip
    - dfdl:alignmentUnits

    - dfdl:alignment
        - *not "implicit"*
            - dfdl:alignmentUnits
    - dfdl:initiator
    - dfdl:separator
        - dfdl:separatorPosition
        - dfdl:separatorPolicy
    - dfdl:terminator
    - dfdl:trailingSkip
        - dfdl:alignmentUnits

22.2.4 dfdl:choice and dfdl:group (when reference is a choice)

- *Unparsing: common*
    - dfdl:byteOrder
    - dfdl:outputNewLine
    - dfdl:encoding
        - 'UTF-16' 'UTF-16BE' 'UTF-16LE'
            - dfdl:utf16Width
    - dfdl:fillByte
- *Unparsing: insertion & framing*
    - dfdl:leadingSkip
        - dfdl:alignmentUnits
    - dfdl:alignment
        - *not "implicit"*
            - dfdl:alignmentUnits
    - dfdl:initiator
    - dfdl:choiceLengthKind
        - *explicit"*
            - dfdl:choiceLength
    - dfdl:terminator
    - dfdl:trailingSkip
        - dfdl:alignmentUnits

23. Expression language

The DFDL expression language allows the processing of values conforming to the data model defined in the DFDL Infoset. It allows properties in the DFDL schema to be dependent of the contents of an instance of a DFDL document, a DFDL variable or another property in the schema. For example the length of an element can be made dependent on the contents of another element in the document.
The main uses of the expression language are as follows:

1. When a DFDL property needs to be set dynamically at parse time from the contents of one or more elements of the data. Properties such as initiator, terminator, length, separator, and nilValues accept an expression.
2. In a dfdl:assert annotation
3. In a dfdl:discriminator annotation to resolve uncertainty when parsing
4. In a dfdl:inputValueCalc property to derive the value of an element in the logical model that doesn't exist in the physical data.
5. In a dfdl:outputValueCalc property to compute the value of an element on unparsing.
6. As the value in a dfdl:setVariable annotation or the dfdl:defaultValue in a dfdl:defineVariable.

The DFDL expression language is a subset of XPath 2.0 [XPath2]. DFDL uses a subset of XML schema and has a simpler information model, so only a subset of XPath 2.0 expressions is meaningful in DFDL Schemas. For example there are no attributes in DFDL so the attribute axis is not needed.

23.1 Expression Language Data Model

The DFDL expression language operates on the DFDL infoset with the addition of the hidden elements. That is, it operates on the *augmented* infoset.
During parsing, expressions can reference any element preceding the current position. During parsing only a limited degree of reference to elements following the current position is allowed. Forward reference can occur only in the context of adfdl:discriminator annotation and implementations may have varying ability to support forward reference.
During unparsing, expressions can reference any element either preceding or following the current element in the data stream.

23.2 Variables

A variable is a binding between a (qualified) name and a (typed) value. Variables are defined using the dfdl:defineVariable annotation (see 7.7); defining a variable causes an initial instance also to be created. Further instances of variables are created using the dfdl:newVariableInstance annotation. Instances of variables are assigned a value using the dfdl:setVariable annotation. Variables are referenced in expressions by preceding the QName with '$'.
This section describes the semantics of variables. Any implementation consistent with the behavior described here is acceptable.
The memory where the information about a variable is stored during DFDL processing is called the *variable memory*. A variable is a name that is associated with a storage tuple in the variable memory.
Specifically, the variable memory contains:

- a counter used to generate locations for new tuples. Initial value is 1.
- an ordered list of locations. Each location contains a tuple of values:
    - has-been-set flag. This Boolean is originally false. dfdl:setVariable changes this flag to true.
    - has-been-referenced flag. This Boolean is originally false. Evaluation of an expression that uses the variable value changes the value to true.

- has-value flag. This Boolean is originally true if the dfdl:defineVariable or dfdl:newVariableInstance annotation has a default value specified, or if a default value has been supplied externally. Otherwise it is false, but is set to true if a dfdl:setVariable annotation is processed.
- typeID. This string is a type identifier taken from the type specified in the dfdl:defineVariable annotation.
- value. This is a typed value, or the distinguished value "unknown". The type of the value must correspond to the typeID. The value is optionally specified in dfdl:defineVariable or dfdl:newVariableInstance annotations in which case we refer to it as the *default value* for the variable. A default value may also be provided by the DFDL processor when the variable is defined with external="true".

The variable memory is initialized when a dfdl:defineVariable annotation is encountered.
Each time a dfdl:newVariableInstance annotation is encountered, the parser captures the current value of the counter from the variable memory. It then creates a new variable memory where the location counter's value is one greater, and where the list of locations has been augmented with a new tuple at the location given by the prior value of the location counter. The tuple is initialized based on the specifics of the dfdl:defineVariable annotation.

23.2.1 Rewinding of Variable Memory State

Upon exit of the scope where the new variable instance was created, the newly created variable memory is discarded and the prior variable memory is restored.
Note that the above algorithm insures that each time a dfdl:newVariableInstance is encountered, a fresh location is initialized for it, and once the scope containing that variable goes out of scope, the instance tuple for the variable can no longer be reached. A different variable instance tuple may now be visible if there is one still in an enclosing scope.

23.2.2 Variable Memory State Transitions

The flags in the variable memory tuples are interpreted and modified as follows:

DFDL annotation	*before annotation processed*			*after annotation processed*		
	has-been-set	*has-been-referenced*	*has-value*	*has-been-set*	*has-been-referenced*	*has-value*
defineVariable (without default or external value)	tuple doesn't exist			false	false	false
defineVariable (with default value)	tuple doesn't exist			false	false	true
defineVariable (with external value)	tuple doesn't exist			false	false	true
newVariableInstance (without default value)	tuple doesn't exist			false	false	false
newVariableInstance (with default value)	tuple doesn't exist			false	false	true
setVariable	tuple doesn't exist			schema definition error		
	false	false	false	true	false	true
	false	false	true	true	false	true (also value changed to new value)
	false	true	false	impossible state. The flags cannot get into this configuration.		
	false	true	true	schema definition error – set after		

				reference not allowed.		
	true	false	false	impossible state. The flags cannot get into this configuration.		
	true	false	true	schema definition error – double set not allowed		
	true	true	false	impossible state. The flags cannot get into this configuration.		
	true	true	true	validator should issue warning – double set not allowed unless on separate branches of a choice and this can only be determined reliably at runtime		
reference variable (from DFDL expression)	tuple doesn't exist			schema definition error		
	false	false	false	schema definition error – undefined variable		
	false	false	true	false	true (value is returned)	true
	false	true	false	impossible state. The flags cannot get into this configuration.		
	false	true	true	false	true (value is returned)	true
	true	false	false	impossible state. The flags cannot get into this configuration.		
	true	false	true	true	true (value is returned)	true
	true	true	false	impossible state. The flags cannot get into this configuration.		
	true	true	true	true	true (value is returned)	true

Table 25 Variable memory states.

The above table describes a set of rules which might be abbreviated as:

- write once, read many
- no write after the value has been read

An exception to this behavior occurs whenever the DFDL processor backtracks because it is processing multiple arms of a choice or as a result of speculative parsing. In this case the variable state is also rewound.
It is a schema definition error if a dfdl:setVariable or a variable reference occurs and there is no corresponding variable name defined by a dfdl:defineVariable annotation.
It is a schema definition error if a dfdl:setVariable provides a value of incorrect type which does not correspond to the type specified by the dfdl:defineVariable.
It is a schema definition error if a variable reference in an expression is able to return a value of incorrect type for the evaluation of that expression. That is, DFDL - including the expressions contained in it - is a statically type-checkable language. DFDL implementations may issue these schema definition errors prior to processing time.

23.3 General Syntax

DFDL expressions follow the XPath 2.0 syntax rules but are always enclosed in curly braces “{“ and “}”.
When expressions are used for a property which accepts a string literal then “{{“should be used to escape when a “{“is required as a character.
Examples

```
{ /book/title }
{ $x+2 }
```

```
{ if (fn:exists(../field1))  then 1 else 0  }
```

The result of evaluating the expression must be a single atomic value of the type expected by the context. Expressions must not return a sequence containing more than one item or a processing error will occur. If the expression returns an empty sequence it will be treated as returning *nil*.

23.4 DFDL Expression Syntax

Refer to XML Path Language (XPath) 2.0 [XPath2 for a description of XPath expressions

```
DFDL Expression      ::=  "{" Expr "}"
Expr                 ::=  ExprSingle
ExprSingle           ::=   IfExpr
                         | OrExpr
IfExpr               ::=  "if" "(" Expr ")" "then" ExprSingle
                          "else" ExprSingle
OrExpr               ::=  AndExpr ( "or" AndExpr )*
AndExpr              ::=  ComparisonExpr ( "and"
                          ComparisonExpr )*
ComparisonExpr       ::=  AdditiveExpr ( (ValueComp
                          ) AdditiveExpr)?

AdditiveExpr         ::=  MultiplicativeExpr ( ("+" | "-")
                          MultiplicativeExpr )*
MultiplicativeExpr   ::=  UnaryExpr  ( ("*" | "div" | "idiv"
                         | "mod") UnaryExpr  )*
UnaryExpr            ::=  ("-" | "+")* ValueExpr
ValueExpr            ::=  PathExpr
ValueComp            ::=  "eq" | "ne" | "lt" | "le" | "gt" |
                          "ge"
PathExpr             ::=  ("/" RelativePathExpr?)
                         | RelativePathExpr
RelativePathExpr     ::=  StepExpr (("/") StepExpr)*
StepExpr             ::=  FilterExpr | AxisStep
AxisStep             ::=  (ReverseStep | ForwardStep)
                          Predicate
ForwardStep          ::=  (ForwardAxis NodeTest) |
                          AbbrevForwardStep
ForwardAxis          ::=  ("child" "::")
                         | ("self" "::")

AbbrevForwardStep    ::=  NodeTest
ReverseStep          ::=  (ReverseAxis NodeTest) |
                          AbbrevReverseStep
ReverseAxis          ::=  ("parent" "::")
                          ")
AbbrevReverseStep    ::=  ".."
NodeTest             ::=  NameTest
```

```
NameTest            ::=  QName
FilterExpr          ::=  PrimaryExpr Predicate
Predicate           ::=  "[" Expr "]"
PrimaryExpr         ::=  Literal | VarRef |
                         ParenthesizedExpr | ContextItemExpr
                         | FunctionCall
Literal             ::=  NumericLiteral | StringLiteral
NumericLiteral      ::=  IntegerLiteral | DecimalLiteral |
                         DoubleLiteral
VarRef              ::=  "$" VarName
VarName             ::=  QName
ParenthesizedExpr   ::=  "(" Expr? ")"
ContextItemExpr     ::=  "."
FunctionCall        ::=  QName "(" (ExprSingle ("," 
                         ExprSingle)*)? ")"
```

Table 26 DFDL Expression Language

Notes:

1. Only *If* and *path* expression types are supported
2. Only the *child*, *parent*, and *self* axes are supported
3. Predicates are only used to index arrays and so must be integer expressions otherwise a schema definition error occurs
4. A subset of the XPath 2.0 operators are supported

23.5 Constructors, Functions and Operators

23.5.1 Constructor Functions for XML Schema Built-in Types

The following constructor functions for the built-in types are supported:

- `xs:string($arg as xs:anyAtomicType?) as xs:string?`
- `xs:boolean($arg as xs:anyAtomicType?) as xs:boolean?`
- `xs:decimal($arg as xs:anyAtomicType?) as xs:decimal?`
- `xs:float($arg as xs:anyAtomicType?) as xs:float?`
- `xs:double($arg as xs:anyAtomicType?) as xs:double?`
- `xs:dateTime($arg as xs:anyAtomicType?) as xs:dateTime?`
- `xs:time($arg as xs:anyAtomicType?) as xs:time?`
- `xs:date($arg as xs:anyAtomicType?) as xs:date?`
- `xs:hexBinary($arg as xs:anyAtomicType?) as xs:hexBinary?`
- `xs:integer($arg as xs:anyAtomicType?) as xs:integer?`

- `xs:long($arg as xs:anyAtomicType?) as xs:long?`
- `xs:int($arg as xs:anyAtomicType?) as xs:int?`
- `xs:short($arg as xs:anyAtomicType?) as xs:short?`
- `xs:byte($arg as xs:anyAtomicType?) as xs:byte?`
- `xs:nonNegativeInteger($arg as xs:anyAtomicType?) as xs:nonNegative Integer?`
- `xs:unsignedLong($arg as xs:anyAtomicType?) as xs:unsignedLong?`
- `xs:unsignedInt($arg as xs:anyAtomicType?) as xs:unsignedInt?`
- `xs:unsignedShort($arg as xs:anyAtomicType?) as xs:unsignedShort?`
- `xs:unsignedByte($arg as xs:anyAtomicType?) as xs:unsignedByte?`

A Special Constructor Function for xs:dateTime
A special constructor function is provided for constructing a `xs:dateTime` value from an `xs:date` value and an `xs:time` value.
`fn:dateTime($arg1 as xs:date?, $arg2 as xs:time?) as xs:dateTime?`

23.5.2 Standard XPath Functions

23.5.2.1 Boolean functions

The following additional constructor functions are defined on the boolean type.

Function	*Meaning*
fn:true	Constructs the xs:boolean value 'true'.
fn:false	Constructs the xs:boolean value 'false'.

Table 27 Boolean functions

The following functions are defined on boolean values:

Function	*Meaning*
fn:not	Inverts the `xs:boolean` value of the argument.

Table 28 Boolean functions

23.5.2.2 Numeric Functions

The following functions are defined on numeric types. Each function returns a value of the same type as the type of its argument.

Function	*Meaning*
fn:abs	Returns the absolute value of the argument.
fn:ceiling	Returns the smallest number with no fractional part that is greater than or equal to the argument.
fn:floor	Returns the largest number with no fractional part that is less than or equal to the argument.
fn:round	Rounds to the nearest number with no fractional part.
fn:round-half-to-even	Takes a number and a precision and returns a number rounded to the given precision. If the fractional part is exactly half, the result is the number whose least significant digit is even.

Table 29 Numeric Functions

23.5.2.3 String Functions

The following functions are defined on values of type `xs:string` and types derived from it.

Function	*Meaning*
`fn:concat`	`Concatenates two or more xs:anyAtomicType arguments cast to xs:string.`
`fn:substring`	`Returns the xs:string located at a specified place within an argument xs:string.`
`fn:string-length`	`Returns the length of the argument.`
`fn:upper-case`	`Returns the upper-cased value of the argument.`
`fn:lower-case`	`Returns the lower-cased value of the argument.`

Function	*Meaning*
`fn:contains`	`Indicates whether one xs:string contains another xs:string. A collation may be specified.`
`fn:starts-with`	`Indicates whether the value of one xs:string begins with the collation units of another xs:string. A collation may be specified.`
`fn:ends-with`	`Indicates whether the value of one xs:string ends with the collation units of another xs:string. A collation may be specified.`
`fn:substring-before`	`Returns the collation units of one xs:string that precede in that xs:string the collation units of another xs:string. A collation may be specified.`
`fn:substring-after`	`Returns the collation units of xs:string that follow in that xs:string the collation units of another xs:string. A collation may be specified.`

Table 30 String Functions

23.5.2.4 Date, Time functions:

Function	*Meaning*
fn:year-from-dateTime	Returns the year from an xs:dateTime value.
fn:month-from-dateTime	Returns the month from an xs:dateTime value.
fn:day-from-dateTime	Returns the day from an xs:dateTime value.
fn:hours-from-dateTime	Returns the hours from an xs:dateTime value.
fn:minutes-from-dateTime	Returns the minutes from an xs:dateTime value.
fn:seconds-from-dateTime	Returns the seconds from an xs:dateTime value.
fn:year-from-date	Returns the year from an xs:date value.
fn:month-from-date	Returns the month from an xs:date value.
fn:day-from-date	Returns the day from an xs:date value.
fn:hours-from-time	Returns the hours from an xs:time value.
fn:minutes-from-time	Returns the minutes from an xs:time value.
fn:seconds-from-time	Returns the seconds from an xs:time value.

Table 31 Date, Time functions:

23.5.2.5 Sequences functions

The following functions are defined on sequences. (Note that DFDL v1.0 does not support sequences of length > 1.)

Function	*Meaning*
fn:empty	Indicates whether or not the provided sequence is empty.
fn:exists	Indicates whether or not the provided sequence is not empty.

Table 32 Sequences functions

23.5.2.6 Node functions

This section discusses functions and operators on nodes.

Function	*Meaning*
fn:name	Returns the name of the context node or the specified node as an xs:string.
fn:local-name	Returns the local name of the context node or the specified node as an xs:NCName.
fn:namespace-uri	Returns the namespace URI as an xs:anyURI for the xs:QName of the argument node or the context node if the argument is omitted. This may be the URI corresponding to the zero-length string if the xs:QName is in no namespace.

Table 33 Node functions

23.5.3 DFDL Functions

Function	*Meaning*
dfdl:representationLength	Returns the unparsed length the specified node as an xs:unsignedlong. The length is the number of 'bytes', 'characters' or 'bits' depending on second argument
dfdl:unpaddedLength	Returns the unpadded length the specified node as an xs:unsignedlong. The unpadded length excludes any padding or filling. The length is the number of 'bytes', 'characters' or 'bits' depending on second argument
dfdl:property	Returns the value of requested DFDL property of the specified node as an xs:string. Ex dfdl:property(‘byteorder’, ‘./address ‘)
dfdl:testbit	Returns Boolean true if the bit number given by arg #2 is set on in the byte given by arg #1, otherwise returns Boolean false.
dfdl:setBits	Returns an unsigned byte being the value of the bit positions provided by the Boolean arguments, where true=1, false=0. The number of arguments must be 8.
dfdl:countWithDefault	Returns the count the number of occurrences including the effect of defaulting as an xs:int
dfdl:count	Returns the number of occurrences in an array as an xs:int.
dfdl:position	Returns the position of the current item within an array as an xs:int.
dfdl:checkConstraints	Returns boolean true if the specified node value satisfies the XML schema constraints specified. Returns false if the specified node does not meet the constraints or does not exist.

Table 34 DFDL Functions

Notes:
dfdl:unpaddedLength(path) - returns the unpadded length which excludes any padding or filling which might be added for a *specified length*

If the element declaration in the DFDL schema corresponding to the infoset item is not potentially represented, then the unpadded length is defined to be 0.

The unpadded length includes the length contributions from introduced escape characters required to escape contained delimiters (if such are defined, and will appear in the output representation).

The unpadded length is also a function of the dfdl:encoding property. Multi-byte and variable-width character set encodings will commonly contribute more bytes to the unpadded length than a single-byte character set would.

The unpadded length is computed from the DFDL infoset value, ignoring the dfdl:length or dfdl:textOutputMinLength property. Other DFDL properties which affect the length of a text or binary representation are respected, it is only an explicit length which is ignored.

For a complex type, this means a bottom up totaling of the dfdl:representationLength() of all the contents and framing of the complex type.

dfdl:representationLength(path) – returns the length of the representation of the infoset data item as identified by the path argument. This includes padding or filling or truncation which might be carried out for a *specified length* item.

If the element declaration in the DFDL schema corresponding to the infoset item is not potentially represented, then the length is defined to be 0.
When unparsing with dfdl:lengthKind="explicit", the calculation of dfdl:representationLength() returns the value of the dfdl:length property.

For both dfdl:representationLength and dfdl:unpaddedLength, the representation length excludes any alignment filling as well as excluding any leading or trailing skip bytes. That is, the returned length is about the length of the content, and not about the position of that content in the output data stream.

24. DFDL Regular Expressions

A DFDL regular expression may be specified for the dfdl:lengthPattern format property and the dfdl:testPattern attribute of the dfdl:assert and dfdl:disciminator annotations.

A DFDL regular expression may be either a PERL regular expression [PERLRE] or a Java® regular expression [JAVARE]. For portability it is recommended that use is restricted to a common subset of the PERL and Java syntax.

25. Security Considerations

All locations must be properly initialized before writing so as to prevent accidental (or purposeful) transmission of data in the unused parts of data formats. Even when a DFDL description does not specify that data should be written to a particular part of the output representation, a defined pattern should always be written.

When unparsing data it is a schema definition error if the representation properties that control filling and padding are not defined by the DFDL schema. The DFDL processor must fail if they are not defined so that it is certain no region of the output data has unspecified contents.

If regions within a DFDL-described data object are encrypted, then when decrypting them proper means must be used to assure secure passage of passwords to the decrypting software. Such means are beyond the scope of the DFDL language specification.

In addition, if encryption passwords/keys are stored in DFDL schema-described data, then proper means must be used to assure that the decrypted form of these passwords is not revealed. Such means are beyond the scope of the DFDL language specification.

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[RDP] recursive descent parser**.** A "top-down" parser built from a set of mutually-recursive procedures or a non-recursive equivalent where each such procedure usually implements one of the productions of the grammar. Thus the structure of the resulting program closely mirrors that of the grammar it recognises.
["Recursive Programming Techniques", W.H. Burge, 1975, ISBN 0-201-14450-6].
(1995-04-28)

31. Appendix A:Escape Scheme Use Cases

31.1 Escape Character same as dfdl:escapeEscapeCharacater

EscapeKind='escapeCharacter', escapeCharacter='/', ecsapeEscapeCharacater='/', separator=';', extraEscapeCharacter='?'

Data	*Result*
……..	……..
……/……..	……//……..
……/…./……..	……//….//……..
……//……..	……////……..
/……..	//……..
……../	……..//
/……/……..	//……//……..
……/……../	……//……..//
……;……..	……/;……..
……/;……..	……///;……..
;……..	/;……..
……?……..	……/?……..

31.2 Escape Character different from dfdl:escapeEscapeCharacater

EscapeKind='escapeCharacter', escapeCharacter='/', ecsapeEscapeCharacater='%', separator=';', extraEscapeCharacter='?'

Data	*Result*
……..	……..
……/……..	……%/……..
……/…./……..	……%/….%/……..
……//……..	……%/%/……..
/……..	%/……..
……../	……..%/
/……/……..	%/……%/……..
……/……../	……%/……..%/
……;……..	……/;……..
……/;……..	……%//;……..
;……..	/;……..
……?……..	……/?……..
……%……..	……%……..
……%/……..	……%%/……..
……/%……..	……%/%……..

EscapeKind='escapeCharacter', escapeCharacter='/', ecsapeEscapeCharacater='%', separator='sep', extraEscapeCharacter='?'

Data	*Result*
……sep……..	……/sep……..
……/sep……..	……%//sep……..
sep……..	/sep……..

31.3 Escape block with different start and end characters

EscapeKind='escapeBlock', escapeBlockStart='[', escapeBlockEnd=']',
ecsapeEscapeCharacater='%', separator=';', extraEscapeCharacter='?'

Data	*Result*
……..	……..
[……..	[[……..]
]……..	]……..
……[……..	……[……..
……]……..	……]……..
……..]	……..]
[[……..	[[[……..]
……..]]	……..]]
……[[……..	……[[……..
……]]……..	……]]……..
[……..]	[[……..%]]
[……]……..	[[……%]……..]
……[……..]	……[……..]
[……[……..]	[[……[……..%]]
[……]……..]	[[……%]……..%]]
[[……..]	[[[……..%]]
[……..]]	[[……..%]%]]
[[……..]]	[[[……..%]%]]
……%……..	……%……..
……%%……..	……%%……..
……%[……..	……%[……..
……%]……..	……%]……..
%[……..	%[……..
……..%]	……..%]
%[……..%]	%[……..%]
[……%……..]	[[……%……..%]]
[……%]……..]	[[……%%]……..%]]
……;……..	[……;……]
……%;……..	[……%;……]
[……;……]	[[……;……%]]
……?……..	[……?……]

31.4 Escape block with same start and end characters

EscapeKind='escapeBlock', escapeBlockStart=' '', escapeBlockEnd=' '',
ecsapeEscapeCharacater='%', separator=';', extraEscapeCharacter='?'

Data	*Result*
……..	……..
'……..	'%'……..'
……'……..	……'……..
……..'	……..'
''……..	'%'%'……..'
……..''	……..''
……''……..	……''……..
'……..'	'%'……..%''

'……'……..	'%'……%'……..'
……'……..'	……'……..'
'……'……..'	'%'……%'……..%"
''……..'	'%'%'……..%"
'……..."	'%'……..%'%"
''……..."	'%'%'……..%'%"
……%……..	……%……..
……%%……..	……%%……..
……%'……..	……%'……..
%'……..	%'……..
……..%'	……..%'
'……..%'	'%'……..%%"
%'……..%'	%'……..%'
'……%……..'	'%'……%……..%"
'……%'……..'	'%'……%%'……..%"
……;……..	'……;……..'
……%;……..	'……%;……..'
'……;……..'	'%'……;……..%"
……?……..	'……?……..'

32. Appendix B: Encoding of delimiters different to encoding of data (eg, initiator and terminator different to data)

- Use <xs:sequence> to wrap the element and carry the delimiters, for example:

```
    <sequence dfdl:encoding="ascii" dfdl:separator=":">
        <sequence dfdl:encoding=" ebcdic-cp-us" dfdl:initiator="VAL"
dfdl:terminator="END">
            <element name="val" type="..." dfdl:encoding="ascii" />
        </sequence>
    </sequence>
```

The same technique can be used with dfdl:ignoreCase when the case-sensitivity of data is different to that of surrounding delimiters.