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OGC Network Common Data Form (NetCDF) Core Encoding Standard version 1.0

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i. Abstract

This document specifies the network Common Data Form (netCDF) core standard and extension mechanisms. The OGC netCDF encoding supports electronic encoding of geospatial data, specifically digital geospatial information representing space and time-varying phenomena.

NetCDF is a data model for array-oriented scientific data. A freely distributed collection of access libraries implementing support for that data model, and a machine-independent format are available. Together, the interfaces, libraries, and format support the creation, access, and sharing of multi-dimensional scientific data.

ii. Keywords

Ogcdoc, netcdf, netcdf-core, multi-dimensional

iii. Preface

This document specifies the core of the OGC netCDF encoding standard.

iv. Terms and definitions

This document uses the specification terms defined in Subclause 5.3 of [OGC 06-121r8], which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this standard.

v. Submitting organizations

The following organizations submitted this Candidate Implementation Specification to the Open Geospatial Consortium Inc.

- IMAA-CNR Italy
- METEO-FRANCE
- Natural Environment Research Council (NERC)
- Northrop Grumman Corporation
- University Corporation for Atmospheric Research (UCAR)
- US National Oceanic and Atmospheric Administration (NOAA)

vi. Submission contact points

Name	Organization
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Stefano Nativi	University of Florence, CNR/IMAA

vii. Changes to the OpenGIS® Abstract Specification

The OpenGIS® Abstract Specification does not require any changes to accommodate the technical contents of this (part of this) document.

viii. Future work

Based on this netCDF core standard, several extensions are foreseen. An outline of how these extensions can be defined is provided in the CF-netCDF Primer, OGC-10-091r3.

Foreword

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The Open Geospatial Consortium shall not be held responsible for identifying any or all such patent rights.

Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the standard set forth in this document, and to provide supporting documentation.

Introduction

The OGC netCDF encoding supports electronic encoding of geospatial data, specifically digital geospatial information representing space and time-varying phenomena.

This document specifies the netCDF core; every netCDF encoding *shall* adhere to the mandatory requirements as specified in this standard.

NetCDF (network Common Data Form) is a data model for array-oriented scientific data. A freely distributed collection of access libraries implementing support for that data model, and a machine-independent format are available. Together, the interfaces, libraries, and format support the creation, access, and sharing of multi-dimensional scientific data.

NetCDF data is intended to make possible the creation of collections of data that are:

- Self-Describing: A netCDF dataset may include descriptive information about the data they contain. Hence a netCDF dataset may constitute a complete and independent unit with no need for external metadata.
- Portable: Computers with different ways of storing integers, characters, and floating point numbers can access netCDF data.
- Direct-access: A small subset of a large data set may be accessed efficiently, without first reading through all the preceding data.
- Appendable: Data may be appended to a properly structured netCDF file without copying the data set or redefining its structure.
- Sharable: One writer and multiple readers may simultaneously access the same netCDF file. Using parallel netCDF interfaces, multiple writers may write a file concurrently.
- Archivable: Access to current and earlier forms of netCDF data will be supported by current and future versions of the software.

The purpose of netCDF is to provide a data model, software libraries, and machine-independent data format for geoscience data. Together, the netCDF interfaces, libraries, and format support the creation, access, and sharing of scientific data. With suitable community conventions, netCDF can help improve interoperability among data providers, data users, and data services.

OGC Abstract Specification: NetCDF Core

1 Scope

This OGC standard defines the netCDF data model and the core set of requirements to which every netCDF encoding must adhere. Extensions to the NetCDF core standard add further functionality to the core requirements. In particular, netCDF extensions to the core are required for specific encodings, such as the 64-bit Offset Format. This document indicates which extensions, at minimum, need to be considered in addition to the core for creating useful standards that can be implemented to meet interoperability requirements of domains and information communities.

2 Conformance

Standardization targets are netCDF implementations (currently: encodings).

This document establishes a single requirements class, *core*, of

http://www.opengis.net/spec/netcdf/1.0/req/core

with a single pertaining conformance class, *core*, with URI

http://www.opengis.net/spec/netcdf/1.0/conf/core.

Requirements and conformance test URIs defined in this document are relative to

http://www.opengis.net/spec/netcdf/1.0/.

Annex A (normative) specifies conformance tests which shall be exercised by any encoded dataset claiming to implement an OGC netCDF encoding.

3 Normative references

The OGC NetCDF Core standard consists solely of this document.

The complete standard is identified by OGC URI http://www.opengis.net/spec/netcdf/1.0.

The document has OGC URI http://www.opengis.net/doc/IS/netcdf/1.0.

4 Terms and definitions

For the purposes of this document, the terms and definitions given in the above references apply. In addition, the following terms and definitions apply.

4.1 attribute

Attributes hold metadata. An attribute contains information about properties of a variable or an entire dataset. The usage of this term in the context of netCDF is given in Chapter 6.

4.2 coordinate variable

A coordinate variable is a variable that identifies a coordinate axis.

4.3 data

The ISO definition of data is the reinterpretable representation of information in a formalized manner suitable for communication, interpretation, or processing [ISO/IEC 2382-1].

4.4 data model

A data model is a description of the organization of data in a manner that reflects an information structure [ISO/IEC 11179-1].

4.5 data type

According to ISO, the definition of a data type is the specification of a value domain with operations allowed on values in this domain [ISO 19103]. The usage of this term in the context of netCDF is given in Chapter 6.

4.6 data value

According to OGC Observations and Measurements, a data value is the result of a specialized event called an observation. An observation is an act of observing a property or phenomenon, with the goal of producing an estimate of the value of the property [OGC 07-022r1].

4.7 dataset

According to ISO, a dataset is an identifiable collection of data [ISO 19101].

4.8 dimension

Dimensions are used to specify variable shapes, common grids, and coordinate systems. The usage of this term in the context of netCDF is given in Chapter 6.

Note that certain specifications of common grids and coordinate systems are done in netCDF conventions which are beyond the scope of this netCDF core specification and are part of extension specifications.

4.9 domain

A domain is a well-defined set [ISO 19103].

4.10 encoding

An encoding is a conversion of data into a series of codes [ISO 19118].

4.11 global attribute (dataset attribute)

Global attributes apply to a whole data set and may be used to record properties of all the data in a file, such as processing history or conventions used.

4.12 grid

A grid is a network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in an algorithmic way [ISO 19123].

Note that certain specifications of common grids and coordinate systems are done in netCDF conventions which are beyond the scope of this netCDF core specification and are part of extension specifications.

4.13 metadata

Metadata is data about data [ISO 19115].

4.14 model

A model is an abstraction of some aspects of reality [ISO 19109].

4.15 netCDF

NetCDF (network Common Data Form) is a data model for array-oriented scientific data, a freely distributed collection of access libraries implementing support for that data model, and a machine-independent format. Together, the interfaces, libraries, and format support the creation, access, and sharing of scientific data.

The classic model represents information in a netCDF data set using dimensions, variables, and attributes, to capture the meaning of array-oriented scientific data.

Note that this document is the specification of the netCDF classic data model. The formal requirements are given in Chapter 6.

4.16 netCDF conventions

The mere use of netCDF is not sufficient to make data "self-describing" and meaningful to both humans and machines. The names of variables and dimensions should be meaningful and conform to any relevant conventions. Dimensions should have corresponding coordinate variables where sensible.

Conventions provide a mechanism whereby a community can specify standard ways to represent quantities and coordinate systems within the simple framework provided by netCDF, using only dimensions, variables, attributes, and a limited set of six primitive types.

Note that the specification of conventions is not covered in the core netCDF specification, but is left to be done in extension specifications.

4.17 record

A record is a finite, named collection of related items (objects or values).

The usage of this term in the context of netCDF is given in Chapter 6.

4.18 record dimension (unlimited length dimension)

In the netCDF classic model, at most one dimension can have the unlimited length, which means variables can grow along that dimension. Record dimension is another term for an unlimited dimension.

The usage of this term in the context of netCDF is given in Chapter 6.

4.19 shape

The shape of a variable is specified with a list of zero or more dimensions.

The usage of this term in the context of netCDF is given in Chapter 6.

4.20 variable

A variable has a name, type, shape, attributes, and values. In face, much of the netCDF specification consists of defining the specific characteristics of variables. Variables hold data values. In the netCDF model, a variable can hold a multidimensional array of values of the same type.

The usage of this term in the context of netCDF is given in Chapter 6.

4.21 variable attribute

Variable attributes record the properties of one variable.

The usage of this term in the context of netCDF is given in Chapter 6.

4.22 NetCDF-specific definitions

The following table lists the definitions specific to the context of this specification. They are all of definition type "property." The base URI to be used with the tokens is:

http://www.opengis.net/def/property/netcdf/1.0/{URI_token}

Table 1 -- NetCDF-specific Definitions

Defined Term	URI Token	Source Clause in this document: OGC 10-090
attribute	attribute	4.1
coordinate variable	coordinateVariable	4.2
dimension	dimension	4.6
global attribute	globalAttribute	4.11

netCDF	netcdf	4.15
netCDF conventions	netcdfConventions	4.16
record	record	4.17
record dimension	recordDimension	4.18
shape	shape	4.19
variable	variable	4.20
variable attribute	variableAttribute	4.20

5 Document Conventions

5.1 UML notation

All the diagrams that appear in this specification are presented using the Unified Modeling Language (UML) static structure diagram, as described in Subclause 5.2 of OGC Web Services Common [OGC 06-121r8].

5.2 Data dictionary tables

The UML model data dictionary is specified herein in a series of tables. The contents of the columns in these tables are described in Subclause 5.5 of [OGC 06-121r8]. The contents of these data dictionary tables are normative, including any table footnotes.

5.3 Namespace prefix conventions

Since there are no XML schemas used in this specification, there are no namespace mappings. It is possible that extensions may involve schemas, in which case the namespace mappings will be listed in those specification documents.

6 NetCDF classic data model

This Clause specifies the underlying data model for a netCDF classic dataset used in the further Clauses of this standard.

6.1 NetCDF classic model overview

The classic model represents information in a netCDF data set using dimensions, variables, and attributes, to capture the meaning of array-oriented scientific data. Figure 1 presents a UML diagram of the classic data model.

6.2 NetCDF classic data model UML notation

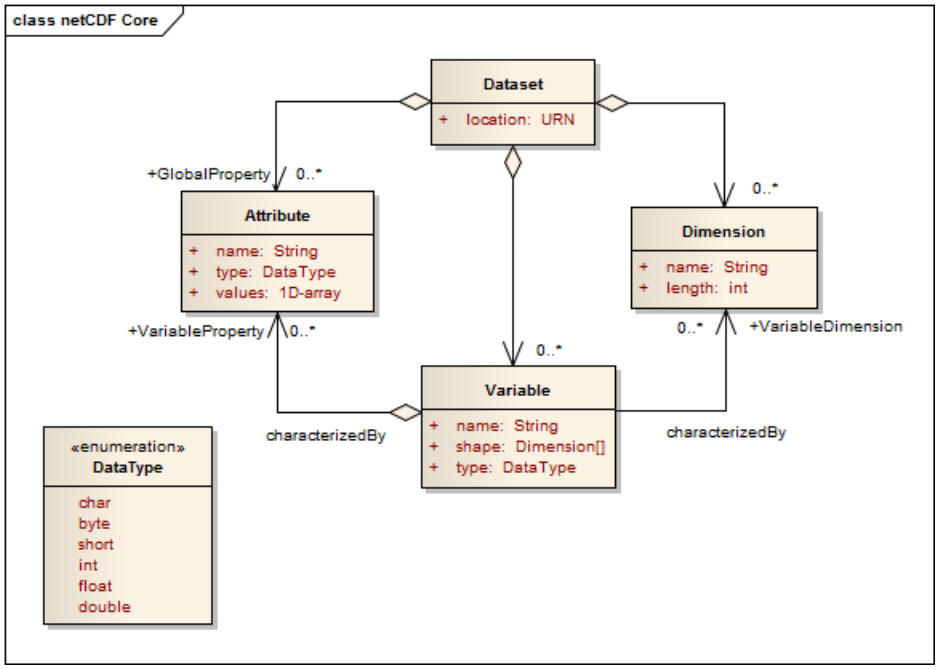

Figure 1: netCDF classic data model

For a more comprehensive explanation of the netCDF data model, see the NetCDF User's Guide[1] or the online NetCDF Workshop for Developers and Data Providers [3].

Requirement 1 http://www.opengis.net/spec/netcdf/1.0/req/core/data-model-elements:

NetCDF classic datasets shall represent information using dimensions, variables and attributes using the primitive data types as shown in the UML diagram in Figure 1.

6.3 Primitive data types

Requirement 2 http://www.opengis.net/spec/netcdf/1.0/req/core/primitive-data-types:

Variables and attributes shall have one of six primitive data types: char, byte, short, int, float, double.

6.4 Variables

Variables hold data values. In the classic model, a variable can hold a multidimensional array of values of the same type. A variable has a name, type, shape, attributes, and values. The shape of a variable is specified with a list of zero or more dimensions:

- 0 dimensions: a scalar variable with only one value.
- 1 dimension: a 1-D (vector) variable.
- 2 dimensions: a 2-D (matrix or grid) variable.

- ...
- N dimensions: a N-D (matrix or grid) variable.

A variable may have zero or more variable attributes.

Requirement 3 http://www.opengis.net/spec/netcdf/1.0/req/core/variable-name-type-value:

A variable shall have a name, type, and data values.

Requirement 4 http://www.opengis.net/spec/netcdf/1.0/req/core/variable-shape:

The shape of a variable shall be specified with a list of zero or more dimensions.

6.5 Dimensions

Dimensions are used to specify variable shapes, common grids, and coordinate systems A dimension has a name and a length. Dimensions may be shared among variables, indicating a common grid. Dimensions may be associated with coordinate variables to identify coordinate axes. In the classic model, at most one dimension can have the unlimited length, which means variables can grow along that dimension. Record dimension is another term for an unlimited dimension. (In the enhanced model, multiple dimensions can have the unlimited length.)

Note that certain specifications of common grids and coordinate systems are done in netCDF conventions which are beyond the scope of this netCDF core specification and are part of extension specifications. Likewise this core specification is confined to the netCDF classic data model so the specification of the enhanced model is left to an extension specification.

Requirement 5 http://www.opengis.net/spec/netcdf/1.0/req/core/dimension-shapes:

Dimensions shall specify variable shapes which may be shared as common grids.

Requirement 6 http://www.opengis.net/spec/netcdf/1.0/req/core/dimension-name-length:

A dimension shall have a name and a length.

Requirement 7 http://www.opengis.net/spec/netcdf/1.0/req/core/record-dimension:

At most one dimension (the record dimension) shall have unlimited length

6.5.1 Attribute

Attributes hold metadata. An attribute contains information about properties of a variable or an entire data set. Variable attributes may be used to specify properties such as units. Attributes that apply to a whole data set, also called global attributes, may be used to record properties of all the data in a file, such as processing history or conventions used. An attribute may have zero, one, or multiple values (1-D), but attributes cannot be multidimensional.

NetCDF conventions are defined primarily in terms of attributes. Thus the names of attributes are typically standardized in conventions rather than the names of variables. NetCDF conventions are specified in extensions to this core specification.

An attribute may have zero, one, or multiple values (one dimensional).

A netCDF dataset may have zero or more global attributes.

Requirement 8 http://www.opengis.net/spec/netcdf/1.0/req/core/global-attribute-metadata:

Global attributes shall hold metadata about the entire dataset.

Requirement 9 http://www.opengis.net/spec/netcdf/1.0/req/core/variable-attribute:

A variable attribute shall hold metadata about one variable.

Requirement 10 http://www.opengis.net/spec/netcdf/1.0/req/core/attribute-dimension:

An attribute shall have at most one dimension.

Bibliography

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[ISO 19115, *Geographic information – Metadata*, 2003] (Metadata)

[ISO 19118, *Geographic information – Encoding*, 2005] (Encoding)

[ISO 19123, *Geographic information -- Schema for coverage geometry and functions*, 2005] (Grid)

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http://www.unidata.ucar.edu/netcdf/docs/netcdf.html

Unidata UCAR, NetCDF Reference Implementations
ftp://ftp.unidata.ucar.edu/pub/netcdf/netcdf.tar.gz

Annex A: Conformance Class Abstract Test Suite (Normative).

A netCDF encoding must satisfy the following characteristics to be conformant with this specification. Note, however, that an encoding extension is needed in order to actually implement executable tests corresponding to these abstract tests.

A.1 Conformance Test Class: netCDF Core

Applies for conformance class netCDF with URI
http://www.opengis.net/spec/netcdf/1.0/conf/core

A.1.1 Requirement 1

Test ID	**Conformance Test for Requirement 1** **http://www.opengis.net/spec/netcdf/1.0/conf/core/data-model-elements:**
Test purpose	NetCDF classic datasets shall represent information using dimensions, variables and attributes using the primitive data types as shown in the UML diagram in Figure 1.
Test method	Open the dataset and check that it represents information using dimensions, variables and attributes using the primitive data types as shown in the UML diagram in Figure 1.

A.1.2 Requirement 2

Test ID	**Conformance Test for Requirement 2** **http://www.opengis.net/spec/netcdf/1.0/conf/core/primitive-data-types**
Test purpose	Variables and attributes shall have one of six primitive data types: char, byte, short, int, float, double.
Test method	Open the dataset and check that all variables and attributes have one of six primitive data types: char, byte, short, int, float, double.

.

A.1.3 Requirement 3

Test ID	**Conformance Test for Requirement 3** **http://www.opengis.net/spec/netcdf/1.0/conf/core/variable-name-type-value**
Test purpose	A variable shall have a name, type, and values.
Test method	Open the dataset and check that all variables have a name, type, and values.

A.1.4 Requirement 4

Test ID	**Conformance Test for Requirement 4** **http://www.opengis.net/spec/netcdf/1.0/conf/core/variable-shape**
Test purpose	The shape of a variable shall be specified with a list of zero or more dimensions
Test method	Open the dataset and check that, for any variable for which there is a shape, the shape is specified with a list of zero or more dimensions.

A.1.5 Requirement 5

Test ID	**Conformance Test for Requirement 5** **http://www.opengis.net/spec/netcdf/1.0/conf/core/dimension-shapes**
Test purpose	Dimensions shall specify variable shapes which may be shared as common grids.
Test method	Open the dataset and check that, for any variable for which there is a shape dimensions specify the variable shape.

A.1.6 Requirement 6

Test ID	**Conformance Test for Requirement 6** **http://www.opengis.net/spec/netcdf/1.0/conf/core/dimension-name-length**
Test purpose	A dimension shall have a name and a length.
Test method	Open the dataset and check that all dimensions have a name and a length.

A.1.7 Requirement 7

Test ID	**Conformance Test for Requirement 7** **http://www.opengis.net/spec/netcdf/1.0/conf/core/record-dimension**
Test purpose	At most one dimension (the record dimension) shall have unlimited length
Test method	Open the dataset and check that at most one dimension (the record dimension) has unlimited length.

A.1.8 Requirement 8

Test ID	**Conformance Test for Requirement 8** **http://www.opengis.net/spec/netcdf/1.0/conf/core/global-attribute-metadata**
Test purpose	Global attributes shall hold metadata about the entire dataset
Test method	Open the dataset and check that any global attributes present hold metadata about the entire dataset..

A.1.9 Requirement 9

Test ID	**Conformance Test for Requirement 9** **http://www.opengis.net/spec/netcdf/1.0/conf/core/variable-attribute**
Test purpose	A variable attribute shall hold metadata about one variable
Test method	Open the dataset and check that each variable attribute holds metadata about one variable

A.1.10 Requirement 10

Test ID	**Conformance Test for Requirement 10** **http://www.opengis.net/spec/netcdf/1.0/conf/core/attribute-dimension**
Test purpose	An attribute shall have at most one dimension.
Test method	Open the dataset and check that each attribute has at most one dimension.

- end of ATS –

Annex B: Revision history

Date	Release	Author	Paragraph modified	Description
2010-08-27	1.0.0	Ben Domenico, Stefano Nativi	All	Created
2010-10-20	1.0.1	Bruce Wright and Ben Domenico	4, 4.21, 6.4, 6.5, 6.5.1, A.1.3, A.1.5, A.1.10, A.1.13	Added one definition, removed unnecessary requirements and corresponding conformance tests.
2010-12-28	1.0.2	Ben Domenico	4.22	Added sentence specifying base URI for definitions. Reformatted section so URIs appear on separate lines for clarity
2010-12-28	1.0.2	Ben Domenico	6.,Annex A	Added leading "." to relative URIs.
2010-12-28	1.0.2	Ben Domenico	2,3	Changed URI references according to recommendations of OGC Naming Authority
2010-12-28	1.0.2	Ben Domenico	Table of Contents	Updated Table of Contents to get page numbers correct after edits.
2011-01-07	1.0.2	Ben Domenico	5.3	Removed Table 2: Namespace mappings table because no schemas are used in this specification
2011-01-22	1.0.2	Carl Reed	Various	Prepare for publication as OGC standard
2011-02-16	1.0.2	Ben Domenico	Various	Prepare for publication