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Open Geospatial Consortium

TOPIC NN - ABSTRACT CONCEPTUAL MODEL FOR TIME

ABSTRACT SPECIFICATION TOPIC

CANDIDATE SWG DRAFT

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Note

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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.

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I ABSTRACT

Traditionally, geospatial communities used 2D coordinates and the vertical and temporal aspects were considered attributes rather than fully fledged coordinate systems. In an increasingly dynamic, speedier and multidimensional world, much confusion and lack of interoperability has occurred because of inconsistent approaches to time. Much effort has been expended by various international bodies to establish the Gregorian Calendar as a consistent timeline. This suffices for low precision, such as to the nearest minute, but not so when second or sub-second accuracy is required. For example, there has been differing practices and no consensus on whether leap seconds should be part of the Gregorian timeline.

The fundamental concepts of events, clocks, timescales, coordinates and calendars have been long established, but there is no clear, straightforward defining document. This document aims to to give clear consistent definitions of the fundamental concepts and terminology, so that people are well aware of the advantages and disadvantages of adopting a particular technological approach and then perhaps they can contribute to building better and more interoperable systems using other more detailed documents such as logical and implementation standards that have an agreed common conceptual basis and terminology.

This document is consistent with ISO 19111 and W3C REC-owl-time-20171019 in OWL.

The aim of this document is to establish clear concepts and terminology.

II KEYWORDS

The following are keywords to be used by search engines and document catalogues.

ogcdoc, OGC document, abstract specification, conceptual model, time, temporal referencing, referencing by coordinates, calendar, clock, timescale

III PREFACE

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IV SECURITY CONSIDERATIONS

No security considerations have been made for this document.

V SUBMITTING ORGANIZATIONS

The following organizations submitted this Document to the Open Geospatial Consortium (OGC):

- Met Office, HeazelTech

VI SUBMITTERS

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VII INTRODUCTION

When OGC standards involve time, they generally refer to the ISO documents such as ISO 19108 (now largely superseded), ISO 19111, ISO 8601, and their freely available OGC equivalents, such as OGC 18-005r4 (the equivalent to ISO 19111).

Much effort over decades has gone into establishing complex structures to represent calendar based time, such as the ISO 8601 notation, and many date-time schemas. Because of this effort, many people use calendar based “coordinates”, with the attendant ambiguities, imprecision and inappropriate scope.

The aim of this document is to establish clear concepts and terminology, so that people are well aware of the advantages and disadvantages of adopting a particular technological approach and then perhaps contribute to building better interoperable systems.

2

CONFORMANCE

2 CONFORMANCE

Clause 6 of this International Standard uses the Unified Modeling Language (UML) to present conceptual schemas for describing the higher level classes of time and temporal reference systems. These schemas define conceptual classes that

a) may be considered to comprise a cross-domain application schema, or

b) may be used in application schemas, profiles and implementation specifications.

This flexibility is controlled by a set of UML types that can be implemented in a variety of manners. Use of alternative names that are more familiar in a particular application is acceptable, provided that there is a one- to-one mapping to classes and properties in this International Standard. The UML model in this International Standard defines conceptual classes; various software systems define implementation classes or data structures. All of these reference the same information content. The same name may be used in implementations as in the model, so that types defined in the UML model may be used directly in application schemas.

Annex A defines a set of conformance tests that will support applications whose requirements range from the minimum necessary to define data structures to full object implementation.

1

SCOPE

1 SCOPE

This document defines the major underlying concepts regarding time. It does not define any concrete temporal reference systems or give detailed guidance on implementations.

3

NORMATIVE REFERENCES

3 NORMATIVE REFERENCES

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO: ISO 19111:2019, *Geographic information – Referencing by coordinates*, 2019, https://www.iso.org/standard/74039.html

W3C: Time Ontology in OWL, 2017, https://www.w3.org/TR/2017/REC-owl-time-20171019/Unresolved directive in sections/03-references.adoc — include::..\..\..\Temporal-Abstract-Spec — Copy\abstract-specification\sections\03-references.adoc[]

4

TERMS AND DEFINITIONS

4 TERMS AND DEFINITIONS

This document uses the terms defined in OGC Policy Directive 49, 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 document and OGC documents do not use the equivalent phrases in the ISO/IEC Directives, Part 2.

This document also uses terms defined in the OGC Standard for Modular specifications (OGC 08-131r3), also known as the ‘ModSpec’. The definitions of terms such as standard, specification, requirement, and conformance test are provided in the ModSpec.

For the purposes of this document, the following additional terms and definitions apply.

4.1. conceptual model

description of common concepts and their relationships, particularly in order to facilitate exchange of information between parties within a specific domain. A conceptual model is explicitly chosen to be independent of design or implementation concerns.

[**SOURCE:**]

4.2. compound coordinate reference system

coordinate reference system using at least two independent coordinate reference systems

Note 1 to entry: Coordinate reference systems are independent of each other if coordinate values in one cannot be converted or transformed into coordinate values in the other.

[**SOURCE:** ISO 19111]

4.3. coordinate

one of a sequence of numbers designating the position of a point

Note 1 to entry: In a spatial coordinate reference system, the coordinate numbers are qualified by units.

[**SOURCE:** ISO 19111]

4.4. coordinate epoch

epoch to which coordinates in a dynamic coordinate reference system are referenced

[**SOURCE:** ISO 19111]

4.5. coordinate reference system

coordinate system that is related to an object by a datum

Note 1 to entry: Geodetic and vertical datums are referred to as reference frames.

Note 2 to entry: For geodetic and vertical reference frames, the object will be the Earth. In planetary applications, geodetic and vertical reference frames may be applied to other celestial bodies.

[**SOURCE:** ISO 19111]

4.6. coordinate system

set of mathematical rules for specifying how coordinates are to be assigned to points

[**SOURCE:** ISO 19111]

4.7. **datum**

reference frame ADMITTED

parameter or set of parameters that realize the position of the origin, the scale, and the orientation of a coordinate system

[**SOURCE:** ISO 19111]

4.8. **derived coordinate reference system**

coordinate reference system that is defined through the application of a specified coordinate conversion to the coordinates within a previously established coordinate reference system

Note 1 to entry: The previously established coordinate reference system is referred to as the base coordinate reference system.

Note 2 to entry: A derived coordinate reference system inherits its datum or reference frame from its base coordinate reference system.

Note 3 to entry: The coordinate conversion between the base and derived coordinate reference system is implemented using the parameters and formula(s) specified in the definition of the coordinate conversion.

[**SOURCE:** ISO 19111]

4.9. **dynamic coordinate reference system**

coordinate reference system that has a dynamic reference frame

Note 1 to entry: Coordinates of points on or near the crust of the Earth that are referenced to a dynamic coordinate reference system may change with time, usually due to crustal deformations such as tectonic motion and glacial isostatic adjustment.

Note 2 to entry: Metadata for a dataset referenced to a dynamic coordinate reference system should include coordinate epoch information.

[**SOURCE:** ISO 19111]

4.10. dynamic reference frame

dynamic datum ADMITTED

reference frame in which the defining parameters include time evolution

Note 1 to entry: The defining parameters that have time evolution are usually a coordinate set.

[**SOURCE:** ISO 19111]

4.11. engineering coordinate reference system

coordinate reference system based on an engineering datum

Example 1 System for identifying relative positions within a few kilometres of the reference point, such as a building or construction site.

Example 2 Coordinate reference system local to a moving object such as a ship or an orbiting spacecraft.

Example 3 Internal coordinate reference system for an image. This has continuous axes. It may be the foundation for a grid.

4.12. engineering datum

local datum ADMITTED

datum describing the relationship of a coordinate system to a local reference

Note 1 to entry: Engineering datum excludes both geodetic and vertical reference frames.

[**SOURCE:** ISO 19111]

4.13. epoch

<geodesy> point in time

Note 1 to entry: In this document an epoch is expressed in the Gregorian calendar as a decimal year.

Example 2017-03-25 in the Gregorian calendar is epoch 2017.23.

[**SOURCE:** ISO 19111]

4.14. frame reference epoch

epoch of coordinates that define a dynamic reference frame

[**SOURCE:** ISO 19111]

4.15. linear coordinate system

one-dimensional coordinate system in which a linear feature forms the axis

Example 1 Distances along a pipeline.

Example 2 Depths down a deviated oil well bore.

[**SOURCE:** ISO 19111]

4.16. parameter reference epoch

epoch at which the parameter values of a time-dependent coordinate transformation are valid

Note 1 to entry: The transformation parameter values first need to be propagated to the epoch of the coordinates before the coordinate transformation can be applied.

[**SOURCE:** ISO 19111]

4.17. **parametric coordinate reference system**

coordinate reference system based on a parametric datum

[**SOURCE:** ISO 19111]

4.18. **parametric coordinate system**

one-dimensional coordinate system where the axis units are parameter values which are not inherently spatial

[**SOURCE:** ISO 19111]

4.19. **parametric datum**

datum describing the relationship of a parametric coordinate system to an object

Note 1 to entry: The object is normally the Earth.

[**SOURCE:** ISO 19111]

4.20. **point motion operation**

coordinate operation that changes coordinates within one coordinate reference system due to the motion of the point

Note 1 to entry: The change of coordinates is from those at an initial epoch to those at another epoch.

Note 2 to entry: In this document the point motion is due to tectonic motion or crustal deformation.

[**SOURCE:** ISO 19111]

4.21. reference frame

datum ADMITTED

parameter or set of parameters that realize the position of the origin, the scale, and the orientation of a coordinate system

[**SOURCE:** ISO 19111]

4.22. spatio-parametric coordinate reference system

compound coordinate reference system in which one constituent coordinate reference system is a spatial coordinate reference system and one is a parametric coordinate reference system

Note 1 to entry: Normally the spatial component is "horizontal" and the parametric component is "vertical".

[**SOURCE:** ISO 19111]

4.23. spatio-parametric-temporal coordinate reference system

compound coordinate reference system comprised of spatial, parametric and temporal coordinate reference systems

[**SOURCE:** ISO 19111]

4.24. spatio-temporal coordinate reference system

compound coordinate reference system in which one constituent coordinate reference system is a spatial coordinate reference system and one is a temporal coordinate reference system

[**SOURCE:** ISO 19111]

4.25. static coordinate reference system

coordinate reference system that has a static reference frame

Note 1 to entry: Coordinates of points on or near the crust of the Earth that are referenced to a static coordinate reference system do not change with time.

Note 2 to entry: Metadata for a dataset referenced to a static coordinate reference system does not require coordinate epoch information.

[**SOURCE:** ISO 19111]

4.26. static reference frame

static datum

reference frame in which the defining parameters exclude time evolution

[**SOURCE:** ISO 19111]

4.27. temporal coordinate reference system

coordinate reference system based on a temporal datum

[**SOURCE:** ISO 19111]

4.28. temporal coordinate system

<geodesy> one-dimensional coordinate system where the axis is time
[**SOURCE:** ISO 19111]

4.29. **temporal datum**

datum describing the relationship of a temporal coordinate system to an object

Note 1 to entry: The object is normally time on the Earth.

[**SOURCE:** ISO 19111]

4.30. **terrestrial reference system**

TRS ADMITTED

set of conventions defining the origin, scale, orientation and time evolution of a spatial reference system co-rotating with the Earth in its diurnal motion in space

Note 1 to entry: The abstract concept of a TRS is realised through a terrestrial reference frame that usually consists of a set of physical points with precisely determined coordinates and optionally their rates of change. In this document terrestrial reference frame is included within the geodetic reference frame element of the data model

[**SOURCE:** ISO 19111]

5

CONVENTIONS

5 CONVENTIONS

5.1. Abbreviated terms

CRS	Coordinate Reference System
TRS	Temporal Reference System
UML	Unified Modelling Language
2D	2-dimensional
3D	3-dimensional

5.2. Identifiers

The normative provisions in this standard are denoted by the URI:

http://www.opengis.net/spec/{standard}/{m.n}

All requirements and conformance tests that appear in this document are denoted by partial URIs which are relative to this base.

6

CHARACTERISTICS OF AN ABSTRACT CONCEPTUAL MODEL

6 CHARACTERISTICS OF AN ABSTRACT CONCEPTUAL MODEL

The terms and definitions clause in this Abstract Specification provides a short definition for “conceptual model”. This clause provides additional information on the OGC use of “conceptual model”.

A conceptual model organizes the vocabulary needed to communicate consistently and thoroughly about the know-how of a problem domain. The aim of a conceptual model is to express the meaning of terms and concepts used by domain experts to discuss the problem, and to find the correct relationships between different concepts.

A conceptual model:

1. is a representation of a system, made of the composition of concepts which are used to help people know, understand, or simulate a subject the model represents. A documented conceptual model represents ‘concepts’ (entities), the relationships between them, and a vocabulary;
2. is explicitly defined to be independent of design or implementation concerns;
3. organizes the vocabulary needed to communicate consistently and thoroughly about the know-how of a problem domain;
4. starts with a glossary of terms and definitions. There is a very high premium on high-quality, design-independent definitions, free of data or implementation biases; the model also emphasizes rich vocabulary; and
5. is always about identifying the correct choice of terms to use in communications, including statements of rules and requirements, especially where high precision and subtle distinctions need to be made. The core concepts of a temporal geospatial problem domain are typically quite stable over time.

7

TEMPORAL ABSTRACT CONCEPTUAL MODEL

7 TEMPORAL ABSTRACT CONCEPTUAL MODEL

This attempt at a Temporal Abstract Conceptual Model follows ISO 19111, which is the ISO adoption of OGC 18-005r4.

The model is also informed by W3C REC-owl-time-20171019.

NOTE: This Mermaid diagram should be converted to PlantUML for Metanorma, by replacing the Mermaid container with the following.

```
@startuml
.
.
@enduml
```

Figure 1

```
classDiagram
class ReferenceSystem {
       Dimension 1..*
       ApplicableLocationTimeOrDomain 1
       AuthoritativeOwnerOrDefiningBody 1
    }
    class SpatialReferenceSystem {
       Dimension 1..*
       ApplicableLocationTimeOrDomain 1
       AuthoritativeOwnerOrDefiningBody 1
    }
    class TemporalReferenceSystem {
       Dimension 1
       ApplicableLocationTimeOrDomain 1
       AuthoritativeOwnerOrDefiningBody 1
    }
ReferenceSystem "1" <|-- "1..*" SpatialReferenceSystem
ReferenceSystem "1" <|-- "1..*" TemporalReferenceSystem
    TemporalReferenceSystem "0..1" <|-- "1" TemporalCoordinateReferenceSystem
    TemporalReferenceSystem "0..1" <|-- "1" Calendar
    TemporalReferenceSystem "0..1" <|-- "1" OrdinalTemporalReferenceSystem
class TemporalCoordinateReferenceSystem {
NameOrId
OptionalEpochDefinedInSomeOtherTemporalReferenceSystem
OptionalNameForEachTick
OptionalEndTimeOrCount
OptionalLocation
OptionalNotation
}
TemporalCoordinateReferenceSystem "1" o-- "1" Timescale
TemporalCoordinateReferenceSystem "1" o-- "1" Epoch
TemporalCoordinateReferenceSystem "1" --> "1..*" Notation
class Calendar {
   NameOrId
   AstronomicalAttribute [e.g. solar, sidereal, lunar, luni-solar]
   PredictiveAttribute [e.g. observed or calculated]
   EpochOrStartTime
   OptionalEndTime
   OptionalLocationOrRegionOfApplicability
   ConstituentUnitsOrClocksAndCountsOrTimescales
   OptionalNotation
```

```
    }
Calendar "1" o-- "0..1" Epoch
Calendar "1" o-- "1..*" Timescale
Calendar "1" o-- "1" Algorithm
Calendar "1" --> "1..*" Notation
class OrdinalTemporalReferenceSystem {
    NameOrId
    ListedOrEnumeratedSequenceOfEvents
    FirstAndLastEvents
    OptionalEpochDefinedInSomeOtherTemporalReferenceSystem
    OptionalLocationOrRegionOfApplicability
    OptionalNotations
    }
OrdinalTemporalReferenceSystem "1" o-- "0..1" Epoch
OrdinalTemporalReferenceSystem "1" o-- "2..*" Event
OrdinalTemporalReferenceSystem "1" --> "1..*" Notation
Timescale "1" o-- "1" Clock
```

Figure 2

8

TEMPORAL REGIMES

8 TEMPORAL REGIMES

8.1. General

To help us think more clearly about time, this paper adopts the term "Regime" to describe the fundamentally different types of time and its measurement under consideration. This is a pragmatic approach that allows the grouping of recommendations and best practices in a practical way, but without obscuring the connection to the underlying theoretical components.

The first three regimes have deep underlying physical and mathematical foundations which cannot be legislated away. The fourth regime, of calendars, uses a seemingly random mixture of ad hoc algorithms, arithmetic, numerology and measurements. Paradoxically, this regime has historically driven advances in mathematics and physics.

The regimes are applicable to other planets and outer space, but with due consideration.

8.2. Events and Operators

The simplest way of relating entities in time is by events that can be ordered, that is, established in a sequence, and this sequence is used as an approximate measure of the passage of time.

In this regime, no clocks or time measurements are defined, only events, that are ordered in relation to each other. For example, geological layers, sediment or ice core layers, archaeological sequences, sequential entries in computer logs without coordinated time.

One set of events may be completely ordered with respect to each other, but another set of similar internally consistent events cannot be cross-referenced until extra information is available. Even then, only partial orderings may be possible.

In this regime, the Allen Operators (Maintaining Knowledge about Temporal Intervals) can be used. If A occurs before B and B occurs before C, then we can correctly deduce that A occurs before C. The full set of operators also covers pairs of intervals. So in our example, B occurs in the interval (A,C). However, we cannot perform arithmetic operations like (B-A) or (C-A) as we have not defined any timescale or measurements. For example, 'subtracting' Ordovician from Jurassic is meaningless.

This regime constitutes an Ordinal Temporal Reference System, with discrete enumerated ordered events.

8.3. Simple Clocks and Discrete Timescales

In this regime, a clock is defined as any regularly repeating physical phenomena, such as pendulum swings, earth's rotation about sun, earth's rotation about its axis, heart beats, vibrations of electrically stimulated quartz crystals or the resonance of the unperturbed ground-state hyperfine transition frequency of the caesium 133 atom. Some phenomena make better clocks that others, in terms of the number of repetitions possible, the consistency of each repetition and the precision of each 'tick'. A mechanism for counting, or possibly measuring, the ticks is desirable.

It is an assumption that the ticks are regular and homogeneous.

There is no sub-division between two successive clock ticks. Measuring time consists of counting the complete number of repetitions of ticks since the clock started, or since some other event at a given clock count.

There is no time measurement before the clock started, or after it stops.

It may seem that time can be measured between 'ticks' by interpolation, but this needs another clock, with faster ticks. This process of devising more precise clocks continues down to the atomic scale, and then the process of physically trying to interpolate between ticks is not possible.

The internationally agreed atomic time, TAI, is an example of a timescale with an integer count as the measure of time, though in practice it is an arithmetic compromise across about two hundred separate atomic clocks, corrected for differing altitudes and temperatures.

In this regime, the Allen Operators (Maintaining Knowledge about Temporal Intervals) also can be used. If A occurs before B and B occurs before C, then we can correctly deduce that A occurs before C. The full set of operators also covers pairs of intervals. So if B occurs in the interval (A,C), we can now perform integer arithmetic operations like (B-A) or (C-A) as we have defined a timescale or measurement.

This regime constitutes a Temporal Coordinate Reference System, with discrete integer units of measure which can be subject to integer arithmetic.

8.4. CRS and Continuous Timescales

This regime takes a clock from the previous regime ands assumes that between any two adjacent ticks, it is possible to interpolate indefinitely to finer and finer precision, using ordinary arithmetic, rather than any physical device.

Alternatively, it may be that the ticks are not counted but measured, and the precision of the clock is determined by the precision of the measurements, such as depth in an ince core, or angular position of an astronomical body,such as the sun, moon or a star.

It is also assumed that time can be extrapolated to before the time when the clock started and into the future, possibly past when the clock stops.

This gives us a continuous number line to perform theoretical measurements. It is a coordinate system. With a datum/origin/epoch, a unit of measure (a name for the ‘tick marks’ on the axis), positive and negative directions and the full range of normal arithmetic. It is a Coordinate Reference System.

In this regime, the Allen Operators (Maintaining Knowledge about Temporal Intervals) also can be used. If A occurs before B and B occurs before C, then we can correctly deduce that A occurs before C. The full set of operators also covers pairs of intervals. So if B occurs in the interval (A,C), we can now perform real number arithmetic operations like (B-A) or (C-A) as we have defined a timescale or measurement, and between any two instants, we can always find an infinite number of other instants.

Some examples are:

1. Unix milliseconds since 1970-01-01T00:00:00.0Z
2. Julian Days, and fractions of a day, since noon on 1st January, 4713 BCE.

This regime constitutes a Temporal Coordinate Reference System, with continuous, floating-point, units of measure, which can be subject to the full range of real arithmetic.

8.5. Calendars

In this regime, counts and measures of time are related to the various combinations of the rotations of the earth, moon and sun or other astronomical bodies. There is no simple arithmetic, so for example, the current civil year count of years in the Current Era (CE) and Before Current Era (BCE) is a calendar, albeit a very simple one, as there is no year zero. That is, Year 14CE – Year 12CE is a duration of 2 years, and Year 12BCE — Year 14BCE is also two years. However Year 1CE — Year 1BCE is one year, not two as there is no year 0CE or 0BCE.

Calendars are social constructs made by combining several clocks and their associated timescales.

This paper only addresses the internationally agreed Gregorian calendar. Astronomical Algorithms provides overwhelming detail for conversion to numerous other calendars that have developed around the world and over the millennia and to meet the various social needs of communities, whether agricultural, religious or other. The reference is comprehensive but not exhaustive, as there are calendars that have been omitted.

A Calendar is a Temporal Reference System, but it is not a Temporal Coordinate Reference System nor an Ordinal Temporal Reference System.

8.6. Other Regimes

8.6.1. General

There may in fact be a series of other regimes, which are out of scope of this document. This could include local solar time, useful, for example, for the calculation of illumination levels and the length of shadows on aerial photography, or relativistic time.

8.6.2. Local Solar Time

Local solar time may or may not correspond to the local statutory or legal time in a country. Local solar time can be construed as a clock and timescale, with an angular measure of of the apparent position of the sun along the ecliptic (path through the sky) as the basic physical principle.

8.6.3. Spacetime

When dealing with moving objects, we find that the location of the object in space depends on its location in time. That is to say, that the location is an event in space and time.

Originally developed by Hermann Minknowski to support work in Special Relativity, the concept of Spacetime is useful whenever the location of an object in space is dependent on its location in time.

Since the speed of light in a vacum is a constant, Spacetime uses that constant to create a coordinate axis with spatial units of measure (meters per second * seconds = meters). The result is coordinate reference system with four orthagonal axis all with the same units of measure.

8.6.4. Relativistic

A regime may be needed for 'space-time', off the planet Earth, such as for recording and predicting space weather approaching from the sun, where the speed of light and relativistic effects may be relevant.

Once off the planet Earth, distances and velocities grow very large. The speed of light becomes a limiting factor in measuring both where and when an event takes place. Special Relativity deals with the accurate measurement of Spacetime events as measured between two moving objects. The core concepts are the Lorentz Transforms. These transforms allow one to calculate the degree of "contraction" a measurement undergos due to the relative velocity between the observing and observed object.

The key to this approach is to ensure each moving feature of interest has its own local clock and time, known as its 'proper time'. This example can be construed as a fitting into the clock and timescale regime. The relativistic effects are addressed through the relationships between the separate clocks, positions and velocities of the features.

Relativistic effects may need to be taken into account for satellites and other space craft because of their relative speed and position in Earth’s gravity well.

8.6.5. Accountancy

The financial and administrative domains often use weeks, quarters, and other calendrical measures. These may be convenient (though often not!) for the requisite tasks, but are usually inappropriate for scientific or technical purposes.

9

NOTATION

9 NOTATION

There are often widely agreed, commonly accepted, notations used for temporal reference systems, but few have been standardised. Any particular notation may be capable of expressing a wider range of times than are valid for the reference system.

Example : The [IETF_RFC_3999] timestamp notation, a restrictive profile of ISO 8601, can express times before 1588CE, when the Gregorian calendar was first introduced in some parts of the world.

10

ATTRIBUTES OF THE REGIMES/CLASSES

10 ATTRIBUTES OF THE REGIMES/CLASSES

The top level `Reference System` is a super-class and does not have many attributes or properties. So far, only the dimension of the reference system and the Location, Time or Domain of Applicability have been identified as essential.

The Dimension is one for time, or a vertical reference system, but may be as much as 6 for spatial location and orientation.

Besides the conventional space and time, there may be other reference systems, such as wavelength/frequency, that can be addressed by the Abstract Conceptual Model.

10.1. Attributes of Events and Ordinal Temporal Reference Systems

1. Name/Id
2. Listed or enumerated sequence of events
3. First and last events
4. Optional Epoch, defined in some other temporal reference system
5. Optional location or region of applicability
6. Optional notations

Example : Ancient annals of a country may give a sequence of emperors which could be used to 'date' another event such as "Emperor Xi built a canal", or may be used to date a particular reign. For example: "In the reign of Emperor Yi, a comet was sighted" and later research identifies this as an appearance of Hailey's Comet.

The events from the list may be instants, such as the change of reign, or intervals, such as the complete reign of each emperor.

Other documents may enable two such 'king lists' to be related, though not completely.

10.2. Attributes of simple Clock and Discrete Timescale

1. Name/Id

2. Optional Epoch/starting time defined in some other temporal reference system
3. Optional name for each tick
4. Optional End time or count
5. Optional location
6. Optional Notation

Example : A well preserved fossilised log is recovered and the tree rings establish an annual 'tick'. The start and end times may be known accurately by comparison and matching with other known tree ring sequences, or perhaps only dated imprecisely via Carbon Dating, or its archaeological or geological context.

10.3. Attributes of a CRS and Continuous Timescales

1. Name/Id
2. Optional Epoch/starting time, defined in some other temporal reference system
3. Optional name for the measure
4. Optional End time or measure
5. Optional location
6. Optional Notation

Example : A long ice core is retrieved from a stable ice-sheet. From long term meteorological observations, the rate of accumulation of ice is known, so linear length can be equated to time (assuming a stable climate too). This enable the dates of some previously unknown large scale volcanic eruptions to be identified and timed. Identifiable nuclear fallout from specific atmospheric atomic bomb tests increase the confidence in the timing accuracy.

11

ATTRIBUTES OF CALENDARS

11 ATTRIBUTES OF CALENDARS

1. Name/id
2. Astronomical Type (e.g. solar, sidereal, lunar, luni-solar)
3. Predictive type (e.g. observed or calculated)
4. Epoch/start time
5. Optional end time
6. Optional location or region of applicability
7. Constituent units or clocks and counts or timescales
8. Optional Notation

Example 1: The modern Gregorian calendar is calculated solar calendar, with various epochs from 1588 CE through to 1922 CE depending on location or country.

+ The constituent timescales are days (earth's rotations), months (moon's orbit around the earth), years (earth's orbit around the sun) and seconds determined by atomic clocks. To accommodate discrepancies, leap days and leap seconds are intercalated in some years. The commonest notations for the Gregorian calendar are ISO 8601 and its various restrictive profiles.

Example 2: The modern Islamic calendar is an observed lunar calendar, and the major religious dates progress throughout the year, year on year. The important months are determined by the observation of new moons from Mecca.

Example 3: The modern Jewish calendar is a calculated luni-solar calendar, and discrepancies in the solar year are addressed by adding 'leap months' every few years.

Example 4: The Ba'hai calendar is a calculated solar calendar, but without any other astronomical aspects. The year consists of 19 months of 19 days each, with 4 or 5 intercalated days for a new year holiday.

Example 5: The West African Yoruba traditional calendar is a solar calendar with months, but rather than subdividing a nominal month of 28 days into 4 weeks, 7 weeks of 4 days are used. This perhaps gave rise to the fortnightly (every 8 days) markets in many villages in the grasslands of north-west Cameroun.

Example 6: Teams controlling remote vehicles on Mars use a solar calendar, with Martian years and martian days (called sols). Months are not used because there are two moons, with different, rather short, 'months'.

12

SYNCHRONISATION OF CLOCKS

12 SYNCHRONISATION OF CLOCKS

If there are two or more clocks, stationary with respect to each other, and a practical method of communicating their times to each other, the clocks can be perfectly synchronized.

However, if the clocks are moving with respect to each other, they cannot be precisely coordinated (unless the communication is instantaneous). As communication speed is limited by the finite constant speed of light, perfect synchronisation is not possible, though repetitive protocols can be used to reduce the synchronization error to any practical desired level.

See A Brief History of Timekeeping, Page 187-191.

13

ABSTRACT TEMPORAL REFERENCE MODEL

13 ABSTRACT TEMPORAL REFERENCE MODEL

13.1. Context

When OGC standards involve time, they generally refer to the ISO documents such as ISO 19108, ISO 19111, ISO 8601, and their freely available OGC equivalents, such as Abstract Specification Topic 2 Referencing by Coordinates (equivalent to <<ISO_19111>>).

When dealing with temporal reference systems, it is necessary to understand all of these standards and how they interact. ISO Technical Committee 211 (ISO/TC 211) provides a useful tool for integrating their standards. The ISO/TC 211 Harmonized Model Management Group provides a single integrated model for most of the ISO/TC 211 standards. That model will provide the foundation for the Abstract Temporal Reference Model.

The Abstract Temporal Reference Model is a “Conceptual” model. It both defines concepts and the associations between those concepts. This “conceptual” model is an extension of a higher level “Semantic” model.

The W3C Time Ontology (W3C REC-owl-time-20171019) is illustrated below.

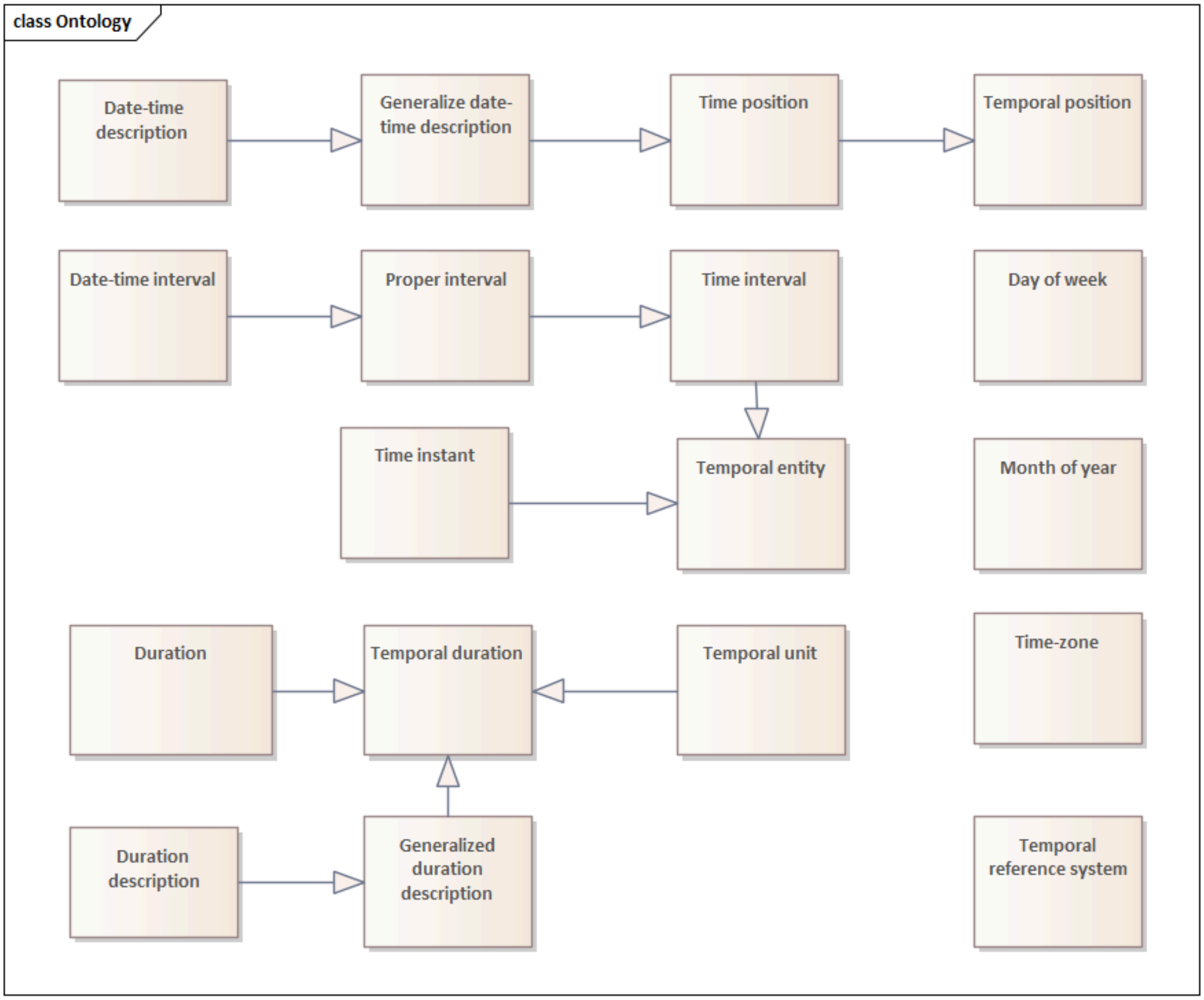

Figure 3

The Abstract Temporal Model divides the world into Spatial, Temporal, and SpatialTemporal Reference Systems.

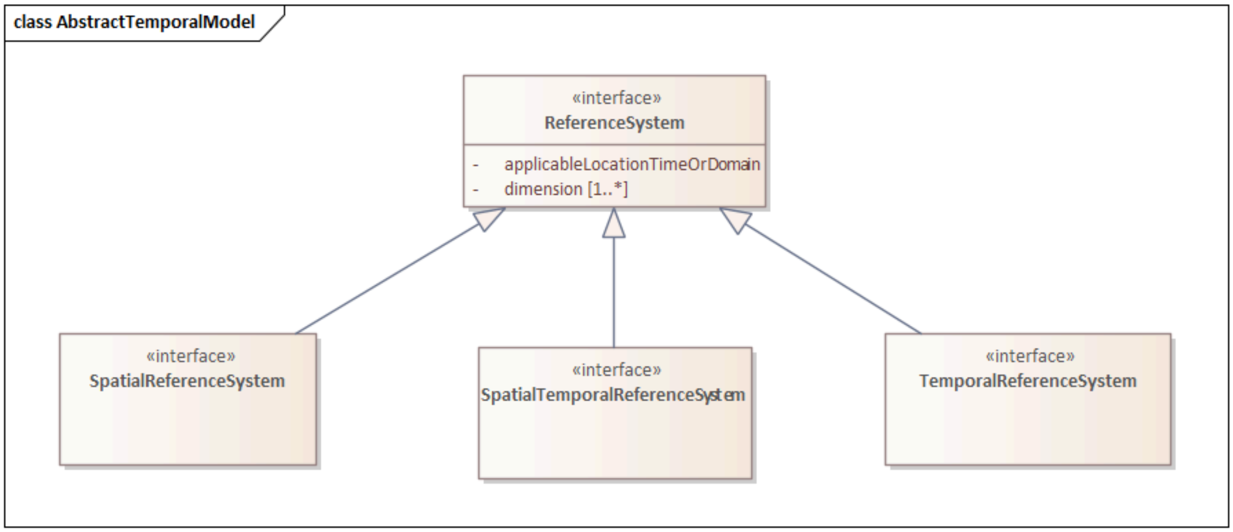

Figure 4

The Temporal Reference System is further divided into Temporal Coordinate Reference Systems and Temporal Ordinal Reference Systems.

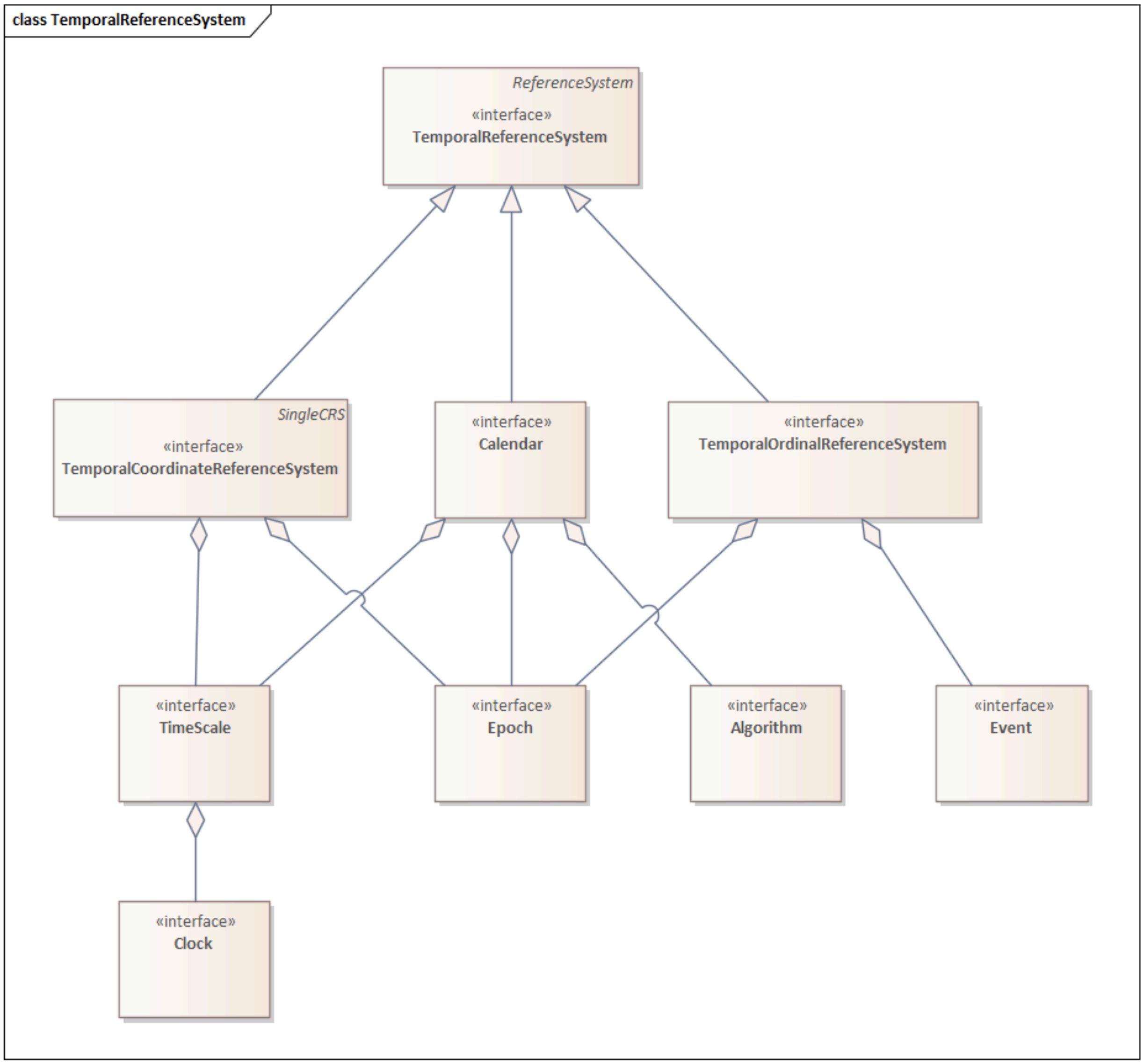

Figure 5

The Temporal Coordinate Reference Systems provide a link to ISO 19111 — Geographic information — Referencing by coordinates.

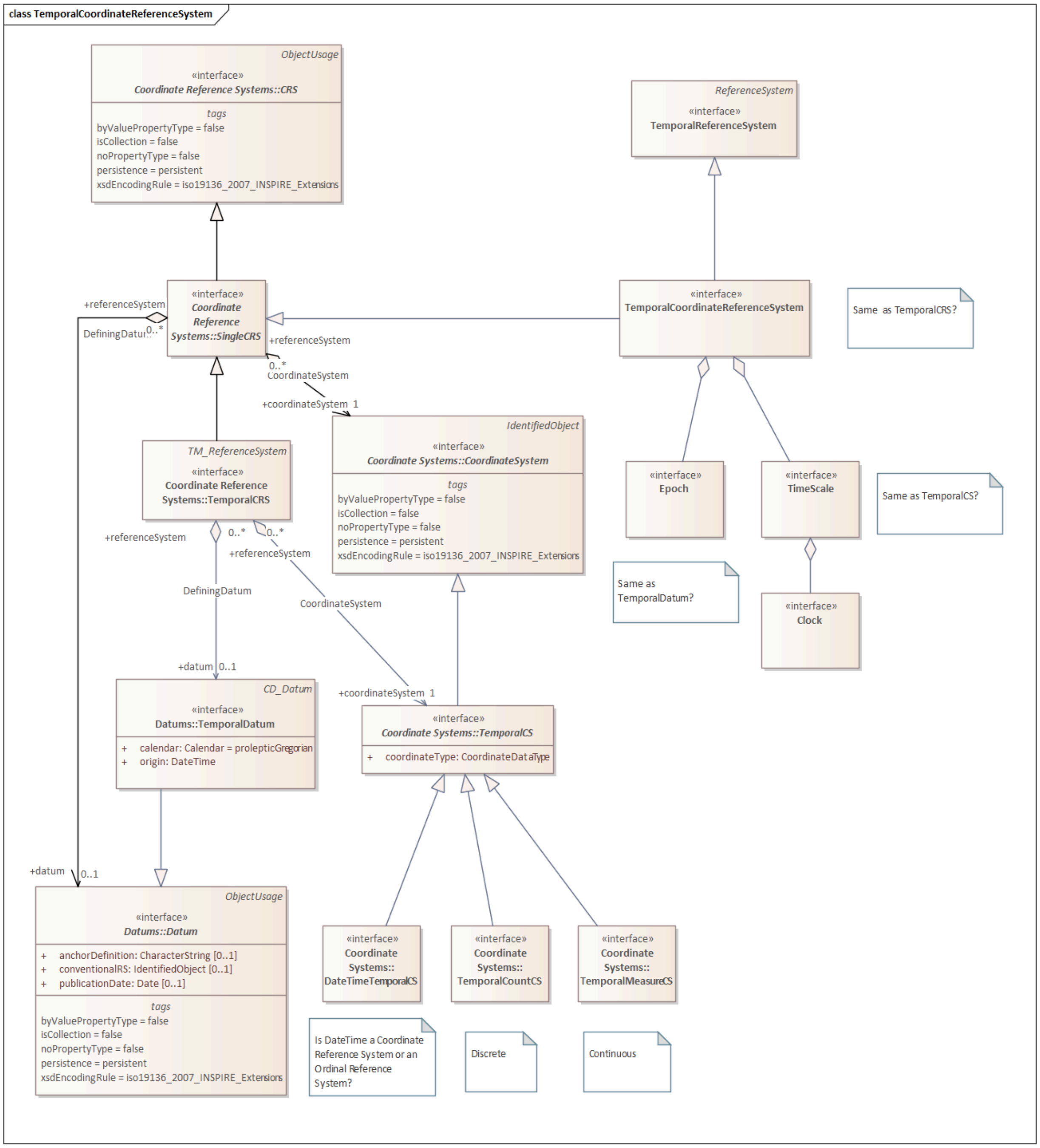

Figure 6

ISO 19111 provides a model for coordinate transformations which can be re-used for temporal coordinate reference systems.

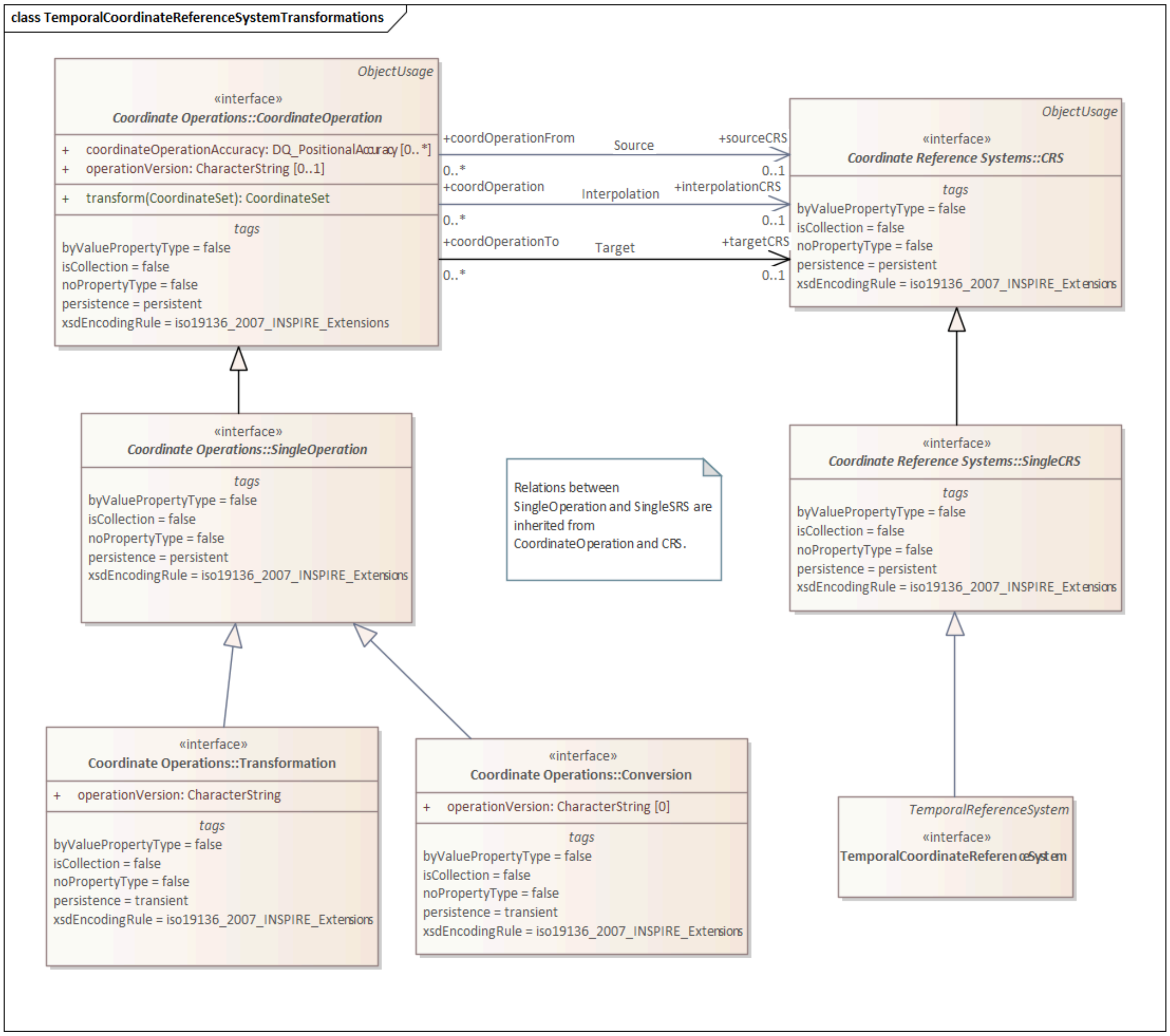

Figure 7

Some Observations:

1. Many temporal reference systems are not coordinate reference systems
2. There is no temporal equivalent to the Compound Reference System
3. DateTime should be represented as a compound reference system consisting of a TM_Calendar and TM_Clock reference system.
4. TM_Calendar could be a type of TM_OrdinalReferenceSystem.
5. TM_Clock should not be defined in terms of a “day”. Many clocks count elapsed time since an epoch. Date and time are not considered.
6. TM_Clock should be a type of TM_CoordinateSystem

7. TM_Calendar can be defined as a Compound Reference System composed of days, months, and years. This would allow to define meaningful calendars for the Moon, Mars, and other non-Terrestrial environments.

8. Is there an ordinal equivalent to TM_Clock. Sunrise, noon, sunset, and midnight?

9. Can a calendar be defined in terms of planting season, Saints days, or other arbitrary events?

A

ANNEX A (NORMATIVE) ANNEX TITLE

A

ANNEX A (NORMATIVE) ANNEX TITLE

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NOTE: Place annex material in sequential order and set `obligation` attribute as “normative” (default) or “informative” according to the case.

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