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Concise Binary Object Representation (CBOR) Tags for Time, Duration, and Period

Abstract

The Concise Binary Object Representation (CBOR, RFC 8949) is a data format whose design goals include the possibility of extremely small code size, fairly small message size, and extensibility without the need for version negotiation.

In CBOR, one point of extensibility is the definition of CBOR tags. RFC 8949 defines two tags for time: CBOR tag 0 (RFC3339 time as a string) and tag 1 (Posix time as int or float). Since then, additional requirements have become known. The present document defines a CBOR tag for time that allows a more elaborate representation of time, as well as related CBOR tags for duration and time period. It is intended as the reference document for the IANA registration of the CBOR tags defined.

The present version (-02) fills in proposals for all TBDs that were outstanding.

About This Document

This note is to be removed before publishing as an RFC.

Status information for this document may be found at https://datatracker.ietf.org/doc/draft-ietf-cbor-time-tag/.

Discussion of this document takes place on the CBOR Working Group mailing list (mailto:cbor@ietf.org), which is archived at https://mailarchive.ietf.org/arch/browse/cbor/. Subscribe at https://www.ietf.org/mailman/listinfo/cbor/.

Source for this draft and an issue tracker can be found at https://github.com/cbor-wg/time-tag.

Status of This Memo

This Internet-Draft will expire on 7 April 2023.

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1. Introduction

The Concise Binary Object Representation (CBOR, [RFC8949]) provides for the interchange of structured data without a requirement for a pre-agreed schema. RFC 8949 defines a basic set of data types, as well as a tagging mechanism that enables extending the set of data types supported via an IANA registry.

In CBOR, one point of extensibility is the definition of CBOR tags. RFC 8949 defines two tags for time: CBOR tag 0 (RFC3339 time as a string) and tag 1 (Posix time as int or float). Since then, additional requirements have become known. The present document defines a CBOR tag for time that allows a more elaborate representation of time, as well as related CBOR tags for duration and time period. It is intended as the reference document for the IANA registration of the CBOR tags defined.

1.1. Terminology

The key words "**MUST**", "**MUST NOT**", "**REQUIRED**", "**SHALL**", "**SHALL NOT**", "**SHOULD**", "**SHOULD NOT**", "**RECOMMENDED**", "**NOT RECOMMENDED**", "**MAY**", and "**OPTIONAL**" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

The term "byte" is used in its now customary sense as a synonym for "octet". Where bit arithmetic is explained, this document uses the notation familiar from the programming language C (including C++14's 0bnnn binary literals), except that the operator "**" stands for exponentiation.

CBOR diagnostic notation is defined in Section 8 of [RFC8949] and Appendix G of [RFC8610].

2. Objectives

For the time tag, the present specification addresses the following objectives that go beyond the original tags 0 and 1:

* Additional resolution for epoch-based time (as in tag 1). CBOR tag 1 only provides for integer and up to binary64 floating point representation of times, limiting resolution to approximately microseconds at the time of writing (and progressively becoming worse over time).

* Indication of timescale. Tags 0 and 1 are for UTC; however, some interchanges are better performed on TAI. Other timescales may be registered once they become relevant (e.g., one of the proposed successors to UTC that might no longer use leap seconds, or a scale based on smeared leap seconds).

By incorporating a way to transport [IXDTF] suffix information (Section 3.6, Section 3.7), additional indications can be provided of intents about the interpretation of the time given, in particular for future times. Intents might include information about time zones, daylight savings times, preferred calendar representations, etc.

Semantics not covered by this document can be added by registering additional map keys for the map inside the tag, the specification for which is referenced by the registry entry (Section 7.3, Section 3). For example, map keys could be registered for:

* Direct representation of natural platform time formats. Some platforms use epoch-based time formats that require some computation to convert them into the representations allowed by tag 1; these computations can also lose precision and cause ambiguities. (The present specification does not take a position on whether tag 1 can be "fixed" to include, e.g., Decimal or BigFloat representations. It does define how to use these representations with the extended time format.)

Additional tags are defined for durations and periods.

3. Time Format

An extended time is indicated by CBOR tag 1001, which tags a map data item (CBOR major type 5). The map may contain integer (major types 0 and 1) or text string (major type 3) keys, with the value type determined by each specific key. Implementations **MUST** ignore key/value types they do not understand for negative integer and text string values of the key. Not understanding key/value for unsigned integer keys is an error.

The map must contain exactly one unsigned integer key, which specifies the "base time", and may also contain one or more negative integer or text-string keys, which may encode supplementary information such as:

* a higher precision time offset to be added to the base time,
* a reference timescale and epoch different from the default UTC and 1970-01-01
* information about clock quality parameters, such as source, accuracy, and uncertainty

Additional keys can be defined by registering them in the Map Key Registry (Section 7.3). Future keys may add:

* intent information such as timezone and daylight savings time, and/or possibly positioning coordinates, to express information that would indicate a local time.

While this document does not define supplementary text keys, a number of unsigned and negative-integer keys are defined below.

3.1. Key 1

Key 1 indicates a value that is exactly like the data item that would be tagged by CBOR tag 1 (Posix time [TIME_T] as int or float). The time value indicated by the value under this key can be further modified by other keys.

3.2. Keys 4 and 5

Keys 4 and 5 are like key 1, except that the data item is an array as defined for CBOR tag 4 or 5, respectively. This can be used to include a Decimal or Bigfloat epoch-based float [TIME_T] in an extended time.

3.3. Keys -3, -6, -9, -12, -15, -18

The keys -3, -6, -9, -12, -15 and -18 indicate additional decimal fractions by giving an unsigned integer (major type 0) and scaling this with the scale factor 1e-3, 1e-6, 1e-9, 1e-12, 1e-15, and 1e-18, respectively (see Table 1). More than one of these keys **MUST NOT** be present in one extended time data item. These additional fractions are added to a base time in seconds [SI-SECOND] indicated by a Key 1, which then **MUST** also be present and **MUST** have an integer value.

Key	meaning	example usage
-3	milliseconds	Java time
-6	microseconds	(old) UNIX time
-9	nanoseconds	(new) UNIX time
-12	picoseconds	Haskell time
-15	femtoseconds	(future)
-18	attoseconds	(future)

Table 1: Key for decimally scaled Fractions

3.4. Key -1: Timescale

Key -1 is used to indicate a timescale. The value 0 indicates UTC, with the POSIX epoch [TIME_T]; the value 1 indicates TAI, with the PTP (Precision Time Protocol) epoch [IEEE1588-2008].

If key -1 is not present, timescale value 0 is implied.

Additional values can be registered in the Timescale Registry (Section 7.2); values **MUST** be integers or text strings.

(Note that there should be no timescales "GPS" or "NTP" -- instead, the time should be converted to TAI or UTC using a single addition or subtraction.)

$$t_{utc} = t_{ntp} - 2208988800$$
$$t_{tai} = t_{gps} + 315964819$$

Figure 1: Converting Common Offset Timescales

3.5. Clock Quality

A number of keys are defined to indicate the quality of clock that was used to determine the point in time.

The first three are analogous to clock-quality-grouping in [RFC8575], which is in turn based on the definitions in [IEEE1588-2008]; two more are specific to this document.

```
ClockQuality-group = (
  ? ClockClass => uint .size 1 ; PTP/RFC8575
  ? ClockAccuracy => uint .size 1 ; PTP/RFC8575
  ? OffsetScaledLogVariance => uint .size 2 ; PTP/RFC8575
  ? Uncertainty => ~time/~duration
  ? Guarantee => ~time/~duration
)
ClockClass = -2
ClockAccuracy = -4
OffsetScaledLogVariance = -5
Uncertainty = -7
Guarantee = -8
```

3.5.1. ClockClass (Key -2)

Key -2 (ClockClass) can be used to indicate the clock class as per Table 5 of [IEEE1588-2008]. It is defined as a one-byte unsigned integer as that is the range defined there.

3.5.2. ClockAccuracy (Key -4)

Key -4 (ClockAccuracy) can be used to indicate the clock accuracy as per Table 6 of [IEEE1588-2008]. It is defined as a one-byte unsigned integer as that is the range defined there. The range between 32 and 47 is a slightly distorted logarithmic scale from 25 ns to 1 s (see Figure 2); the number 254 is the value to be used if an unknown accuracy needs to be expressed.

$$enum_{acc} \approx 48 + \lfloor 2 \cdot log_{10} \frac{acc}{\mathrm{s}} - \epsilon \rfloor$$

Figure 2: Approximate conversion from accuracy to accuracy enumeration value

3.5.3. OffsetScaledLogVariance (Key -5)

Key -5 (OffsetScaledLogVariance) can be used to represent the variance exhibited by the clock when it has lost its synchronization with an external reference clock. The details for the computation of this characteristic are defined in Section 7.6.3 of [IEEE1588-2008].

3.5.4. Uncertainty (Key -7)

Key -7 (Uncertainty) can be used to represent a known measurement uncertainty for the clock, as a numeric value in seconds or as a duration (Section 4).

For this document, uncertainty is defined as in Section 2.2.3 of [GUM]: "parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand". More specifically, the value for this key represents the extended uncertainty for k = 2, in seconds.

3.5.5. Guarantee (Key -8)

Key -8 (Guarantee) can be used to represent a stated guarantee for the accuracy of the point in time, as a numeric value in seconds or as a duration (Section 4) representing the maximum allowed deviation from the true value.

While such a guarantee is unattainable in theory, existing standards such as [RFC3161] stipulate the representation of such guarantees, and therefore this format provides a way to represent them as well; the time value given is nominally guaranteed to not deviate from the actual time by more than the value of the guarantee, in seconds.

3.6. Keys -10, 10: Time Zone Hint

Keys -10 and 10 can be used to provide a hint about the time zone that would best fit for displaying the time given to humans, using a text string in the format defined for time-zone-name or time-numoffset in [IXDTF]. Key -10 is equivalent to providing this information as an elective hint, while key 10 provides this information as critical (i.e., it **MUST** be used when interpreting the entry with this key).

Keys -10 and 10 **MUST NOT** both be present.

```
time-zone-info = tstr .abnf
                 ("time-zone-name / time-numoffset" .det IXDTFtz)
IXDTFtz = '
   time-hour       = 2DIGIT  ; 00-23
   time-minute     = 2DIGIT  ; 00-59
   time-numoffset  = ("+" / "-") time-hour ":" time-minute



   time-zone-initial = ALPHA / "." / "_"
   time-zone-char    = time-zone-initial / DIGIT / "-" / "+"
   time-zone-part    = time-zone-initial *13(time-zone-char)
                       ; but not "." or ".."
   time-zone-name    = time-zone-part *("/" time-zone-part)
   ALPHA             =  %x41-5A / %x61-7A   ; A-Z / a-z
   DIGIT             =  %x30-39 ; 0-9
' ; extracted from [IXDTF] and [RFC3339]; update as needed
```

3.7. Keys -11, 11: IXDTF Suffix Information

Similar to keys -10 and 10, keys -11 (elective) and 11 (critical) can be used to provide additional information in the style of IXDTF suffixes, such as the calendar that would best fit for displaying the time given to humans. The key's value is a map that has IXDTF suffix-key names as keys and corresponding suffix values as values, specifically:

```
suffix-info-map = { * suffix-key => suffix-values }
suffix-key = tstr .abnf ("suffix-key" .det IXDTF)
suffix-values = one-or-more<suffix-value>
one-or-more<T> = T / [ 2* T ]
suffix-value = tstr .abnf ("suffix-value" .det IXDTF)

IXDTF = '
   key-initial       = lcalpha / "_"
   key-char          = key-initial / DIGIT / "-"
   suffix-key        = key-initial *key-char

   suffix-value      = 1*alphanum
   alphanum          = ALPHA / DIGIT
   lcalpha           =  %x61-7A
   ALPHA             =  %x41-5A / %x61-7A   ; A-Z / a-z
   DIGIT             =  %x30-39 ; 0-9
' ; extracted from [IXDTF]; update as needed!
```

When keys -11 and 11 both are present, the two maps **MUST NOT** have entries with the same map keys.

Figure 4 of [IXDTF] gives an example for an extended date-time with both time zone and suffix information:

```
1996-12-19T16:39:57-08:00[America/Los_Angeles][u-ca=hebrew]
```

A time tag that is approximating this example, in CBOR diagnostic notation, would be:

```
/ 1996-12-19T16:39:57-08:00[America//Los_Angeles][u-ca=hebrew] /
1001({ 1: 851042397,
     -10: "America/Los_Angeles",
     -11: { "u-ca": "hebrew" }
})
```

Note that both -10 and -11 are using negative keys and therefore provide elective information, as in the IXDTF form. Note also that in this example the time numeric offset (-08:00) is lost in translating from the [RFC3339] information in the IXDTF into a Posix time that can be included under Key 1 in a time tag.

4. Duration Format

A duration is the length of an interval of time. Durations in this format are given in SI seconds, possibly adjusted for conventional corrections of the timescale given (e.g., leap seconds).

Except for using Tag 1002 instead of 1001, durations are structurally identical to time values. Semantically, they do not measure the time elapsed from a given epoch, but from the start to the end of (an otherwise unspecified) interval of time.

In combination with an epoch identified in the context, a duration can also be used to express an absolute time.

Without such context, durations are subject to some uncertainties underlying the timescale used. E.g., for durations intended as a determinant of future time periods, there is some uncertainty of what irregularities (such as leap seconds, timescale corrections) will be exhibited by the timescale in that period. For durations as measurements of past periods, abstracting the period to a duration loses some detail about timescale irregularities. For many applications, these uncertainties are acceptable and thus the use of durations is appropriate.

Note that [ISO8601:1988] durations are rather different from the ones defined in the present specification; there is no intention to support ISO 8601 durations here.

5. Period Format

A period is a specific interval of time, specified as either two times giving the start and the end of that interval, or as one of these two plus a duration.

They are given as an array of unwrapped time and duration elements, tagged with Tag 1003:

```
Period = #6.1003([
  start: ~Time / null
  end: ~Time / null
  ? duration: ~Duration / null
])
```

If the third array element is not given, the duration element is null. Exactly two out of the three elements must be non-null, this can be clumsily expressed in CDDL as:

```
Period = #6.1003([
  (start: ~Time,
   ((end: ~Time,
     ? duration: null) //
    (end: null,
     duration: ~Duration))) //
  (start: null,
   end: ~Time,
   duration: ~Duration)
])
```

6. CDDL typenames

For the use with the CBOR Data Definition Language, CDDL [RFC8610], the type names defined in Figure 3 are recommended:

```
etime = #6.1001({* (int/tstr) => any})
duration = #6.1002({* (int/tstr) => any})
period = #6.1003([~etime/null, ~etime/null, ~duration/null])
```

Figure 3: Recommended type names for CDDL

7. IANA Considerations

7.1. CBOR tags

In the registry [IANA.cbor-tags], IANA has allocated the tags in Table 2 from what was at the time the FCFS space, with the present document as the specification reference.

Tag	Data Item	Semantics
1001	map	[RFCthis] extended time
1002	map	[RFCthis] duration
1003	array	[RFCthis] period

Table 2: Values for Tags

IANA is requested to change the "Data Item" column for Tag 1003 from "map" to "array".

7.2. Timescale Registry

This specification defines a new subregistry titled "Timescale Registry" in the "CBOR Time Tag Parameters" registry [IANA.cbor-time-tag-parameters], with a combination of "Expert Review" and "RFC Required" as the Registration Procedure (Sections 4.5 and 4.7 of [BCP26]).

Each entry needs to provide a timescale name (a sequence of uppercase ASCII characters and digits, where a digit may not occur at the start: [A-Z][A-Z0-9]*), a value (unsigned integer), and brief description of the semantics, and a specification reference (RFC). The initial contents are shown in Table 3.

Timescale	Value	Semantics	Reference
UTC	0	UTC with POSIX Epoch	[RFCthis]
TAI	1	TAI with PTP Epoch	[RFCthis]

Table 3: Initial Content of Timescale Registry

7.3. Map Key Registry

This specification defines a new subregistry titled "Map Key Registry" in the "CBOR Time Tag Parameters" registry [IANA.cbor-time-tag-parameters], with "Specification Required" as the Registration Procedure (Section 4.6 of [BCP26]).

The designated expert is requested to assign the key values with the shortest encodings (1+0 and 1+1 encoding) to registrations that are likely to enjoy wide use and can benefit from short encodings.

Each entry needs to provide a map key value (integer), a brief description of the semantics, and a specification reference (RFC). The initial contents are shown in Table 3.

Value	Semantics	Reference
-18	attoseconds	[RFCthis]
-15	femtoseconds	[RFCthis]
-12	picoseconds	[RFCthis]
-11	IXDTF Suffix Information (elective)	[RFCthis], [IXDTF]
-10	IXDTF Time Zone Hint (elective)	[RFCthis], [IXDTF]
-9	nanoseconds	[RFCthis]
-8	Guarantee	[RFCthis]
-7	Uncertainty	[RFCthis]
-6	microseconds	[RFCthis]
-5	Offset-Scaled Log Variance	[RFCthis]
-4	Clock Accuracy	[RFCthis]
-3	milliseconds	[RFCthis]
-2	Clock Class	[RFCthis]

Value	Semantics	Reference
1	Time value (as in CBOR Tag 1)	[RFCthis]
4	Time value as in CBOR Tag 4	[RFCthis]
5	Time value as in CBOR Tag 5	[RFCthis]
10	IXDTF Time Zone Hint (critical)	[RFCthis], [IXDTF]
11	IXDTF Suffix Information (critical)	[RFCthis], [IXDTF]

Table 4

8. Security Considerations

The security considerations of RFC 8949 apply; the tags introduced here are not expected to raise security considerations beyond those.

Time, of course, has significant security considerations; these include the exploitation of ambiguities where time is security relevant (e.g., for freshness or in a validity span) or the disclosure of characteristics of the emitting system (e.g., time zone, or clock resolution and wall clock offset).

9. References

9.1. Normative References

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