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Date and Time on the Internet: Timestamps with additional information

Abstract

This document defines an extension to the timestamp format defined in [RFC3339] for representing additional information including a time zone.

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1. Introduction

Dates and times are used in a very diverse set of internet applications, all the way from server-side logging to calendaring and scheduling.

Each distinct instant in time can be represented in a descriptive text format using a timestamp, and [ISO8601] standardizes a widely-adopted timestamp format, which forms the basis of [RFC3339]. However, this format doesn't allow timestamps to contain any additional relevant information, which means that any contextual information related to a given timestamp needs to be either handled separately or attached to it in a non-standard manner.

This is already a pressing issue for applications that handle each instant with an associated time zone name, to take into account things like DST transitions. Most of these applications attach the timezone to the timestamp in a non-standard format, atleast one of which is fairly well-adopted. Furthermore, applications might want to attach even more information to the timestamp, including but not limited to the calendar system it must be represented in.

This document seeks to standardize an extension syntax for timestamps as specified in [\[RFC3339\]](#) that has the following properties:

- The extension suffix should be completely optional, making existing [\[RFC3339\]](#) timestamps compatible with this format.
- The format should be compatible to the pre-existing popular syntax for attaching time zone names to timestamps.
- The format should allow a generalized way to attach any additional information to the timestamp.

2. Definitions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [\[RFC2119\]](#).

UTC Coordinated Universal Time as maintained since 1988 by the Bureau International des Poids et Mesures (BIPM) in conjunction with leap seconds as announced by the International Earth Rotation and Reference Frames Service [\[IERS\]](#). From 1972 through 1987 UTC was maintained entirely by Bureau International de l'Heure (BIH). Before 1972 UTC was not generally recognized and civil time was determined by individual jurisdictions using different techniques for attempting to follow Universal Time based on measuring the rotation of the earth.

ABNF Augmented Backus-Naur Form, a format used to represent permissible strings in a protocol or language, as defined in [\[RFC2234\]](#).

Internet Date/Time Format The date/time format defined in section 4 of this document.

Timestamp This term is used in this document to refer to an unambiguous representation of some instant in time.

Z A suffix which, when applied to a time, denotes a UTC offset of 00:00; often spoken "Zulu" from the ICAO phonetic alphabet representation of the letter "Z".

Time Zone A time zone that is included in the Time Zone Database (often called `tz` or `zoneinfo`) maintained by IANA.

For more information about time scales, see Appendix E of [\[RFC1305\]](#), Section 3 of [\[ISO8601\]](#), and the appropriate ITU documents [\[ITU-R-TF\]](#).

3. Local Time

3.1. Coordinated Universal Time (UTC)

Because the daylight saving rules for local time zones are so convoluted and can change based on local law at unpredictable times, true interoperability is best achieved by using Coordinated Universal Time (UTC). This specification by itself does not cater to local time zone rules. However, certain implementations may be expected to. For these situations, a timestamp may additionally include a local time zone that the implementations can take into account.

3.2. Local Offsets

The offset between local time and UTC is often useful information. For example, in electronic mail (RFC2822, [\[RFC2822\]](#)) the local offset provides a useful heuristic to determine the probability of a prompt response. Attempts to label local offsets with alphabetic strings have resulted in poor interoperability in the past [\[RFC1123\]](#). As a result, RFC2822 [\[RFC2822\]](#) has made numeric offsets mandatory.

Numeric offsets are calculated as "local time minus UTC". So the equivalent time in UTC can be determined by subtracting the offset from the local time. For example, 18:50:00-04:00 is the same time as 22:50:00Z. (This example shows negative offsets handled by adding the absolute value of the offset.)

Numeric offsets may differ from UTC by any number of seconds, or even a fraction of seconds. This can be easily represented by including an optional seconds value in the offset, which may further optionally include a fraction of seconds behind a decimal point, for example +12:34:56.789. This is especially useful in the case of certain historical time zones.

3.3. Unknown Local Offset Convention

If the time in UTC is known, but the offset to local time is unknown, this can be represented with an offset of "-00:00". This differs semantically from an offset of "Z" or "+00:00", which imply that UTC is the preferred reference point for the specified time. RFC2822 [\[RFC2822\]](#) describes a similar convention for email.

3.4. Unqualified Local Time

A number of devices currently connected to the Internet run their internal clocks in local time and are unaware of UTC. While the Internet does have a tradition of accepting reality when creating specifications, this should not be done at the expense of interoperability. Since interpretation of an unqualified local time zone will fail in approximately 23/24 of the globe, the interoperability problems of unqualified local time are deemed unacceptable for the Internet.

Systems that are configured with a local time, are unaware of the corresponding UTC offset, and depend on time synchronization with other Internet systems, MUST use a mechanism that ensures correct synchronization with UTC. Some suitable mechanisms are:

- Use Network Time Protocol [[RFC1305](#)] to obtain the time in UTC.
- Use another host in the same local time zone as a gateway to the Internet. This host MUST correct unqualified local times that are transmitted to other hosts.
- Prompt the user for the local time zone and daylight saving rule settings.

4. Extended Date and Time format

This section discusses desirable qualities of formats for the timestamp extension suffix and defines such a format that extends [[RFC3339](#)] for use in Internet protocols.

4.1. Informative

The format should allow implementations to specify additional important information in addition to the bare timestamp. This is done by allowing implementations to include an informative suffix at the end with as many tags as required, each with a key and value separated by an equals sign. The value can be a hyphen delimited list of multiple values.

In case a key is repeated or conflicted, the implementations should give precedence to whichever value is positioned first.

4.2. Namespaced

Since the suffix can include all sorts of additional information, different standards bodies/organizations need a way to identify which part adheres to their standards. For this, all information needs to be namespaced. Each key is therefore divided into two hyphen-separated sections: the namespace and the key. For example, the calendar as defined by the Unicode consortium could be included as `u-ca=<value>`.

All single-character namespaces are reserved for BCP47 extensions recorded in the BCP47 extensions registry. For these namespaces:

- Case differences are ignored.
- The namespace is restricted to single alphanum, corresponding to extension singletons ('x' can be used for a private use extension).
- In addition, for CLDR extensions:
 - There must be a namespace-key and it is restricted to 2 alphanum characters.
 - A suffix-value is limited to 3*8alphanum.

Multi-character namespaces can be registered specifically for use in this format. They are assigned by IANA using the "IETF Review" policy defined by [RFC5226]. This policy requires the development of an RFC, which SHALL define the name, purpose, processes, and procedures for maintaining the subtags. The maintaining or registering authority, including name, contact email, discussion list email, and URL location of the registry, MUST be indicated clearly in the RFC. The RFC MUST specify or include each of the following:

- The specification MUST reference the specific version or revision of this document that governs its creation and MUST reference this section of this document.
- The specification and all keys defined by the specification MUST follow the ABNF and other rules for the formation of keys as defined in this document. In particular, it MUST specify that case is not significant and that keys MUST NOT exceed eight characters in length.
- The specification MUST specify a canonical representation.
- The specification of valid keys MUST be available over the Internet and at no cost.
- The specification MUST be in the public domain or available via a royalty-free license acceptable to the IETF and specified in the RFC.
- The specification MUST be versioned, and each version of the specification MUST be numbered, dated, and stable.
- The specification MUST be stable. That is, namespace keys, once defined by a specification, MUST NOT be retracted or change in meaning in any substantial way.
- The specification MUST include, in a separate section, the registration form reproduced in this section (below) to be used in registering the namespace upon publication as an RFC.
- IANA MUST be informed of changes to the contact information and URL for the specification.

IANA will maintain a registry of allocated multi-character namespaces. This registry MUST use the record-jar format described by the ABNF in [RFC5646]. Upon publication of a namespace as an RFC, the maintaining authority defined in the RFC MUST forward this registration form to <<mailto:iesg@ietf.org>>, who MUST forward the request to <<mailto:iana@iana.org>>. The maintaining authority of the namespace MUST maintain the accuracy of the record by sending an updated full copy of the record to <<mailto:iana@iana.org>> with the subject line "TIMESTAMP FORMAT NAMESPACE UPDATE" whenever content changes. Only the 'Comments', 'Contact_Email', 'Mailing_List', and 'URL' fields MAY be modified in these updates.

Failure to maintain this record, maintain the corresponding registry, or meet other conditions imposed by this section of this document MAY be appealed to the IESG [RFC2028] under the same rules as other IETF decisions (see [RFC2026]) and MAY result in the authority to maintain the extension being withdrawn or reassigned by the IESG.

```
%%  
Identifier:  
Description:  
Comments:  
Added:  
RFC:  
Authority:  
Contact_Email:  
Mailing_List:  
URL:  
%%
```

Figure 1: Format of Records in the Timestamp Format Namespace Registry

'Identifier' contains the multi-character sequence assigned to the namespace. The Internet-Draft submitted to define the namespace SHOULD specify which sequence to use, although the IESG MAY change the assignment when approving the RFC.

'Description' contains the name and description of the namespace.

'Comments' is an OPTIONAL field and MAY contain a broader description of the namespace.

'Added' contains the date the namespace's RFC was published in the "date-full" format specified in [Figure 2](#). For example: 2004-06-28 represents June 28, 2004, in the Gregorian calendar.

'RFC' contains the RFC number assigned to the namespace.

'Authority' contains the name of the maintaining authority for the namespace.

'Contact_Email' contains the email address used to contact the maintaining authority.

'Mailing_List' contains the URL or subscription email address of the mailing list used by the maintaining authority.

'URL' contains the URL of the registry for this namespace.

The determination of whether an Internet-Draft meets the above conditions and the decision to grant or withhold such authority rests solely with the IESG and is subject to the normal review and appeals process associated with the RFC process.

4.3. Syntax Extensions to [RFC3339]

The following rules extend the ABNF syntax defined in [RFC3339] in order to allow the inclusion of an optional suffix.

```
time-zone-char = ALPHA / "." / "_"
time-zone-part = time-zone-char *13(time-zone-char / DIGIT / "-" /
"+" ) ; but not "." or ".."
time-zone-name = time-zone-part *("/" time-zone-part)
time-zone      = "[" time-zone-name "]"

namespace      = 1*alphanum
namespace-key  = 1*alphanum
suffix-key     = namespace ["-" namespace-key]

suffix-value   = 1*alphanum
suffix-values  = suffix-value *("-" suffix-value)
suffix-tag     = "[" suffix-key "=" suffix-values "]"
suffix        = [time-zone] *suffix-tag

date-time-ext = date-time suffix
```

Figure 2

4.4. Examples

Here are some examples of Internet extended date/time format.

```
1996-12-19T16:39:57-08:00
```

Figure 3

This represents 39 minutes and 57 seconds after the 16th hour of December 19th, 1996 with an offset of -08:00 from UTC. Note that this is equivalent to 1996-12-20T00:39:57Z in UTC.

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

Figure 4

This represents the exact same instant as the previous example but additionally specifies the human time zone associated with it ("Pacific Time") for time-zone-aware implementations to take into account.

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

Figure 5

This represents the exact same instant but it informs calendar-aware implementations that they should project it to the Hebrew calendar.

```
1996-12-19T16:39:57-08:00[x-foo=bar][x-baz=bat]
```

Figure 6

This timestamp utilizes the private use namespace to declare two additional pieces of information in the suffix that can be interpreted by any compatible implementations and ignored otherwise.

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- [ZELLER] "Zeller, Chr. Kalender-Formeln. Acta Math. 9 (1887), 131—136. doi:10.1007/BF02406733".
- [IERS] "International Earth Rotation Service Bulletins".

Appendix A. Day of the Week

The following is a sample C subroutine loosely based on Zeller's Congruence [[ZELLER](#)] which may be used to obtain the day of the week for dates on or after 0000-03-01:

```
char *day_of_week(int day, int month, int year)
{
    int cent;
    char *dayofweek[] = {
        "Sunday", "Monday", "Tuesday", "Wednesday",
        "Thursday", "Friday", "Saturday"
    };

    /* adjust months so February is the last one */
    month -= 2;
    if (month < 1) {
        month += 12;
        --year;
    }
    /* split by century */
    cent = year / 100;
    year %= 100;
    return (dayofweek[((26 * month - 2) / 10 + day + year
                      + year / 4 + cent / 4 + 5 * cent) % 7]);
}
```

Figure 7

Appendix B. Leap Years

Here is a sample C subroutine to calculate if a year is a leap year:

```
/* This returns non-zero if year is a leap year. Must use 4 digit
   year.
*/
int leap_year(int year)
{
    return (year % 4 == 0 && (year % 100 != 0 || year % 400 == 0));
}
```

Figure 8

Appendix C. Leap Seconds

In 1970 CCIR Recommendation 460 produced international agreement that starting on 1972-01-01 radio broadcast time signals should provide SI seconds with occasional leaps of 1 SI second as necessary to agree with Universal Time. The time scale in radio broadcasts became known as

UTC, and the current version of that recommendation is [ITU-R-TF]. Since 1988 IERS has the [responsibility for announcing when leap seconds will be introduced into UTC](#). Further information about leap seconds can be found at the [US Navy Oceanography Portal](#). In particular, it notes that:

The decision to introduce a leap second in UTC is the responsibility of the International Earth Rotation Service [IERS]. According to the CCIR Recommendation, first preference is given to the opportunities at the end of December and June, and second preference to those at the end of March and September.

When required, insertion of a leap second occurs as an extra second at the end of a day in UTC, represented by a timestamp of the form YYYY-MM-DDT23:59:60Z. A leap second occurs simultaneously in all time zones, so that time zone relationships are not affected. See section [Section 4.4](#) for some examples of leap second times.

The following table is an excerpt from the table maintained by the IERS. The source data are located at the [Earth Orientation Parameters Product Centre at Observatoire de Paris](#).

For dates after the initial adjustment on 1972-01-01 this table shows the date of the leap second, and the difference between the time scale TAI (which is not adjusted by leap seconds) and UTC after that leap second.

UTC Date	TAI - UTC After Leap Second
1972-06-30	11
1972-12-31	12
1973-12-31	13
1974-12-31	14
1975-12-31	15
1976-12-31	16
1977-12-31	17
1978-12-31	18
1979-12-31	19
1981-06-30	20
1982-06-30	21

UTC Date	TAI - UTC After Leap Second
1983-06-30	22
1985-06-30	23
1987-12-31	24
1989-12-31	25
1990-12-31	26
1992-06-30	27
1993-06-30	28
1994-06-30	29
1995-12-31	30
1997-06-30	31
1998-12-31	32
2005-12-31	33
2008-12-31	34
2012-06-30	35
2015-06-30	36
2016-12-31	37

Table 1: Historic leap seconds

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