

# anytime: Easier Date and Time Conversion

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The `anytime` package provides functions which convert from both a number of different input variable types (integer, numeric, character, factor) and different input formats which are tried heuristically offering a powerful and versatile date and time converter that (generally) requires no user input and operates autonomously.

## Motivation

R excels at computing with dates, and times. Using a *typed* representation for your data is highly recommended not only because of the functionality offered but also because of the added safety stemming from proper representation.

But there is a small nuisance cost in interactive work as well as in programming. Users must have told `as.POSIXct()` about a million times that the origin is (of course) the `epoch`. Do we really have to say it a million more times? Similarly, when parsing dates that are *some variant* of the common `YYYYMMDD` format, do we really have to manually convert from `integer` or `numeric` or `factor` or `ordered` to `character`? Having one of several common separators and/or date formats (`YYYY-MM-DD`, `YYYY/MM/DD`, `YYYYMMDD`, `YYYY-mon-DD` and so on, with or without times), do we really need a format string? Or could a smart converter function do this for us?

The `anytime()` function aims to provide such a *general purpose* converter returning a proper `POSIXct` (or `Date`) object no matter the input (provided it was parseable), relying on `Boost Date_Time` for the (efficient, performant) conversion. `anydate()` is an additional wrapper returning a `Date` object instead. `utctime()` and `utcdatetime()` are two variants which interpret input as *coordinated universal time* (UTC), i.e. free of any `timezone`.

## Examples

We set up the R environment and display for the examples below. Note that the package caches the (local) `timezone` information (and `anytime:::setTZ()` can be used to reset this value later).

```
Sys.setenv(TZ=anytime:::getTZ()) # TZ helper
library(anytime)                 # caches TZ info
options(width=50,                 # column width
         digits.secs=6)          # fractional secs
```

**From Integer, Numeric, Factor or Ordered.** For numeric dates in the range of the (numeric) `yyyymmdd` format, we use `anydate()`.

```
## integer
anydate(20160101L + 0:2)
# [1] "2016-01-01" "2016-01-02" "2016-01-03"

## numeric
anydate(20160101 + 0:2)
# [1] "2016-01-01" "2016-01-02" "2016-01-03"
```

Numeric input also works for datetimes if its range corresponds to the range of `as.numeric()` values of `POSIXct` variables:

```
## integer
anytime(1451628000L + 0:2)
# [1] "2016-01-01 00:00:00 CST"
# [2] "2016-01-01 00:00:01 CST"
# [3] "2016-01-01 00:00:02 CST"

## numeric
anytime(1451628000 + 0:2)
# [1] "2016-01-01 00:00:00 CST"
# [2] "2016-01-01 00:00:01 CST"
# [3] "2016-01-01 00:00:02 CST"
```

This is a change from version 0.3.0; the old behaviour (which was not fully consistent in how it treated numeric input values, but convenient for input in the ranges shown here) can be enabled via either an argument to the function or a global options, see `help(anytime)` for details:

```
## integer
anytime(20160101L + 0:2, oldHeuristic=TRUE)
# [1] "2016-01-01 CST" "2016-01-02 CST"
# [3] "2016-01-03 CST"

## numeric
anytime(20160101 + 0:2, oldHeuristic=TRUE)
# [1] "2016-01-01 CST" "2016-01-02 CST"
# [3] "2016-01-03 CST"
```

In general, it is now preferred to use `anydate()` on values in this range (or resort to using `oldHeuristics=TRUE` as shown).

**Factor or Ordered.** Factor variables and their order variant are also supported directly.

```
## factor
anytime(as.factor(20160101 + 0:2))
# [1] "2016-01-01 CST" "2016-01-02 CST"
# [3] "2016-01-03 CST"

## ordered
anytime(as.ordered(20160101 + 0:2))
# [1] "2016-01-01 CST" "2016-01-02 CST"
# [3] "2016-01-03 CST"
```

Note that `factor` and `ordered` variables may *appear* to be like numeric variables, they are in fact converted to `character` first and treated just like `character` input (described in the next section).

**Character: Simple.** `Character` input is supported in a variety of formats. We first show simple formats.

```
## Dates: Character
anytime(as.character(20160101 + 0:2))
# [1] "2016-01-01 CST" "2016-01-02 CST"
# [3] "2016-01-03 CST"

## Dates: alternate formats
anytime(c("20160101", "2016/01/02", "2016-01-03"))
# [1] "2016-01-01 CST" "2016-01-02 CST"
# [3] "2016-01-03 CST"
```

**Character: ISO.** ISO8661 date(time) formats are supported with both “T” and a space as separator of date and time.

```
## Datetime: ISO with/without fractional seconds
anytime(c("2016-01-01 10:11:12",
          "2016-01-01T10:11:12.345678"))
# [1] "2016-01-01 10:11:12.000000 CST"
# [2] "2016-01-01 10:11:12.345678 CST"
```

**Character: Textual month formats.** Date formats with month abbreviations are supported in a number of common orderings.

```
## ISO style
anytime(c("2016-Sep-01 10:11:12",
          "Sep/01/2016 10:11:12",
          "Sep-01-2016 10:11:12"))
# [1] "2016-09-01 10:11:12 CDT"
# [2] "2016-09-01 10:11:12 CDT"
# [3] "2016-09-01 10:11:12 CDT"

## Datetime: Mixed format
## (cf http://stackoverflow.com/questions/39259184)
anytime(c("Thu Sep 01 10:11:12 2016",
          "Thu Sep 01 10:11:12.345678 2016"))
# [1] "2016-09-01 10:11:12.000000 CDT"
# [2] "2016-09-01 10:11:12.345678 CDT"
```

**Character: Dealing with DST.** This shows an important aspect. When not working in localtime (by overriding to UTC) the *change in difference* to UTC is correctly covered (which the underlying Boost Date\_Time library does not do by itself).

```
## Datetime: pre/post DST
anytime(c("2016-01-31 12:13:14",
          "2016-08-31 12:13:14"))
# [1] "2016-01-31 12:13:14 CST"
# [2] "2016-08-31 12:13:14 CDT"
## important: catches change
anytime(c("2016-01-31 12:13:14",
          "2016-08-31 12:13:14"), tz="UTC")
# [1] "2016-01-31 18:13:14 UTC"
# [2] "2016-08-31 17:13:14 UTC"
```

## Technical Details

The actual parsing and conversion is done by two different Boost libraries. First, the top-level R function checks the input argument type and branches on date or datetime types. All other types get handed to a function using `Boost lexical_cast` to convert from anything numeric to a string representation. This textual representation is then parsed by Boost Date\_Time to create the corresponding date,

or datetime, type. (There are also a number of special cases where numeric values are directly converted; see below for a discussion.) We use the **BH** package (Eddelbuettel *et al.*, 2019a) to access these Boost libraries, and rely on **Rcpp** (Eddelbuettel and François, 2011; Eddelbuettel, 2013; Eddelbuettel *et al.*, 2019b) for a seamless C++ interface to and from R.

The Boost Date\_Time library is addressing the need for parsing date and datetimes from text. It permits us to loop over a suitably large number of *candidate formats* with considerable ease. The formats are generally variants of the ISO 8601 date format, *i.e.*, of the YYYY-MM-DD ordering. We also allow for textual representation of months, *e.g.*, Jan for January. This feature is not internationalised.

The list of current formats can be retrieved by the `getFormats()` function. Users can also add to this list at runtime by calling `addFormats()`, as well as removing formats. User-provided formats are tried before the formats supplied by the package.

```
fmts <- getFormats()
length(fmts)
# [1] 83
head(fmts, 10)
# [1] "%Y-%m-%d %H:%M:%S%f" "%Y-%m-%e %H:%M:%S%f"
# [3] "%Y-%m-%d %H%M%S%f" "%Y-%m-%e %H%M%S%f"
# [5] "%Y/%m/%d %H:%M:%S%f" "%Y/%m/%e %H:%M:%S%f"
# [7] "%Y%m%d %H%M%S%f" "%Y%m%d %H:%M:%S%f"
# [9] "%m/%d/%Y %H:%M:%S%f" "%m/%e/%Y %H:%M:%S%f"
tail(fmts, 10)
# [1] "%d-%b-%Y" "%e-%b-%Y" "%Y-%B-%d" "%Y-%B-%e"
# [5] "%Y%B%d" "%Y%B%e" "%B/%d/%Y" "%B/%e/%Y"
# [9] "%B-%d-%Y" "%B-%e-%Y"
```

As a fallback for, *e.g.*, different behavior on Windows where Boost does not consult the TZ environment variable, and to be generally as close as possible to parsing by the R language and system, we also support the parser from R itself. As R does not expose this part of its API at the C level, we use the **Rcpp** package (Eddelbuettel and François, 2011; Eddelbuettel, 2013; Eddelbuettel *et al.*, 2019b). This code path is enabled when `useR=TRUE` is used.

## Output Formats

A related topic is faithful and easy to read *representation* of datetime objects in output, *i.e.*, formatting and printing such objects.

In the spirit of *no configuration* used on the parsing side, formatting support is provided via several functions. These all follow different known standards and are accessible by the name of the standard, or, in one case, the non-standard convention. All return a character representation.

```
pt <- anytime("2016-01-31 12:13:14.123456")
iso8601(pt)
# [1] "2016-01-31T12:13:14"
rfc2822(pt)
# [1] "Sun, 31 Jan 2016 12:13:14.123456 -0600"
rfc3339(pt)
# [1] "2016-01-31T12:13:14.123456-0600"
yyymmdd(pt)
# [1] "20160131"
```

Table 1. Comparison of anytime and base R to fasttime

| test     | replications | elapsed | relative |
|----------|--------------|---------|----------|
| anytime  | 1e+05        | 16.556  | 20.515   |
| baseR    | 1e+05        | 15.692  | 19.445   |
| fasttime | 1e+05        | 0.807   | 1.000    |

### Ambiguities

The **anytime** package is designed to operate heuristically on a number of *plausible* and *sane* formats. This cannot possibly cover all conceivable cases.

**North America versus the world.** In general, **anytime** tries to gently nudge users towards ISO 8601 order of *year* followed by *month* and *day*. But for example in the United States, another prevalent form insists on month-day-year ordering. As many users are likely to encounter such input format, **anytime** accomodates this use provided a separator is used: input with either a slash (/) or a hyphen (-) is accepted and parsed.

### Asserts

The **anytime** package also contains two helper functions that can assist in defensive programming by validating input arguments. The `assertTime()` and `assertDate()` functions validate if the given input can be parsed, respectively, as `Datetime` or `Date` objects. In case one of the inputs cannot be parsed, an error is triggered. Otherwise the parsed input is returned invisibly.

### Comparison

The **anytime** aims to satisfy two goal: be performant, and the same time flexible in terms of not requiring an explicit input format. We can gauge the relative performance via several pairwise compariosns.

**Speed.** The `as.POSIXct()` function in R provides a useful baseline as it is also implemented in compiled code. The `fastPOSIXct()` function from the **fasttime** package (Urbanek, 2016) excels at converting one (and only one) input format *fast* to a (UTC-only) datetime object. A simple benchmark converting 100 input strings 100,000 times finds both `as.POSIXct()` and `anytime()` at very comparable and similar performance, but well over one order of magnitude slower than the highly-focussed `fastPOSIXct()`. Table 1 shows the detailed results; the underlying code can be seen in the appendix. This result is reasonable: a highly specialised function can (yand should) outperform two (relatively fast) universal converters. `anytime()` is still compelling as it easier to use than `as.POSIXct()` by not requiring a format string (for formats other than ISO 8601).

**Generality.** The **parsedate** package (Csárdi and Torvalds, 2019) brings the very general date parsing utility from the git version control software to R. In a similar comparison of 100 input strings parsed 10,000 times, we find its `parse_date()` function to be more than an order of magnitude slower than `anytime()` or `as.POSIXct()`—see table 2 for the results based on the code in the appendix. Again, this result is reasonable as the greater flexibility of **parsedate** comes at a cost in performance relative to the more restricted alternatives.

Table 2. Comparison of anytime and base R to parsedate

| test      | replications | elapsed | relative |
|-----------|--------------|---------|----------|
| anytime   | 10000        | 1.653   | 1.069    |
| baseR     | 10000        | 1.546   | 1.000    |
| parsedate | 10000        | 21.827  | 14.118   |

Table 3. Comparison of anytime to two lubridate functions

| test            | replications | elapsed | relative |
|-----------------|--------------|---------|----------|
| anytime         | 10000        | 1.652   | 1.000    |
| parse_date_time | 10000        | 12.770  | 7.730    |
| ymd_hms         | 10000        | 25.162  | 15.231   |

**All-in.** The **lubridate** package (Spinu et al., 2018) is a widely-used package for working with dates and times. It offers a very any-wide variety of functions for working with dates and times: we count a full 168 exported functions in the current version. Its parser for dates and times requires at least a *hint*: the user has to specify whether input is ordered as, say, year-month-day, or day-month-year, or another form. **lubridate** has changed its internals considerably over the years. Early versions did not contain compiled code; a C-based parser was added first, and current versions embed the CCTZ C++ library (White and Miller, 2019) which was first made available to R by the **RcppCCTZ** package (Eddelbuettel, 2019).

While **lubridate** is less general than **anytime** (in that it generally requires user input on the ordering of date elements), it is also slower as can be seen from the results in table 3 based on the code in the appendix. The more-widely used form (here `ymd_hms()`) is over an order of magnitude slower; the less well-known function `parse_data_times()` (which still requires *hints*) is still several times slower as shown below.

### Summary

We describe the **anytime** package which offers fast, convenient and reliable date and datetime conversion for R users along with helper functions for formatting and assertions. Different types of input are illustrated and described in detail, and performance is analyzed via several benchmark comparisons.

We show that the **anytime** package is no slower than the base R parser, and much faster than either the most flexible parsing alternative, or a commonly-used package in this space—all the while freeing users from having to supply explicit formats specified in advance. The combination of features, performance and ease-of-use may make **anytime** a compelling alternative for R users parsing and analysing dates and times.

### Appendix

The benchmark results shown in tables 1, 2 and 3 are based on the code included below, and obtained via execution under R version 3.6.1 running under Ubuntu 19.04 with Linux kernel 5.0.0-25 on an Intel i7-8700k processor.

```
library(anytime)
library(rbenchmark)
library(fasttime)
```

```

inp <- rep("2019-01-02 03:04:05", 100)
res1 <- benchmark(fasttime=fastPOSIXct(inp),
                  baseR=as.POSIXct(inp),
                  anytime=anytime(inp),
                  replications=1e5)[, 1:4]

res1

library(parsedate)
inp <- rep("2019-01-02 03:04:05", 100)
res2 <- benchmark(parsedate=parse_date(inp),
                  baseR=as.POSIXct(inp),
                  anytime=anytime(inp),
                  replications=1e4)[, 1:4]

res2

suppressMessages(library(lubridate))
inp <- rep("2019-01-02 03:04:05", 100)
res3 <- benchmark(ymd_hms=ymd_hms(inp),
                  parse_date_time=
                    parse_date_time(inp,
                                     "ymd_HMS"),
                  anytime=anytime(inp),
                  replications=1e4)[, 1:4]

res3

```

## References

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