

# Package ‘atime’

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**Type** Package

**Title** Asymptotic Timing

**Version** 2026.4.2

**Depends** R (>= 3.5.0)

**Description** Computing and visualizing comparative asymptotic timings of different algorithms and code versions. Also includes functionality for comparing empirical timings with expected references such as linear or quadratic, <[https://en.wikipedia.org/wiki/Asymptotic\\_computational\\_complexity](https://en.wikipedia.org/wiki/Asymptotic_computational_complexity)> Also includes functionality for measuring asymptotic memory and other quantities.

**License** GPL-3

**URL** <https://github.com/tdhock/atime>, <https://atime-docs.netlify.app>

**BugReports** <https://github.com/tdhock/atime/issues>

**Imports** data.table, bench, lattice, git2r, utils, stats, grDevices

**Suggests** directlabels, ggplot2, testthat, stringi, re2, binsegRcpp, grates, fastymd, wbs, fpop, changepoint, LOPART, PeakSegDisk, callr, readr, dplyr, tidyr, nc, RColorBrewer, Matrix, litedown

**VignetteBuilder** litedown

**NeedsCompilation** no

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## Contents

atime . . . . .	2
atime_grid . . . . .	3
atime_pkg . . . . .	5

atime_test . . . . .	7
atime_test_list . . . . .	8
atime_versions . . . . .	9
atime_versions_exprs . . . . .	11
atime_versions_remove . . . . .	13
glob_find_replace . . . . .	14
issue107 . . . . .	14
issue109 . . . . .	15
references_best . . . . .	16

## Index 18

---

atime	<i>Asymptotic timing</i>
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### Description

Computation time and memory for several R expressions of several different data sizes.

### Usage

```
atime(
  N, setup, expr.list=NULL, times=10, seconds.limit=0.01, verbose=FALSE,
  result=FALSE, N.env.parent=NULL, ...)
```

### Arguments

N	numeric vector of at least two unique data sizes, default is $2^{\text{seq}(2, 20)}$ .
setup	expression to evaluate for every data size, before timings.
expr.list	named list of expressions to time.
times	number of times to evaluate each timed expression.
seconds.limit	if the median timing of any expression exceeds this many seconds, then no timings for larger N are computed.
verbose	logical, print messages after every data size?
result	logical: save the result of evaluating each expression? Or a function to compute a result, given the value obtained after evaluating each expression. If each result is a data frame with one row, then the numeric column names will be saved as more units to analyze (in addition to kilobytes and seconds).
N.env.parent	environment to use as parent of environment created for each data size N, or NULL to use default parent env.
...	named expressions to time.

### Details

Each iteration involves first computing the setup expression, and then computing several times the ...expressions. For convenience, expressions may be specified either via code (...) or data (expr.list arg).

**Value**

list of class `atime` with elements `unit.col.vec` (character vector of column names to analyze), `seconds.limit` (numeric input param), `measurements` (data table of results).

**Author(s)**

Toby Dylan Hocking

**See Also**

[atime\\_grid](#) for avoiding repetition when measuring asymptotic properties of several similar expressions.

**Examples**

```
data.table::setDTthreads(1) # for CRAN.

## Polynomial and exponential time string functions.
atime_result_string <- atime::atime(
  seconds.limit=0.001,
  N=unique(as.integer(10^seq(0,3,l=100))),
  setup={
    subject <- paste(rep("a", N), collapse="")
    pattern <- paste(rep(c("a?", "a"), each=N), collapse="")
    linear_size_replacement <- paste(rep("REPLACEMENT", N), collapse="")
  },
  PCRE.match=regexpr(pattern, subject, perl=TRUE),
  TRE.match=regexpr(pattern, subject, perl=FALSE),
  constant.replacement=gsub("a","constant size replacement",subject),
  linear.replacement=gsub("a",linear_size_replacement,subject))
plot(atime_result_string)
```

---

atime\_grid

*Asymptotic timing grid*

---

**Description**

Create expressions for asymptotic timing by substituting values into expressions.

**Usage**

```
atime_grid(
  param.list = list(),
  ...,
  name.value.sep="=",
  expr.param.sep=" ",
  collapse = ",",
  symbol.params=character())
```

**Arguments**

`param.list` Named list of items to replace in ... expressions, default empty list means nothing to replace.

... Named expressions which each must contain each name of `param.list`.

`name.value.sep` string: separator between names and values from `param.list`, default "=".

`expr.param.sep` string: separator between expressions and parameters, default " ".

`collapse` string: separator between parameters, default ", ".

`symbol.params` character vector: these elements of `param.list` will be converted to symbols before substitution.

**Value**

Named list of expressions which can be used as `expr.list` argument of `atime`.

**Author(s)**

Toby Dylan Hocking

**Examples**

```
data.table::setDTthreads(1) # for CRAN.

## Example 0: with no param.list, same as quote inside named list.
atime::atime_grid(m=mean(data), s=sum(data))
list(m=quote(mean(data)), s=quote(sum(data)))

## Example 1: polynomial vs exponential time regex.
(expr.list <- atime::atime_grid(
  list(PERL=c(TRUE, FALSE)),
  expr.param.sep="\n",
  regexpr=regexpr(pattern, subject, perl=PERL)))
atime.list <- atime::atime(
  seconds.limit=0.001,
  N=unique(as.integer(10^seq(0,2,l=30))),
  setup={
    subject <- paste(rep("a", N), collapse="")
    pattern <- paste(rep(c("a?", "a"), each=N), collapse="")
  },
  expr.list=expr.list)
plot(atime.list)

## Example 2: symbol.params arg.
sub.param.list <- list(FUN=c("sub","gsub"), PERL=c(TRUE,FALSE))
## with base R we can use as.symbol and substitute:
sapply(sub.param.list$FUN,function(name)substitute(fun("a","",subject), list(fun=as.symbol(name))))
## with atime_grid the analog is to use symbol.params argument:
(sub.expr.list <- atime::atime_grid(
  sub.param.list,
  replace=FUN("a","",subject,perl=PERL),
  symbol.params="FUN"))
```

```

sub.atime.list <- atime::atime(
  seconds.limit=0.001,
  setup={
    subject <- paste(rep("a",N),collapse="")
  },
  expr.list=sub.expr.list)
plot(sub.atime.list)

## Customize ggplot, which shows expr.name column as direct labels.
sub.atime.edited <- sub.atime.list
library(data.table)
sub.atime.edited$measurements <- data.table(sub.atime.list$measurements)[
, expr.name := paste0("PERL=",PERL)]
if(require(ggplot2)){
  plot(sub.atime.edited)+
  facet_grid(unit ~ FUN, labeller=label_both, scales="free")
}

```

---

atime\_pkg

*Asymptotic timing package tests*


---

## Description

R package performance testing, by computing time/memory usage of several R expressions of several different data sizes, for several package versions (base, HEAD, CRAN, merge-base, other historical references specified by user). `atime_pkg_test_info` returns an environment containing test code/calls (useful for running a single test), whereas `atime_pkg` runs all tests and saves results/plots to disk.

## Usage

```

atime_pkg(pkg.path=".", tests.dir=NULL)
atime_pkg_test_info(pkg.path=".", tests.dir=NULL)

```

## Arguments

<code>pkg.path</code>	path to git repository containing R package.
<code>tests.dir</code>	path to directory which contains <code>atime/tests.R</code> , relative to <code>pkg.path</code> (default <code>NULL</code> means first existing directory of <code>"inst"</code> or <code>".ci"</code> ).

## Details

There should be a `tests.R` code file which defines `test.list`, a list with names corresponding to different tests. Each element should be a list with at least three named elements: `N`, `setup`, `expr`, (possibly others such as `pkg.edit.fun` and `version_name="1234567890abcdef"`) to be passed as named arguments to `atime_versions`, along with the following versions which are passed using the `sha.vec` argument: `base` ref comes from `GITHUB_BASE_REF` environment variable (default

master), HEAD ref is the branch that you want to merge into base, CRAN is current published version (sha value ""), merge-base is most recent common ancestor commit between base and HEAD. For visualization, default colors are provided for versions with names: HEAD, base, CRAN, merge-base, Before, Regression, Slow, Fixed, Fast; other version names will be gray using the default colors. If tests.R defines a variable named `version.colors`, then it should be a character vector of colors to be used instead of the default (names for versions, values for colors). If tests.R defines a variable named `pval.thresh`, then it should be a positive numeric value between 0 and 1 (any smaller p-values will generate messages about slowdowns in HEAD\_issues.md).

### Value

`atime_pkg_test_info` returns an environment in which the code of tests.R was evaluated, including a variable `test.call` which is a list of un-evaluated `atime_versions` calls, one for each test (use with `eval` to run a single test). `atime_pkg` returns a named list of two elements (preview and all), each a data table with one row per test shown in result figures. Side effect is that data/plot files are saved in `atime` directory, including `tests.RData` (test results which can be read into R if you want to make your own alternative plots/analyses), `tests_all_facet.png` (plot summarizing all test results), `tests_preview_facet.png` (plot summarizing only most significant results), and `install_seconds.txt` (total number of seconds used to install different package versions). Plots emphasize differences between HEAD and a comparison version, which is defined as the first of these versions which is available: merge-base, base, CRAN. Plots show test cases, first sorted by `pred.Nx`, which is the ratio of N values at the time limit (positive for speedup, negative for slowdown). Ties are broken using `P.value`, un-paired, two-sided, two-sample T-test for difference of mean times at largest N.

### Author(s)

Toby Dylan Hocking

### See Also

[atime\\_test](#) for defining each test, [atime\\_test\\_list](#) for defining common arguments in each element of the test list.

### Examples

```
if(FALSE){

  ## Clone binsegRcpp, and checkout a branch which has performance tests.
  tdir <- tempfile()
  dir.create(tdir)
  git2r::clone("https://github.com/tdhock/binsegRcpp", tdir)
  repo <- git2r::repository(tdir)
  git2r::checkout(repo, "another-branch")

  ## Run one test.
  info.env <- atime::atime_pkg_test_info(tdir)
  test_name <- "binseg(1:N,maxSegs=N/2) DIST=l1"
  (one.call <- info.env$test.call[[test_name]])
  one.result <- eval(one.call)
  plot(one.result) # constant difference for small N should be visible.
}
```

```

## Run all tests.
result.list <- atime::atime_pkg(tdir)
inst.atime <- file.path(tdir, "inst", "atime")
dir(inst.atime)
tests.RData <- file.path(inst.atime, "tests.RData")
(objs <- load(tests.RData))
plot(pkg.results[[test_name]]) # should look similar.

atime::atime_versions_remove("binsegRcpp")

}

## https://github.com/tdhock/binsegRcpp/blob/atime-test-funs/.ci/atime/tests.R
## has another real example, see how to run it in tests/testthat/test-versions.R

```

---

atime\_test

*Define an atime performance test*


---

## Description

Use this to define an element of your `test.list` in `atime/tests.R`, prior to running `atime_pkg`.

## Usage

```

atime_test(
  N, setup, expr, times, seconds.limit, verbose,
  pkg.edit.fun, result, ...)

```

## Arguments

<code>N</code>	numeric vector of data sizes to vary.
<code>setup</code>	expression to evaluate for every data size, before timings. In contrast to <code>expr</code> , no replacement of <code>Package:</code> is performed.
<code>expr</code>	code with package double-colon prefix, for example <code>PKG::fun(argA, argB)</code> , where <code>PKG</code> is the name of the package specified by <code>pkg.path</code> . This code will be evaluated for each different package version, by replacing <code>PKG:</code> by <code>PKG.SHA:</code> . To run different versions of implicitly-called functions like <code>DT[i, j]</code> , you need to call them explicitly, as in <code>data.table::`[.data.table` (DT, i, j)</code> .
<code>times</code>	number of times to evaluate each timed expression.
<code>seconds.limit</code>	if the median timing of any expression exceeds this many seconds, then no timings for larger <code>N</code> are computed.
<code>verbose</code>	logical, print messages after every data size?
<code>pkg.edit.fun</code>	function called to edit package before installation, should typically replace instances of <code>PKG</code> with <code>PKG.SHA</code> , default works with Rcpp packages.
<code>result</code>	logical, save results? (default <code>FALSE</code> )
<code>...</code>	named versions.

**Value**

List of expressions.

**Author(s)**

Toby Dylan Hocking

**See Also**

[atime\\_test\\_list](#) for defining common arguments in each element of the test list, [atime\\_pkg](#) for running tests.

**Examples**

```
atime::atime_test(
  N=c(1,10),
  setup=data.vec <- rnorm(N),
  expr=binsegRcpp::binseg("mean_norm",data.vec))

## https://github.com/tdhock/binsegRcpp/blob/atime-test-funs/.ci/atime/tests.R
## has a real example, see how to run it in tests/testthat/test-versions.R
```

---

atime_test_list	<i>Define an atime performance test list</i>
-----------------	--

---

**Description**

Use this to define `test.list` in your `atime/tests.R` file, prior to running [atime\\_pkg](#). Arguments in ... should all be named; if `name` is an argument of `atime_versions`, it will be copied to each test; otherwise it should be the name of a test.

**Usage**

```
atime_test_list(
  N, setup, expr, times, seconds.limit,
  verbose, pkg.edit.fun, result,
  tests = NULL, ...)
```

**Arguments**

...	names for tests, values are lists of arguments to pass to <a href="#">atime_versions</a> (combined with <code>tests</code> ).
<code>tests</code>	list of tests, with names for tests, values are lists of arguments to pass to <a href="#">atime_versions</a> (combined with ...).
<code>N</code>	integer vector of data sizes.

setup	expression that depends on N, to run before timings. Not evaluated before copying to each test.
expr	expression to time. Not evaluated before copying to each test.
times	number of times to run expr.
seconds.limit	number of seconds after which we stop trying larger N.
verbose	logical: print output?
pkg.edit.fun	function for editing package prior to testing.
result	logical: save results?

**Value**

List representing performance tests, from ... and tests; each element is a list of arguments to pass to [atime\\_versions](#).

**Author(s)**

Toby Dylan Hocking

**See Also**

[atime\\_test](#) for defining each test, [atime\\_pkg](#) for running tests.

**Examples**

```
(test.list.named <- atime::atime_test_list(
  N=as.integer(10^seq(1,3,by=0.5)),
  setup={
    set.seed(1)
    data.vec <- rnorm(N)
  },
  mean_norm=atime::atime_test(expr=binsegRcpp::binseg("mean_norm", data.vec)),
  poisson=atime::atime_test(expr=binsegRcpp::binseg("poisson", data.vec)),
  NULL))

## https://github.com/tdhock/binsegRcpp/blob/atime-test-funs/.ci/atime/tests.R
## has a real example, see how to run it in tests/testthat/test-versions.R
```

---

atime\_versions

*Asymptotic timing of git versions*


---

**Description**

Computation time and memory for a single R expression evaluated using several different git versions.

**Usage**

```
atime_versions(
  pkg.path, N, setup, expr, sha.vec=NULL,
  times=10, seconds.limit=0.01, verbose=FALSE,
  pkg.edit.fun=pkg.edit.default, result=FALSE,
  N.env.parent=NULL,
  ...)
```

**Arguments**

<code>pkg.path</code>	Path to R package in a git repo.
<code>N</code>	numeric vector of data sizes to vary.
<code>setup</code>	expression to evaluate for every data size, before timings. In contrast to <code>expr</code> , no replacement of <code>Package::</code> is performed.
<code>expr</code>	code with package double-colon prefix, for example <code>PKG::fun(argA, argB)</code> , where <code>PKG</code> is the name of the package specified by <code>pkg.path</code> . This code will be evaluated for each different package version, by replacing <code>PKG::</code> by <code>PKG.SHA::</code> . To run different versions of implicitly-called functions like <code>DT[i, j]</code> , you need to call them explicitly, as in <code>data.table::`[.data.table`(DT, i, j)</code> .
<code>sha.vec</code>	named character vector / list of versions.
<code>times</code>	number of times to evaluate each timed expression.
<code>seconds.limit</code>	if the median timing of any expression exceeds this many seconds, then no timings for larger <code>N</code> are computed.
<code>verbose</code>	logical, print messages after every data size?
<code>pkg.edit.fun</code>	function called to edit package before installation, should typically replace instances of <code>PKG</code> with <code>PKG.SHA</code> , default works with Rcpp packages.
<code>result</code>	logical or function, passed to <code>atime</code> .
<code>N.env.parent</code>	environment to use as parent of environment created for each data size <code>N</code> , or <code>NULL</code> to use default parent env.
<code>...</code>	named versions.

**Details**

For convenience, versions can be specified either as code (...), data (`sha.vec`), or both. Each version should be either "" (to use currently installed version of package, or if missing, install most recent version from CRAN) or a SHA1 hash, which is passed as branch arg to `git2r::checkout`; version names used to identify/interpret the output/plots.

**Value**

list of class `atime` with elements `seconds.limit` (numeric input param), `timings` (data table of results).

**Author(s)**

Toby Dylan Hocking

**See Also**

`atime_versions_exprs` converts `expr` into a list of expressions, one for each version, passed to `atime` as the `expr.list` argument.

**Examples**

```
if(FALSE){

  tdir <- tempfile()
  dir.create(tdir)
  git2r::clone("https://github.com/tdhock/binsegRcpp", tdir)
  atime.list <- atime::atime_versions(
    pkg.path=tdir,
    setup={
      max.segs <- as.integer(N/2)
      data.vec <- 1:N
    },
    expr=binsegRcpp::binseg_normal(data.vec, max.segs),
    cv="908b77c411bc7f4fcbcf53759245e738ae724c3e",
    "rm unord map"="dcd0808f52b0b9858352106cc7852e36d7f5b15d",
    mvl_construct="5942af606641428315b0e63c7da331c4cd44c091")
  plot(atime.list)

  atime::atime_versions_remove("binsegRcpp")

  gdir <- tempfile()
  dir.create(gdir)
  git2r::clone("https://github.com/tdhock/grates", gdir)
  glist <- atime::atime_versions(
    file.path(gdir, "pkg"),
    current = "1aae646888dcedb128c9076d9bd53fcb4075dcda",
    old     = "51056b9c4363797023da4572bde07e345ce57d9c",
    setup   = date_vec <- rep(Sys.Date(), N),
    expr    = grates::as_yearmonth(date_vec))
  plot(glist)

  atime::atime_versions_remove("grates")

}
```

---

`atime_versions_exprs` *Create expressions for different git versions*

---

**Description**

Install different git commit versions as different packages, then create a list of expressions, one for each version. For most use cases `atime_versions` is simpler, but `atime_versions_exprs` is more flexible for the case of comparing different versions of one expression to another expression.

**Usage**

```
atime_versions_exprs(
  pkg.path, expr, sha.vec=NULL,
  verbose=FALSE,
  pkg.edit.fun=pkg.edit.default, ...)
```

**Arguments**

<code>pkg.path</code>	Path to git repo containing R package.
<code>expr</code>	code with package double-colon prefix, for example <code>PKG::fun(argA, argB)</code> , where <code>PKG</code> is the name of the package specified by <code>pkg.path</code> . This code will be evaluated for each different package version, by replacing <code>PKG::</code> by <code>PKG.SHA::</code> . To run different versions of implicitly-called functions like <code>DT[i, j]</code> , you need to call them explicitly, as in <code>data.table::`[.data.table`(DT, i, j)</code> .
<code>sha.vec</code>	named character vector / list of versions.
<code>verbose</code>	logical, print messages after every data size?
<code>pkg.edit.fun</code>	function called to edit package before installation, should typically replace instances of <code>PKG</code> with <code>PKG.SHA</code> , default works with Rcpp packages, but does not work with all packages. For an example of a custom package editing function, see the <code>atime</code> vignette about <code>data.table</code> .
<code>...</code>	named versions.

**Details**

For convenience, versions can be specified either as code (...), data (`sha.vec`), or both. Each version should be either "" (to use currently installed version of package, or if missing, install most recent version from CRAN) or a SHA1 hash, which is passed as branch arg to `git2r::checkout`; version names used to identify/interpret the output/plots. Each version is installed as a separate package (to whatever R library is first on `.libPaths()`), using the package name `PKG.SHA`.

**Value**

A list of expressions, one for each version, created by replacing `PKG::` in `expr` with `PKG.SHA::`. This list can be used as `expr.list` argument of `atime()`, instead of writing code like `atime(name1=Package.SHA1::fun(argA, argB), name2=Package.SHA2::fun(argA, argB))`.

**Author(s)**

Toby Dylan Hocking

**Examples**

```
if(FALSE){
  if(requireNamespace("changepoint")){
    tdir <- tempfile()
    dir.create(tdir)
    git2r::clone("https://github.com/tdhock/binsegRcpp", tdir)
```

```

expr.list <- atime::atime_versions_exprs(
  pkg.path=tdir,
  expr=binsegRcpp::binseg_normal(data.vec, max.segs),
  cv="908b77c411bc7f4fcbcf53759245e738ae724c3e",
  "rm unord map"="dcd0808f52b0b9858352106cc7852e36d7f5b15d",
  "mv1_construct"="5942af606641428315b0e63c7da331c4cd44c091")
atime.list <- atime::atime(
  N=2^seq(2, 20),
  setup={
    max.segs <- as.integer(N/2)
    data.vec <- 1:N
  },
  expr.list=expr.list,
  changepoint=changepoint::cpt.mean(
    data.vec, penalty="Manual", pen.value=0, method="BinSeg",
    Q=max.segs-1))
plot(atime.list)
}

atime::atime_versions_remove("binsegRcpp")

}

```

---

atime\_versions\_remove *Remove packages installed by atime*

---

## Description

atime\_versions\_exprs installs different git versions of a package, and this function removes them. This can be useful if you have changed compilers, which may have different performance characteristics, so you can then re-compile all package versions using the same compiler.

## Usage

```
atime_versions_remove(Package)
```

## Arguments

Package	Name of package without SHA.
---------	------------------------------

## Details

The library searched is the first on `.libPaths()`.

## Value

integer exit status code from unlink, non-zero if removal failed.

**Author(s)**

Toby Dylan Hocking

---

glob\_find\_replace      *Find and replace within files*

---

**Description**

Find and replace for every file specified by glob.

**Usage**

```
glob_find_replace(glob, FIND, REPLACE)
```

**Arguments**

glob	character string: glob defining files.
FIND	character string: regex to find.
REPLACE	character string: regex to use for replacement.

**Value**

nothing.

**Author(s)**

Toby Dylan Hocking

**Examples**

```
## see vignette("data.table", package="atime")
```

---

issue107      *atime result for issue 107*

---

**Description**

atime was run on windows, to test a speed and memory increase. Memory increases linearly, but the predict method did not return the correct N value for kilobytes=1e4.

**Usage**

```
data("issue107")
```

**Format**

List from running `atime`.

**References**

<https://github.com/Rdatatable/data.table/issues/7687>

**Examples**

```
data(issue107, package="atime")
refs <- atime::references_best(issue107)
pred <- predict(refs, kilobytes=1e4)
pred$pred
if(requireNamespace("directlabels"))plot(pred)
```

---

issue109

*atime results for issue 109*

---

**Description**

`atime` was run on GitHub Actions, to test `data.table`. One test had a speed improvement, and was shown on the right of the facet plot.

**Usage**

```
data("issue109")
```

**Format**

List from running `atime_pkg()`.

**References**

<https://github.com/Rdatatable/data.table/pull/7401#issuecomment-3457752439>

**Examples**

```
data(issue109, package="atime")
```

---

references_best	<i>Best references</i>
-----------------	------------------------

---

**Description**

Compute best asymptotic references, for all empirical measurements which are present (not missing) and increasing with data size.

**Usage**

```
references_best(L, fun.list=NULL)
```

**Arguments**

L	List output from atime.
fun.list	List of asymptotic complexity reference functions, default NULL means to use package default.

**Value**

list of class "references\_best" with elements references (data table of all references), plot.references (data table of references to show using plot method, default is to show closest larger and smaller references), measurements (data table of measurements).

**Author(s)**

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**Examples**

```
## Polynomial and exponential time string functions.
atime_result_string <- atime::atime(
  seconds.limit=0.001,
  N=unique(as.integer(10^seq(0,4,l=100))),
  setup={
    subject <- paste(rep("a", N), collapse="")
    pattern <- paste(rep(c("a?", "a"), each=N), collapse="")
    linear_size_replacement <- paste(rep("REPLACEMENT", N), collapse="")
  },
  PCRE.match=regexpr(pattern, subject, perl=TRUE),
  TRE.match=regexpr(pattern, subject, perl=FALSE),
  constant.replacement=gsub("a","constant size replacement",subject),
  linear.replacement=gsub("a",linear_size_replacement,subject))
(refs_best_string <- atime::references_best(atime_result_string))
## plot method shows each expr and unit in a separate panel.
## default is to show closest larger and smaller references.
plot(refs_best_string)
## modifying plot.references changes violet references shown by plot.
refs_best_string$plot.references <- refs_best_string$ref[c("N", "N^2", "N^3", "2^N"),on="fun.name"]
```

```
plot(refs_best_string)
## predict method computes N for given units (default seconds limit).
(pred_string <- predict(refs_best_string))
plot(pred_string)
```

# Index

## \* datasets

issue107, [14](#)

issue109, [15](#)

atime, [2](#), [4](#), [10](#), [11](#)

atime\_grid, [3](#), [3](#)

atime\_pkg, [5](#), [7-9](#)

atime\_pkg\_test\_info (atime\_pkg), [5](#)

atime\_test, [6](#), [7](#), [9](#)

atime\_test\_list, [6](#), [8](#), [8](#)

atime\_versions, [8](#), [9](#), [9](#)

atime\_versions\_exprs, [11](#), [11](#)

atime\_versions\_remove, [13](#)

glob\_find\_replace, [14](#)

issue107, [14](#)

issue109, [15](#)

references\_best, [16](#)