Package ‘xts’

Type Package
Title eXtensible Time Series
Version 0.12.1
Depends zoo (>= 1.7-12)
Imports methods
LinkingTo zoo
Suggests timeSeries, timeDate, tseries, chron, fts, tis, RUnit
LazyLoad yes
Description Provide for uniform handling of R’s different time-based data classes by extending zoo, maximizing native format information preservation and allowing for user level customization and extension, while simplifying cross-class interoperability.
License GPL (>= 2)
URL https://github.com/joshuaulrich/xts
BugReports https://github.com/joshuaulrich/xts/issues
NeedsCompilation yes
Author Jeffrey A. Ryan [aut, cph],
Joshua M. Ulrich [cre, aut],
Ross Bennett [ctb],
Corwin Joy [ctb]
Maintainer Joshua M. Ulrich <josh.m.ulrich@gmail.com>
Repository CRAN
Date/Publication 2020-09-09 16:40:03 UTC

R topics documented:

  xts-package ........................................... 3
  .parseISO8601 ......................................... 3
  addEventLines ....................................... 5
  addLegend ............................................ 6
  addPanel ............................................. 7
R topics documented:

addPolygon .................................................. 8
addSeries .................................................... 9
align.time .................................................... 9
apply.monthly ................................................. 10
as.environment.xts .......................................... 11
as.xts ........................................................ 12
as.xts.methods ................................................. 14
axTicksByTime ................................................ 16
CLASS ........................................................ 17
coredata.xts ................................................ 18
diff.xts ....................................................... 19
dimnames.xts ................................................ 20
daypoints ...................................................... 22
first ............................................................ 23
firstof ......................................................... 25
indexTZ ......................................................... 26
isOrdered ...................................................... 27
make.index.unique ............................................. 28
merge.xts ..................................................... 30
na.locf.xts .................................................. 32
ndays .......................................................... 33
period.apply .................................................. 34
period.max .................................................... 35
period.min ..................................................... 36
period.prod ................................................... 37
period.sum .................................................... 38
periodicity .................................................... 39
plot.xts ....................................................... 40
rbind.xts ..................................................... 43
sample_matrix ............................................... 44
split.xts ...................................................... 45
tclass ........................................................ 46
timeBased ..................................................... 49
timeBasedSeq ................................................ 50
to.period ...................................................... 51
window.xts ................................................... 54
xts ............................................................ 55
xtsAPI ........................................................ 57
xtsAttributes ............................................... 59
xtsInternals .................................................. 60
[.xts ........................................................ 61

Index ......................................................... 65
xts-package

xts: extensible time-series

Description

Extensible time series class and methods, extending and behaving like zoo.

Details

<table>
<thead>
<tr>
<th>Package:</th>
<th>xts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Package</td>
</tr>
<tr>
<td>Version:</td>
<td>0.10-2</td>
</tr>
<tr>
<td>Date:</td>
<td>2018-03-13</td>
</tr>
<tr>
<td>License:</td>
<td>GPL (&gt;= 2)</td>
</tr>
</tbody>
</table>

Easily convert one of R’s many time-series (and non-time-series) classes to a true time-based object which inherits all of zoo’s methods, while allowing for new time-based tools where appropriate. Additionally, one may use xts to create new objects which can contain arbitrary attributes named during creation as name=value pairs.

Author(s)

Jeffrey A. Ryan and Joshua M. Ulrich
Maintainer: Joshua M. Ulrich <josh.m.ulrich@gmail.com>

See Also

xts as.xts reclass zoo

parseISO8601

Internal ISO 8601:2004(e) Time Parser

Description

This function is used internally in the subsetting mechanism of xts. The function is unexported, though documented for use with xts subsetting.

Usage

.parseISO8601(x, start, end, tz="")

.makeISO8601(x)
Arguments

x For .parseISO8601(x), a character string conforming to the ISO 8601:2004(e) rules. For .makeISO8601(x), x should be a time-like object with start and end methods.
start lower constraint on range
end upper constraint of range
tz timezone (tzone) to use internally

Details

This function replicates most of the ISO standard for expressing time and time-based ranges in a universally accepted way.

The best documentation is now the official ISO page as well as the Wikipedia entry for ISO 8601:2004.

The basic idea is to create the endpoints of a range, given a string representation. These endpoints are aligned in POSIXct time to the zero second of the day at the beginning, and the 59.9999th second of the 59th minute of the 23rd hour of the final day.

For dates prior to the epoch (1970-01-01) the ending time is aligned to the 59.0000 second. This is due to a bug/feature in the R implementation of as.POSIXct and mktime0 at the C-source level. This limits the precision of ranges prior to 1970 to 1 minute granularity with the current xts workaround.

Recurring times over multiple days may be specified using the T notation. See the examples for details.

Value

A list of length two, with an entry named ‘first.time’ and one names ‘last.time’.

For .makeISO8601, a character vector of length one describing the ISO-style format for a given time-based object.

Note

There is no checking done to test for a properly constructed ISO format string. This must be correctly entered by the user, lest bad things may happen.

When using durations, it is important to note that the time of the duration specified is not necessarily the same as the realized periods that may be returned when applied to an irregular time series. This is not a bug, rather it is a standards and implementation gotcha.

Author(s)

Jeffrey A. Ryan

References

https://www.iso.org/iso-8601-date-and-time-format.html
**addEventLines**

*Add vertical lines to an existing xts plot*

**Description**

Add vertical lines and labels to an existing xts plot

**Usage**

```
addEventLines(events, main = "", on = 0, lty = 1, lwd = 1, col = 1, ...)  
```

**Arguments**

- `events`:
  xts object of events and their associated labels. It is assumed that the first column of events is the event description/label.

- `main`:
  main title for a new panel if drawn.

- `on`:
  panel number to draw on. A new panel will be drawn if `on` is `NA`. The default, `on` is `0`, will add to the active panel. The active panel is defined as the panel on which the most recent action was performed. Note that only the first element of `on` is checked for the default behavior to add to the last active panel.

- `lty`:
  set the line type, same as in `par`.

- `lwd`:
  set the line width, same as in `par`.

- `col`:
  color palette to use, set by default to rational choices.

- `...`:
  any other passthrough parameters to `text` to control how the event labels are drawn.

**Examples**

- # the start and end of 2000
  - `parseISO8601('2000')`

- # the start of 2000 and end of 2001
  - `parseISO8601('2000/2001')`

- # May 1, 2000 to Dec 31, 2001
  - `parseISO8601('2000-05/2001')`

- # May 1, 2000 to end of Feb 2001
  - `parseISO8601('2000-05/2001-02')`

- # Jan 1, 2000 to Feb 29, 2000; note the truncated time on the LHS
  - `parseISO8601('2000-01/02')`

- # 8:30 to 15:00 (used in xts subsetting to extract recurring times)
  - `parseISO8601('T08:30/T15:00')`
Author(s)
Ross Bennett

Examples

```r
## Not run:
library(xts)
data(sample_matrix)
sample.xts <- as.xts(sample_matrix)
events <- xts(letters[1:3],
            as.Date(c("2007-01-12", "2007-04-22", "2007-06-13")))
plot(sample.xts[,4])
addEventLines(events, srt=90, pos=2)

## End(Not run)
```

addLegend

Add Legend

Description
Add Legend

Usage

```r
addLegend(legend.loc = "topright", legend.names = NULL, col = NULL,
ncol = 1, on = 0, ...)
```

Arguments

- `legend.loc`<br>legend.loc places a legend into one of nine locations on the chart: bottomright, bottom, bottomleft, left, topleft, top, topright, right, or center.
- `legend.names`<br>character vector of names for the legend. If `NULL`, the column names of the current plot object are used.
- `col`<br>fill colors for the legend. If `NULL`, the colorset of the current plot object data is used.
- `ncol`<br>number of columns for the legend
- `on`<br>panel number to draw on. A new panel will be drawn if `on=NA`. The default, `on=0`, will add to the active panel. The active panel is defined as the panel on which the most recent action was performed. Note that only the first element of `on` is checked for the default behavior to add to the last active panel.
- `...`<br>any other passthrough parameters to `legend`.

Author(s)
Ross Bennett
addPanel

Add a panel to an existing xts plot

Description

Apply a function to the data of an existing xts plot object and plot the result. FUN should have arguments x or R for the data of the existing xts plot object to be passed to. All other additional arguments for FUN are passed through . . .

Usage

addPanel(FUN, main = "", on = NA, type = "l", col = NULL, lty = 1, lwd = 1, pch = 1, ...)

Arguments

FUN
an xts object to plot.
main
main title for a new panel if drawn.
on
panel number to draw on. A new panel will be drawn if on=NA.
type
the type of plot to be drawn, same as in plot.
col
color palette to use, set by default to rational choices.
lty
set the line type, same as in par.
lwd
set the line width, same as in par.
pch
the type of plot to be drawn, same as in par.
...
additional named arguments passed through to FUN and any other graphical passthrough parameters.

Author(s)

Ross Bennett

Examples

library(xts)
data(sample_matrix)
sample.xts <- as.xts(sample_matrix)

calcReturns <- function(price, method = c("discrete", "log")){
  px <- try.xts(price)
  method <- match.arg(method)[1L]
  returns <- switch(method,
    simple =,
    discrete = px / lag(px) - 1,
    compound =,
    log = diff(log(px))
  reclass(returns, px)
# plot the Close
plot(sample.xts[, "Close"])

# calculate returns
addPanel(calcReturns, method = "discrete", type = "h")

# Add simple moving average to panel 1
addPanel(rollmean, k = 20, on = 1)
addPanel(rollmean, k = 40, col = "blue", on = 1)

---

**addPolygon**

*Add a polygon to an existing xts plot*

**Description**

Draw a polygon on an existing xts plot by specifying a time series of y coordinates. The xts index is used for the x coordinates and the first two columns are the upper and lower y coordinates, respectively.

**Usage**

```r
addPolygon(x, y = NULL, main = "", on = NA, col = NULL, ...)
```

**Arguments**

- `x` an xts object to plot. Must contain 2 columns for the upper and lower y coordinates for the polygon. The first column is interpreted as the upper y coordinates and the second column as the lower y coordinates.
- `y` NULL, not used
- `main` main title for a new panel if drawn.
- `on` panel number to draw on. A new panel will be drawn if on=NA.
- `col` color palette to use, set by default to rational choices.
- `...` passthru parameters to `par`

**Author(s)**

Ross Bennett

**References**

Based on code by Dirk Eddelbuettel from [http://dirk.eddelbuettel.com/blog/2011/01/16/](http://dirk.eddelbuettel.com/blog/2011/01/16/)
addSeries

Add a time series to an existing xts plot

Description

Add a time series to an existing xts plot

Usage

```r
addSeries(x, main = "", on = NA, type = "l", col = NULL, lty = 1,
           lwd = 1, pch = 1, ...)
```

Arguments

- `x`: an xts object to plot.
- `main`: main title for a new panel if drawn.
- `on`: panel number to draw on. A new panel will be drawn if on=NA.
- `type`: the type of plot to be drawn, same as in `plot`.
- `col`: color palette to use, set by default to rational choices.
- `lty`: set the line type, same as in `par`.
- `lwd`: set the line width, same as in `par`.
- `pch`: the type of plot to be drawn, same as in `par`.
- `...`: any other passthrough graphical parameters.

Author(s)

Ross Bennett

align.time

Align seconds, minutes, and hours to beginning of next period.

Description

Change timestamps to the start of the next period, specified in multiples of seconds.

Usage

```r
align.time(x, ...)
```

```
## S3 method for class 'xts'
align.time(x, n=60, ...)

shift.time(x, n=60, ...)

adj.time(x, ...)
```
Arguments

- `x`: object to align
- `n`: number of seconds to adjust by
- `...`: additional arguments. See details.

Details

This function is an S3 generic. The result is to round up to the next period determined by \( n \) modulo \( x \).

Value

A new object of class(`x`)

Author(s)

Jeffrey A. Ryan with input from Brian Peterson

See Also

to.period

Examples

```r
x <- Sys.time() + 1:1000

# every 10 seconds
align.time(x, 10)

# align to next whole minute
align.time(x, 60)

# align to next whole 10 min interval
align.time(x, 10 * 60)
```
as.environment.xts

Arguments

x an time-series object coercible to xts
FUN an R function
... additional arguments to FUN

Details

Simple mechanism to apply a function to non-overlapping time periods, e.g. weekly, monthly, etc. Different from rolling functions in that this will subset the data based on the specified time period (implicit in the call), and return a vector of values for each period in the original data.
Essentially a wrapper to the xts functions endpoints and period.apply, mainly as a convenience.

Value

A vector of results produced by FUN, corresponding to the appropriate periods.

Author(s)

Jeffrey A. Ryan

See Also

dependents,period.apply,to.monthly

Examples

xts.ts <- xts(rnorm(231),as.Date(13514:13744,origin="1970-01-01"))

start(xts.ts)
end(xts.ts)

apply.monthly(xts.ts,mean)
apply.monthly(xts.ts,function(x) var(x))

as.environment.xts

Coerce an 'xts' Object to an Environment by Column

Description

Method to automatically convert an ‘xts’ object to an environment containing vectors representing each column of the original xts object. Each objects will be named according to the column name it is extracted by.

Usage

## S3 method for class 'xts'
as.environment(x)
Arguments

x an xts object

Details

An experimental tool to convert xts objects into environments for simplifying use withing the standard R formula/data paradigm.

Value

An environment containing `ncol(x)` vectors extracted by column from x. Note that environments do not preserve (or have knowledge) of column position, a.k.a order.

Author(s)

Jeffrey A. Ryan

Examples

```r
x <- xts(1:10, Sys.Date()+1:10)
colnames(x) <- "X"
y <- xts(1:10, Sys.Date()+1:10)
colnames(x) <- "Y"
xy <- cbind(x,y)
colnames(xy)
e <- as.environment(xy) # currently using xts-style positive k
ls(xy)
ls.str(xy)
```

as.xts

Convert Object To And From Class xts

Description

Conversion functions to coerce data objects of arbitrary classes to class xts and back, without losing any attributes of the original format.

Usage

```r
as.xts(x, ...)
xtsible(x)
Reclass(x)

try.xts(x, ..., error = TRUE)
reclass(x, match.to, error = FALSE, ...)
```
**Arguments**

- **x**  
  data object to convert. See details for supported types

- **match.to**  
  xts object whose attributes will be passed to x

- **error**  
  error handling option. See Details.

- **...**  
  additional parameters or attributes

**Details**

A simple and reliable way to convert many different objects into a uniform format for use within R. It is possible with a call to `as.xts` to convert objects of class `timeSeries`, `ts`, `irts`, `fts`, `matrix`, `data.frame`, and `zoo`.

`xtsibble` safely checks whether an object can be converted to an xts object; returning TRUE on success and FALSE otherwise.

The help file `as.xts.methods` lists all available xts methods and arguments specific to each coercible type.

Additional name=value pairs may be passed to the function to be added to the new object. A special `print.xts` method will assure that the attributes are hidden from view, but will be available via R’s standard `attr` function, as well as the `xtsAttributes` function.

The returned object will preserve all relevant attribute/slot data within itself, allowing for temporary conversion to use `zoo` and xts compatible methods. A call to `reclass` returns the object to its original class, with all original attributes intact - unless otherwise changed.

It should be obvious, but any attributes added via the ...argument will not be carried back to the original data object, as there would be no available storage slot/attribute.

`Reclass` is designed for top-level use, where it is desirable to have the object returned from an arbitrary function in the same class as the object passed in. Most functions within R are not designed to return objects matching the original object’s class. While this tool is highly experimental at present, it attempts to handle conversion and reconversion transparently. The caveats are that the original object must be coercible to xts, the returned object must be of the same row length as the original object, and that the object to reconvert to is the first argument to the function being wrapped.

`try.xts` and `reclass` are functions that enable external developers access to the reclassing tools within xts to help speed development of time-aware functions, as well as provide a more robust and seamless end-user experience, regardless of the end-user’s choice of data-classes.

The `error` argument to `try.xts` accepts a logical value, indicating where an error should be thrown, a character string allowing for custom error messages to be displayed, or a function of the form `f(x,...)`, to be called upon construction error.

See the accompanying vignette for more details on the above usage and the package in general.

**Value**

An S3 object of class xts.

In the case of `Reclass` and `reclass`, the object returned will be of the original class as identified by `CLASS`. 
as.xts.methods

Convert Object To And From Class xts

Description

Conversion S3 methods to coerce data objects of arbitrary classes to class xts and back, without losing any attributes of the original format.

Usage

```r
## S3 method for class 'xts'
as.xts(x, ..., .RECLASS=FALSE)

## S3 method for class 'timeSeries'
as.xts(x, dateFormat="POSIXct", FinCenter, recordIDs, 
       title, documentation, ..., .RECLASS=FALSE)

## S3 method for class 'zoo'
as.xts(x, order.by=index(x), frequency=NULL, ..., .RECLASS=FALSE)

## S3 method for class 'ts'
as.xts(x, dateFormat, ..., .RECLASS=FALSE)

## S3 method for class 'data.frame'
as.xts(x, order.by, dateFormat="POSIXct", 
       frequency=NULL, ..., .RECLASS=FALSE)

## S3 method for class 'matrix'
as.xts(x, order.by, dateFormat="POSIXct", 
       frequency=NULL, ..., .RECLASS=FALSE)

as.fts.xts(x)
```

Arguments

- `x`  
  data object to convert. See details for supported types

- `dateFormat`  
  what format should the dates be converted to

Author(s)

Jeffrey A. Ryan

See Also

`xts.as.xts.methods`
as.xts.methods

FinCenter    see timeSeries help
recordIDs    see timeSeries help
title        see timeSeries help
documentation see timeSeries help
order.by     see zoo help
frequency    see zoo help
...           additional parameters or attributes
.RECLASS     should conversion be reversible?

Details

A simple and reliable way to convert many different objects into a uniform format for use within R. It is possible with a call to as.xts to convert objects of class timeSeries, ts, matrix, data.frame, and zoo.

Additional name=value pairs may be passed to the function to be added to the new object. A special print.xts method will assure that the attributes are hidden from view, but will be available via R's standard attr function.

If .RECLASS=TRUE, the returned object will preserve all relevant attribute/slot data within itself, allowing for temporary conversion to use zoo and xts compatible methods. A call to reclass returns the object to its original class, with all original attributes intact - unless otherwise changed. This is the default behavior when try.xts is used for conversion, and should not be altered by the user; i.e. don't touch it unless you are aware of the consequences.

It should be obvious, but any attributes added via the ...argument will not be carried back to the original data object, as there would be no available storage slot/attribute.

Value

An S3 object of class xts.

Author(s)

Jeffrey A. Ryan

See Also

xts

Examples

## Not run:
# timeSeries
library(timeSeries)
x <- timeSeries(1:10, 1:10)

str( as.xts(x) )
str( reclass(as.xts(x)) )
str( try.xts(x) )
\texttt{str( reclass\(\texttt{try.xts(x)}\))}

## End(Not run)

---

\textbf{axTicksByTime} \hspace{1cm} \textit{Compute x-Axis Tickmark Locations by Time}

\section*{Description}

Compute x-axis tickmarks like \texttt{axTicks} in base but with respect to time. Additionally the first argument is the object indexed by time which you are looking to derive tickmark locations for.

It is possible to specify the detail you are seeking, or by passing 'auto' to the \texttt{ticks.on} argument, to get a best heuristic fit.

\section*{Usage}

\texttt{axTicksByTime(x, ticks.on='auto', k = 1,}
\texttt{ labels=TRUE, format.labels=TRUE, ends=TRUE,}
\texttt{ gt = 2, lt = 30)}

\section*{Arguments}

\begin{itemize}
  \item \texttt{x} \hspace{1cm} the object indexed by time, or a vector of times/dates
  \item \texttt{ticks.on} \hspace{1cm} what to break on
  \item \texttt{k} \hspace{1cm} frequency of breaks
  \item \texttt{labels} \hspace{1cm} should a labeled vector be returned
  \item \texttt{format.labels} \hspace{1cm} format labels - may be format to use
  \item \texttt{ends} \hspace{1cm} should the ends be adjusted
  \item \texttt{gt} \hspace{1cm} lower bound on number of breaks
  \item \texttt{lt} \hspace{1cm} upper bound on number of breaks
\end{itemize}

\section*{Details}

This function is written for internal use, and documented for those wishing to use outside of the internal function uses. In general it is most unlikely that the end user will call this function directly.

The \texttt{format.labels} allows for standard formatting like that used in \texttt{format, strptime, and strftime}.

\section*{Value}

A vector of index points to break on, possibly with the index names.

\section*{Author(s)}

Jeffrey A. Ryan
CLASS

See Also

endpoints

Examples

data(sample_matrix)
axTicksByTime(as.xts(sample_matrix),'auto')
axTicksByTime(as.xts(sample_matrix),'weeks')
axTicksByTime(as.xts(sample_matrix),'months',7)

CLASS Extract and Set .CLASS Attribute

Description

Simple extraction and replacement function to access xts .CLASS attribute. The .CLASS attribute is used by reclass to transform an xts object back to its original class.

Usage

CLASS(x)

CLASS(x) <- value

Arguments

x an xts object
value the new .CLASS value to assign

Details

It is not recommended that CLASS be called in daily use. While it may be possible to coerce objects to other classes than originally derived from, there is little, if any, chance that the reclass function will perform as expected.

It is best to use the traditional as methods.

Value

Called for its side-effect of changing the .CLASS attribute

Author(s)

Jeffrey A. Ryan

See Also

as.xts, reclass
Description

Mechanism to extract and replace the core data of an xts object.

Usage

```r
## S3 method for class 'xts'
coredata(x, fmt=FALSE, ...)

xcoredata(x,...)
xcoredata(x) <- value
```

Arguments

- `x`: an xts object
- `fmt`: should the rownames be formatted in a non-standard way
- `value`: non-core attributes to assign
- `...`: further arguments [unused]

Details

Extract coredata of an xts object - removing all attributes except `dim` and `dimnames` and returning a matrix object with rownames converted from the index of the xts object.

The `fmt` argument, if TRUE, allows the internal index formatting specified by the user to be used. Alternatively, it may be a valid formatting string to be passed to `format`. Setting to FALSE will return the row names by simply coercing the index class to a character string in the default manner.

`xcoredata` is the functional complement to `coredata`, returning all of the attributes normally removed by `coredata`. Its purpose, along with the replacement function `xcoredata<-` is primarily for use by developers using `xts` to allow for internal replacement of values removed during use of non xts-aware functions.

Value

Returns either a matrix object for coredata, or a list of named attributes.

The replacement functions are called for their side-effects.

Author(s)

Jeffrey A. Ryan

See Also

`coredata`, `xtsAttributes`
Examples

```r
data(sample_matrix)
x <- as.xts(sample_matrix, myattr=100)
coredata(x)
xcoredata(x)
```

---

diff.xts

### Lags and Differences of xts Objects

Description

Methods for computing lags and differences on xts objects. This matches most of the functionality of `zoo` methods, with some default argument changes.

Usage

```r
## S3 method for class 'xts'
lag(x, k = 1, na.pad = TRUE, ...)

## S3 method for class 'xts'
diff(x, lag = 1, differences = 1, arithmetic = TRUE, log = FALSE, na.pad = TRUE, ...)
```

Arguments

- `x`: an xts object
- `k`: period to lag over
- `lag`: period to difference over
- `differences`: order of differencing
- `arithmetic`: should arithmetic or geometric differencing be used
- `log`: should (geometric) log differences be returned
- `na.pad`: pad vector back to original size
- `...`: additional arguments

Details

The primary motivation for having methods specific to xts was to make use of faster C-level code within xts. Additionally, it was decided that lag’s default behavior should match the common time-series interpretation of that operator — specifically that a value at time ‘t’ should be the value at time ‘t-1’ for a positive lag. This is different than lag.zoo as well as lag.ts.

Another notable difference is that na.pad is set to TRUE by default, to better reflect the transformation visually and within functions requiring positional matching of data.

Backwards compatibility with zoo can be achieved by setting `options(xts.compat.zoo.lag=TRUE)`. This will change the defaults of lag.xts to k=-1 and na.pad=FALSE.
Value

An xts object reflected the desired lag and/or differencing.

Author(s)

Jeffrey A. Ryan

References

https://en.wikipedia.org/wiki/Lag

Examples

```r
x <- xts(1:10, Sys.Date()+1:10)
lag(x)  # currently using xts-style positive k

lag(x, k=2)

lag(x, k=-1, na.pad=FALSE)  # matches lag.zoo(x, k=1)

diff(x)
diff(x, lag=1)
diff(x, diff=2)
diff(diff(x))
```

---

**dimnames.xts**

*Dimnames of an xts Object*

**Description**

Get or set dimnames of an xts object.

**Usage**

```r
## S3 method for class 'xts'
dimnames(x)

## S3 replacement method for class 'xts'
dimnames(x) <- value
```

**Arguments**

- **x**: an xts object
- **value**: a list object of length two. See Details.
The functions `dimnames.xts` and `dimnames<-.xts` are methods for the base functions `dimnames` and `dimnames<-`. 

`xts` objects by design are intended for lightweight management of time-indexed data.

Rownames are redundant in this design, as well as quite burdensome with respect to memory consumption and internal copying costs.

`rownames` and `colnames` in `R` make use of `dimnames` method dispatch internally, and thus require only modifications to `dimnames` to enforce the `xts` no rownames requirement.

To prevent accidental setting of rownames, `dimnames<-` for `xts` will simply set the rownames to `NULL` when invoked, regardless of attempts to set otherwise.

This is done for internal compatibility reasons, as well as to provide consistency in performance regardless of object use.

User level interaction with either `dimnames` or `rownames` will produce a character vector of the index, formatted based on the current specification of `indexFormat`. This occurs within the call by converting the results of calling `index(x)` to a character string, which itself first creates the object type specified internally from the underlying numeric time representation.

A list or character string containing coerced row names and/or actual column names.

Attempts to set rownames on `xts` objects via `rownames` or `dimnames` will silently fail. This is your warning.

All `xts` objects have dimension. There are no `xts` objects representable as named or unnamed vectors.

Jeffrey A. Ryan

See Also

`xts`

Examples

```r
x <- xts(1:10, Sys.Date()+1:10)
dimnames(x)
rownames(x)
rownames(x) <- 1:10
rownames(x)
str(x)
```
endpoints  Locate Endpoints by Time

Description

Extract index values of a given xts object corresponding to the last observations given a period specified by on.

Usage

endpoints(x, on="months", k=1)

Arguments

x  an xts object
on  the periods endpoints to find as a character string
k  along every k-th element - see notes

Details

endpoints returns a numeric vector corresponding to the last observation in each period specified by on, with a zero added to the beginning of the vector, and the index of the last observation in x at the end.

Valid values for the argument on include: “us” (microseconds), “microseconds”, “ms” (milliseconds), “milliseconds”, “secs” (seconds), “seconds”, “mins” (minutes), “minutes”, “hours”, “days”, “weeks”, “months”, “quarters”, and “years”.

Value

A numeric vector of endpoints beginning with 0 and ending with the a value equal to the length of the x argument.

Author(s)

Jeffrey A. Ryan

Examples

data(sample_matrix)
endpoints(sample_matrix)
endpoints(sample_matrix, 'weeks')
Return First or Last n Elements of A Data Object

Description
A generic function to return the first or last elements or rows of a vector or two-dimensional data object.
A more advanced subsetting is available for zoo objects with indexes inheriting from POSIXt or Date classes.

Usage

first(x,...)
last(x,...)

## Default S3 method:
first(x,n=1,keep=FALSE,...)

## Default S3 method:
last(x,n=1,keep=FALSE,...)

## S3 method for class 'xts'
first(x,n=1,keep=FALSE,...)

## S3 method for class 'xts'
last(x,n=1,keep=FALSE,...)

Arguments

x 1 or 2 dimensional data object
n number of periods to return
keep should removed values be kept?
... additional args - unused

Details
Provides the ability to identify the first or last n rows or observations of a data set. The generic method behaves much like head and tail from base, except by default only the first or last observation will be returned.
The more useful method for the xts class allows for time based subsetting, given an xtsible object.
n may be either a numeric value, indicating the number of observations to return - forward from first, or backwards from last, or it may be a character string describing the number and type of periods to return.
n may be positive or negative, in either numeric or character contexts. When positive it will return the result expected - e.g. last(X, '1 month') will return the last month’s data. If negative, all data
will be returned except for the last month. It is important to note that this is not the same as calling `first(X, '1 month')` or `first(X, '-1 month')`. All 4 variations return different subsets of data and have distinct purposes.

If `n` is a character string, it must be of the form `n period.type` or `period.type`, where `n` is a numeric value (defaults to 1 if not provided) describing the number of period types to move forward (first) or back (last).

For example, to return the last 3 weeks of a time oriented zoo object, one could call `last(X, '3 weeks')`. Valid period.types are: secs, seconds, mins, minutes, hours, days, weeks, months, quarters, and years.

It is possible to use any frequency specification (secs, mins, days, ...) for the period.type portion of the string, even if the original data is in a higher frequency. This makes it possible to return the last '2 months' of data from an object that has a daily periodicity.

It should be noted that it is only possible to extract data with methods equal to or less than the frequency of the original data set. Attempting otherwise will result in error.

Requesting more data than is in the original data object will produce a warning advising as such, and the object returned will simply be the original data.

**Value**

A subset of elements/rows of the original data.

**Author(s)**

Jeffrey A. Ryan

**Examples**

```r
first(1:100)
last(1:100)

data(LakeHuron)
first(LakeHuron, 10)
last(LakeHuron)

x <- xts(1:100, Sys.Date()+1:100)
first(x, 10)
first(x, '1 day')
first(x, '4 days')
first(x, 'month')
last(x, '2 months')
last(x, '6 weeks')
```
firstof

Create a POSIXct Object

Description
Enable fast creation of time stamps corresponding to the first or last observation in a specified time period.

Usage
firstof(year = 1970, month = 1, day = 1, hour = 0, min = 0, sec = 0, tz = "")

Arguments
year, month, day numerical values to specify a day
hour, min, sec numerical values to specify time within a day
tz timezone used for conversion

Details
A wrapper to the R function ISOdatetime with defaults corresponding to the first or last possible time in a given period.

Value
An object of class POSIXct.

Author(s)
Jeffrey A. Ryan

See Also
ISOdatetime

Examples
firstof(2000)
firstof(2005, 01, 01)

lastof(2007)
lastof(2007, 10)
indexTZ

Query the TimeZone of an xts object

Description

Get the TimeZone of an xts object.

Usage

indexTZ(x, ...)
tzone(x, ...)

indexTZ(x) <- value
tzone(x) <- value

Arguments

x
an xts object

value
a valid TZ object

... unused

Details

As of version 0.6-4 all objects carry the time zone under which they were created in a hidden attribute names .indexTZ.

Going forward from 0.7-4, the TZ variable is now also stored in the index itself, in the tzone attribute. This is to facilitate the transition to removing the xts-specific attributes referenced by tzone, indexFormat, and indexClass. These accessor functions will continue to behave the same under the new internals. Additionally, there is a new getter/setter method with tzone and tzone<-

Internally, all time indexing is converted to POSIXct, seconds since the epoch as defined by a combination of the underlying OS and the TZ variable setting at creation. The current implementation of xts manages time zone information as transparently as possible, delegating all management to R, which is in turn managed in most instances by the underlying operating system.

During printing, and subsetting by time strings the internal POSIX representation is used to identify in human-friendly terms the time at each position.

This is different than previous versions of xts, where the index was stored in its native format (i.e. class).

The ability to create an index using any of the supported timeBased classes (POSIXct, Date, dates, chron, timeDate, yearmon, yearqtr) is managed at the user-interaction point, and the class is merely stored in another index attribute, which is named ‘tclass’. This is accessible and changeable via the tclass and tclass(x)<- functions.

In most cases, all of this makes the subsetting by time strings possible, and also allows for consistent and fast manipulation of the series internally.

Problems may arise when an object that had been created under one TZ (time zone) are used in a session using another TZ. This isn’t usually a issue, but when it is a warning is given upon printing or subsetting. This warning may be controlled with options("xts_check_TZ").
isOrdered

Check If A Vector Is Ordered

Description

Performs check to determine if a vector is strictly increasing, strictly decreasing, not decreasing, or not increasing.

Usage

isOrdered(x, increasing = TRUE, strictly = TRUE)

Arguments

x a numeric vector
increasing test for increasing/decreasing values
strictly are duplicates OK
Details

Designed for internal use with xts, this provides highly optimized tests for ordering.

Value

Logical

Author(s)

Jeffrey A. Ryan

See Also

is.unsorted

Examples

# strictly increasing
isOrdered(1:10, increasing=TRUE)
isOrdered(1:10, increasing=FALSE)
isOrdered(c(1,1:10), increasing=TRUE)
isOrdered(c(1,1:10), increasing=TRUE, strictly=FALSE)

# decreasing
isOrdered(10:1, increasing=TRUE)
isOrdered(10:1, increasing=FALSE)

make.index.unique

Force Time Values To Be Unique

Description

A generic function to force sorted time vectors to be unique. Useful for high-frequency time-series where original time-stamps may have identical values. For the case of xts objects, the default eps is set to ten microseconds. In practice this advances each subsequent identical time by eps over the previous (possibly also advanced) value.

Usage

make.index.unique(x, eps = 1e-06, drop=FALSE, fromLast=FALSE, ...)

make.time.unique(x, eps = 1e-06, drop=FALSE, fromLast=FALSE, ...)
Arguments

- **x**: An xts object, or POSIXct vector.
- **eps**: Value to add to force uniqueness.
- **drop**: Drop duplicates instead of adjusting by `eps`
- **fromLast**: If drop=TRUE, fromLast controls which duplicated times are dropped. If fromLast=FALSE, the earliest observation with an identical timestamp is kept with subsequent observations dropped.

... unused

Details

The returned time-series object will have new time-stamps so that `isOrdered(.index(x))` evaluates to TRUE.

Value

A modified version of x.

Note

Incoming values must be pre-sorted, and no check is done to make sure that this is the case. If the index values are of storage.mode ‘integer’, they will be coerced to ‘double’ if drop=FALSE.

Author(s)

Jeffrey A. Ryan

See Also

- `align.time`

Examples

```r
ds <- options(digits.secs=6) # so we can see the change

x <- xts(1:10, as.POSIXct("2011-01-21") + c(1,1,1,2:8)/1e3)

x

make.index.unique(x)

options(ds)
```
Description

Used to perform merge operation on xts objects by time (index). Given the inherent ordered nature of xts time-series, a merge-join style merge allows for optimally efficient joins.

Usage

```r
## S3 method for class 'xts'
merge(...,
  all = TRUE,
  fill = NA,
  suffixes = NULL,
  join = "outer",
  retside = TRUE,
  retclass = "xts",
  tzone = NULL,
  drop=NULL,
  check.names=NULL)
```

Arguments

- `...` one or more xts objects, or objects coercible to class xts
- `all` a logical vector indicating merge type
- `fill` values to be used for missing elements
- `suffixes` to be added to merged column names
- `join` type of database join
- `retside` which side of the merged object should be returned (2-case only)
- `retclass` object to return
- `tzone` time zone of merged object
- `drop` not currently used
- `check.names` not currently used

Details

This is an xts method compatible with merge.zoo, as xts extends zoo. That documentation should also be referenced. Difference are noted where applicable.

Implemented almost entirely in custom C-level code, it is possible using either the `all` argument or the `join` argument to implement all common database join operations along the to-be-merged objects time-index: 'outer' (full outer - all rows), 'inner' (only rows with common indexes), 'left' (all rows in the left object, and those that match in the right), and 'right' (all rows in the right object, and those that match in the left).
The above join types can also be expressed as a vector of logical values passed to all. `c(TRUE,TRUE)` or `TRUE` for ‘join=”outer”', `c(FALSE,FALSE)` or `FALSE` for ‘join=”inner”', `c(TRUE, FALSE)` for ‘join=”left”', and `c(FALSE,TRUE)` for ‘join=”right”'.

Note that the `all` and `join` arguments imply a two case scenario. For merging more than two objects, they will simply fall back to a full outer or full inner join, depending on the first position of all, as left and right can be ambiguous with respect to sides.

To do something along the lines of `merge.zoo`’s method of joining based on an all argument of the same length of the arguments to join, see the example.

The resultant object will have the timezone of the leftmost argument if available. Use `tzone` to override.

If `retclass` is `NULL`, the joined objects will be split and reassigned silently back to the original environment they are called from. This is for backward compatibility with `zoo`, though unused by `xts`.

If `retclass` is `FALSE` the object will be stripped of its class attribute. This is for internal use.

Value

A new `xts` object containing the appropriate elements of the objects passed in to be merged.

Note

This is a highly optimized merge, specifically designed for ordered data. The only supported merging is based on the underlying time index.

Author(s)

Jeffrey A. Ryan

References

Merge Join Discussion: https://blogs.msdn.microsoft.com/craigfr/2006/08/03/merge-join/

Examples

```r
(x <- xts(4:10, Sys.Date()+4:10))
(y <- xts(1:6, Sys.Date()+1:6))
merge(x,y)
merge(x,y, join='inner')
merge(x,y, join='left')
merge(x,y, join='right')
merge.zoo(zoo(x),zoo(y),zoo(x), all=c(TRUE, FALSE, TRUE))
merge(merge(x,x),y, join='left')[,c(1,3,2)]

# zero-width objects (only index values) can be used
xi <- xts( , index(x))
merge(y, xi)
```
na.locf.xts  

Last Observation Carried Forward

Description

xts method replace ‘NA’ with most recent non-‘NA’

Usage

```r
## S3 method for class 'xts'
na.locf(object, na.rm = FALSE, fromLast = FALSE, maxgap = Inf, ...)
```

Arguments

- `object`: an xts object
- `na.rm`: logical. Should leading/trailing ‘NA’ s be removed? The default for xts FALSE is different than the default S3 method in the zoo package.
- `fromLast`: logical. Cause observations to be carried backward rather than forward. Default is FALSE.
- `maxgap`: runs of more than ‘maxgap’ will retain ‘NA’ s after the maximum gap specified. See na.locf in the zoo package.
- `...`: unused

Details

This is the xts method for the S3 generic na.locf. The primary difference to note is that after the ‘NA’ fill action is carried out, the default it to leave trailing or leading ‘NA’ s in place. This is different than zoo behavior.

Value

See the documentation in zoo.

Author(s)

Jeffrey A. Ryan

References

‘zoo’
Examples

```r
x <- xts(1:10, Sys.Date()+1:10)
x[c(1,2,5,9,10)] <- NA

x
na.locf(x)
na.locf(x, fromLast=TRUE)
na.locf(x, na.rm=TRUE, fromLast=TRUE)
```

### ndays

**Number of Periods in Data**

#### Description

Calculate the number of specified periods in a given time series like data object.

#### Usage

```r
nseconds(x)
nminutes(x)
hours(x)
ndays(x)
nweeks(x)
nmonths(x)
nquarters(x)
years(x)
```

#### Arguments

- `x`: A time-based object

#### Details

Essentially a wrapper to endpoints with the appropriate period specified; the resulting value derived from counting the endpoints.

As a compromise between simplicity and accuracy, the results will always round up to the nearest complete period. So `n**** - 1` will return the completed periods.

For finer grain detail one should call a higher frequency `n****` function.

An alternative summary can be found with `periodicity` and `unclass(periodicity(x))`.

#### Value

The number of observations for the period type specified

#### Author(s)

Jeffrey A. Ryan
period.apply

Description

Apply a specified function to data over a given interval, where the interval is taken to be the data from INDEX[k] to INDEX[k+1], for k=1:(length(INDEX)-1).

Usage

period.apply(x, INDEX, FUN, ...)

Arguments

x  data to apply FUN to
INDEX  numeric vector specifying indexing
FUN  an argument of type function
...  additional arguments for FUN

Details

Similar to the rest of the apply family, calculate a specified functions value given a shifting set of data values. The primary difference is that it is that period.apply applies a function to non-overlapping intervals along a vector.

Useful for applying arbitrary functions over an entire data object by an arbitrary index, as when INDEX is the result of a call to breakpoints.

Value

A vector with length of INDEX minus 1

Author(s)

Jeffrey A. Ryan
period.max

See Also

endpoints apply.monthly

Examples

zoo.data <- zoo(rnorm(31)+10,as.Date(13514:13744,origin="1970-01-01"))
ep <- endpoints(zoo.data,'weeks')
period.apply(zoo.data, INDEX=ep, FUN=function(x) mean(x))
period.apply(zoo.data, INDEX=ep, FUN=mean) # same

glue <- function(x) { paste(x,collapse='') }
period.apply(letters,c(0,5,7,26),glue)

---

period.max Calculate Max By Period

Description

Calculate a maximum for each period of INDEX. Essentially a rolling application of maximum over
a series of non-overlapping sections.

Usage

period.max(x, INDEX)

Arguments

x a univariate data object
INDEX a numeric vector of endpoints to calculate maximum on

Details

Used to calculate a maximum per period given an arbitrary index of sections to be calculated over.
This is an optimized function for maximum. There are additional optimized versions for min, sum,
and prod.
For xts-coercible objects, an appropriate INDEX can be derived from a call to 'endpoints'.

Value

An xts or zoo object of maximums, indexed by the period endpoints.

Author(s)

Jeffrey A. Ryan

See Also

endpoints, period.sum, period.min, period.prod
Examples

```r
period.max(c(1,1,4,2,2,6,7,8,-1,20),c(0,3,5,8,10))
data(sample_matrix)
period.max(sample_matrix[,1],endpoints(sample_matrix))
period.max(as.xts(sample_matrix)[,1],endpoints(sample_matrix))
```

---

**period.min**

*Calculate Min By Period*

Description

Calculate a minimum for each period of INDEX. Essentially a rolling application of minimum over a series of non-overlapping sections.

Usage

```r
period.min(x, INDEX)
```

Arguments

- **x**: a univariate data object
- **INDEX**: a numeric vector of endpoints to calculate maximum on

Details

Used to calculate a minimum per period given an arbitrary index of sections to be calculated over. This is an optimized function for minimum. There are additional optimized versions for max, sum, and prod.

For xts-coercible objects, an appropriate INDEX can be derived from a call to endpoints.

Value

An xts or zoo object of minimums, indexed by the period endpoints.

Author(s)

Jeffrey A. Ryan

See Also

`endpoints`, `period.sum`, `period.max`, `period.prod`
Examples

period.min(c(1,1,4,2,6,7,8,-1,20),c(0,3,5,8,10))

data(sample_matrix)
period.min(sample_matrix[,1],endpoints(sample_matrix))
period.min(as.xts(sample_matrix)[,1],endpoints(sample_matrix))

period.prod Calculate Product By Period

Description

Calculate a product for each period of INDEX. Essentially a rolling application of prod over a series of non-overlapping sections.

Usage

period.prod(x, INDEX)

Arguments

x a univariate data object
INDEX a vector of breakpoints to calculate product on

Details

Used to calculate a product per period given an arbitrary index of sections to be calculated over. This is an optimized function for product. There are additionally optimized versions for min, max, and sum.

For xts-coercible objects, an appropriate INDEX can be derived from a call to endpoints.

Value

An xts or zoo object of products, indexed by the period endpoints.

Author(s)

Jeffrey A. Ryan

See Also

endpoints, period.sum, period.min, period.max
Examples

```r
period.prod(c(1,1,4,2,2,6,7,8,-1,20),c(0,3,5,8,10))

data(sample_matrix)
period.prod(sample_matrix[,1],endpoints(sample_matrix))
period.prod(as.xts(sample_matrix)[,1],endpoints(sample_matrix))
```

---

**period.sum**  
*Calculate Sum By Period*

**Description**

Calculate a sum for each period of INDEX. Essentially a rolling application of sum over a series of non-overlapping sections.

**Usage**

```r
period.sum(x, INDEX)
```

**Arguments**

- `x`  
a univariate data object
- `INDEX`  
a numeric vector of endpoints to calculate sum on

**Details**

Used to calculate a sum per period given an arbitrary index of sections to be calculated over. This is an optimized function for sum. There are additionally optimized versions for min, max, and prod. For xts-coercible objects, an appropriate INDEX can be derived from a call to `endpoints`.

**Value**

An xts or zoo object of sums, indexed by the period endpoints.

**Author(s)**

Jeffrey A. Ryan

**See Also**

`endpoints`, `period.max`, `period.min`, `period.prod`

**Examples**

```r
period.sum(c(1,1,4,2,2,6,7,8,-1,20),c(0,3,5,8,10))

data(sample_matrix)
period.sum(sample_matrix[,1],endpoints(sample_matrix))
period.sum(as.xts(sample_matrix)[,1],endpoints(sample_matrix))
```
periodicity

**Description**

Estimate the periodicity of a time-series-like object by calculating the median time between observations in days.

**Usage**

```r
periodicity(x, ...)
```

**Arguments**

- `x` time-series-like object
- `...` unused

**Details**

A simple wrapper to quickly estimate the periodicity of a given data. Returning an object of type `periodicity`.

This calculates the median number of days between observations as a `difftime` object, the numerical difference, the units of measurement, and the derived scale of the data as a string.

The time index currently must be of either `Date` or `POSIX` class, or coercible to such.

The only list item of note is the `scale`. This is an estimate of the periodicity of the data in common terms - e.g. 7 day dialy data is best described as 'weekly', and would be returned as such.

Possible `scale` values are:

- 'minute', 'hourly', 'daily', 'weekly', 'monthly', 'quarterly', and 'yearly'.

**Value**

An object containing a list containing the `difftime` object, frequency, units, and suitable scale.

**Note**

This function is only a **good estimate** for the underlying periodicity. If the series is too short, or has no real periodicity, the return values will obviously be wrong. That said, it is quite robust and used internally within `xts`.

**Author(s)**

Jeffrey A. Ryan

**See Also**

- `difftime`
Examples

```r
zoo.ts <- zoo(rnorm(231), as.Date(13514:13744, origin="1970-01-01"))
periodicity(zoo.ts)
```

---

**plot.xts**  
*Plotting xts Objects*

**Description**  
Plotting for xts objects.

**Usage**

```r
## S3 method for class 'xts'
plot(x, y = NULL, ..., subset = "", panels = NULL, multi.panel = FALSE, col = 1:8, up.col = NULL, dn.col = NULL, bg = "#FFFFFF", type = "l", lty = 1, lwd = 2, lend = 1, main = deparse(substitute(x)), observation.based = FALSE, ylim = NULL, yaxis.same = TRUE, yaxis.left = TRUE, yaxis.right = TRUE, major.ticks = "auto", minor.ticks = NULL, grid.ticks.on = "auto", grid.ticks.lwd = 1, grid.ticks.lty = 1, grid.col = "darkgray", labels.col = "#333333", format.labels = TRUE, grid2 = "#F5F5F5", legend.loc = NULL)
## S3 method for class 'xts'
lines(x, ..., main = ", on = 0, col = NULL, type = "l", lty = 1, lwd = 1, pch = 1)
## S3 method for class 'xts'
points(x, ..., main = ", on = 0, col = NULL, pch = 1)
```

**Arguments**

- `x`: xts object
- `y`: NULL, not used
- `...`: any passthrough graphical arguments for lines and points
- `subset`: character vector of length one of the subset range using subsetting as in `xts`
- `panels`: character vector of expressions to plot as panels
- `multi.panel`: TRUE/FALSE or an integer less than or equal to the number of columns in the data set. If TRUE, each column of the data is plotted in a separate panel. For example, if `multi.panel = 2`, then the data will be plotted in groups of 2 columns and each group is plotted in a separate panel.
- `col`: color palette to use, set by default to rational choices
- `up.col`: color for positive bars if type="h"
- `dn.col`: color for negative bars if type="h"
- `bg`: background color of plotting area, same as in `par`
plot.xts

- **type**: the type of plot to be drawn, same as in `plot`
- **lty**: set the line type, same as in `par`
- **lwd**: set the line width, same as in `par`
- **lend**: set the line end style, same as in `par`
- **main**: main title
- **observation.based**: TRUE/FALSE (default FALSE). If TRUE, the x-axis is drawn based on observations in the data. If FALSE, the x-axis is drawn based on the time index of the data.
- **ylim**: the range of the y axis
- **yaxis.same**: TRUE/FALSE. If TRUE, the y axis is drawn with the same ylim for multiple panels
- **yaxis.left**: if TRUE, draws the y axis on the left
- **yaxis.right**: if TRUE, draws the y axis on the right
- **major.ticks**: period that specifies where tick marks and labels will be drawn on the x-axis. See Details for possible values.
- **minor.ticks**: period that specifies where minor ticks will be drawn on the x-axis. If NULL, minor ticks are not drawn. See Details for possible values.
- **grid.ticks.on**: period that specifies where vertical grid lines will be drawn. See Details for possible values.
- **grid.ticks.lwd**: line width of the grid
- **grid.ticks.lty**: line type of the grid
- **grid.col**: color of the grid
- **labels.col**: color of the axis labels
- **format.labels**: label format to draw lower frequency x-axis ticks and labels passed to `axTicksByTime`
- **grid2**: color for secondary x axis grid
- **legend.loc**: places a legend into one of nine locations on the chart: bottomright, bottom, bottomleft, left, topleft, top, topright, right, or center. Default NULL does not draw a legend.
- **pch**: the plotting character to use, same as in `par`
- **on**: panel number to draw on. A new panel will be drawn if on=NA. The default, on=0, will add to the active panel. The active panel is defined as the panel on which the most recent action was performed. Note that only the first element of on is checked for the default behavior to add to the last active panel.

**Details**

Possible values for arguments `major.ticks`, `minor.ticks`, and `grid.ticks.on` include ‘auto’, ‘minute’, ‘hours’, ‘days’, ‘weeks’, ‘months’, ‘quarters’, and ‘years’. The default is ‘auto’, which attempts to determine sensible locations from the periodicity and locations of observations. The other values are based on the possible values for the `ticks.on` argument of `axTicksByTime`.
Author(s)
Ross Bennett

References
based on chart_Series in the quantmod package by Jeffrey A. Ryan

See Also
addSeries, addPanel

Examples

```r
## Not run:
data(sample_matrix)
sample.xts <- as.xts(sample_matrix)

# plot the Close
plot(sample.xts[, "Close"])

# plot a subset of the data
plot(sample.xts[, "Close"], subset="2007-04-01/2007-06-31")

# function to compute simple returns
simple.ret <- function(x, col.name){
  x[, col.name] / lag(x[, col.name]) - 1
}

# plot the close and add a panel with the simple returns
plot(sample.xts[, "Close"])
R <- simple.ret(sample.xts, "Close")
lines(R, type="h", on=NA)

# add the 50 period simple moving average to panel 1 of the plot
library(TTR)
lines(SMA(sample.xts[, "Close"], n = 50), on=1, col="blue")

# add month end points to the chart
points(sample.xts[endpoints(sample.xts[, "Close"], on = "months"), "Close"],
col="red", pch=17, on=1)

# add legend to panel 1
addLegend("topright", on=1,
  legend.names = c("Close", "SMA(50)",
  lty=c(1, 1), lwd=c(2, 1),
  col=c("black", "blue", "red")
)

## End(Not run)
```
Concatenate or bind by row two or more xts objects along a time-based index.

## S3 method for class 'xts'
c(...)

## S3 method for class 'xts'
rbind(..., deparse.level = 1)

### Arguments
- ...: objects to bind
- deparse.level: not implemented

### Details
Implemented in C, these functions bind xts objects by row, resulting in another xts object. There may be non-unique index values in either the original series, or the resultant series. Identical indexed series are bound in the order or the arguments passed to rbind. See examples.

All objects must have the same number of columns, as well as be xts objects or coercible to such.
rbind and c are aliases.

For traditional merge operations, see merge.xts and cbind.xts.

### Value
An xts object with one row per row for each object concatenated.

### Note
This differs from rbind.zoo in that non-unique index values are allowed, in addition to the completely different algorithms used internally.

All operations may not behave as expected on objects with non-unique indices. You have been warned.

rbind is a .Primitive function in R. As such method dispatch occurs at the C-level, and may not be consistent with expectations. See the details section of the base function, and if needed call rbind.xts directly to avoid dispatch ambiguity.

### Author(s)
Jeffrey A. Ryan
See Also
merge.xts rbind

Examples

```r
x <- xts(1:10, Sys.Date()+1:10)
str(x)
merge(x,x)
rbind(x,x)
rbind(x[1:5],x[6:10])
c(x,x)
# this also works on non-unique index values
x <- xts(rep(1,5), Sys.Date()+c(1,2,2,2,3))
y <- xts(rep(2,3), Sys.Date()+c(1,2,3))
# overlapping indexes are appended
rbind(x,y)
rbind(y,x)
```

---

**Sample Data Matrix For xts Example and Unit Testing**

### Description
Simulated 180 observations on 4 variables.

### Usage
```
data(sample_matrix)
```

### Format
The format is:
- `num [1:180, 1:4] 50.0 50.2 50.4 50.4 50.2 ...`
- `attr(*, "dimnames")=List of 2`
  - `..$ : chr [1:180] "2007-01-02" "2007-01-03" "2007-01-04" "2007-01-05" ...
  - `..$ : chr [1:4] "Open" "High" "Low" "Close"

### Examples
```
data(.sample.matrix)
```
Description

Creates a list of xts objects split along time periods.

Usage

```r
## S3 method for class 'xts'
split(x, f = "months", drop=FALSE, k = 1, ...)
```

Arguments

- `x`: an xts object
- `f`: a 'character' vector describing the period to split by
- `drop`: ignored by split.xts
- `k`: number of periods to aggregate into each split. See Details.
- `...`: further args to non-xts method

Details

A quick way to break up a large xts object by standard time periods; e.g. 'months', 'quarters', etc. `endpoints` is used to find the start and end of each period (or k-periods). See that function for valid arguments.

If `f` is not a character vector, the NextMethod is called, which would in turn dispatch to the split.zoo method.

Value

A list of xts objects.

Note

`aggregate.zoo` would be more flexible, though not as fast for xts objects.

Author(s)

Jeffrey A. Ryan

See Also

`endpoints`, `split.zoo`, `aggregate.zoo`
Examples

```r
data(sample_matrix)
x <- as.xts(sample_matrix)

split(x)
split(x, f="weeks")
split(x, f="weeks", k=4)
```

---

**tclass**  
*Extracting/Replacing the Class of an xts Index*

**Description**

Generic functions to extract, replace, and format the class of the index of an xts object.

**Usage**

```r
## S3 method for class 'xts'
index(x, ...)

## S3 replacement method for class 'xts'
index(x) <- value

.index(x, ...)
.index(x) <- value

indexClass(x)
indexClass(x) <- value

tclass(x, ...)
tclass(x) <- value

tformat(x)
tformat(x) <- value

convertIndex(x,value)

# time component extraction/conversion

.indexDate(x)

.indexday(x)
.indexmday(x)
.indexwday(x)
.indexweek(x)
.indexmon(x)
.indexyday(x)
```
### tclass

- `.indexyear(x)`
- `.indexhour(x)`
- `.indexmin(x)`
- `.indexsec(x)`

**Arguments**

- `x` - xts object
- `value` - desired new class or format. See details
- `...` - additional arguments (unused)

**Details**

The main accessor methods to an xts object's index is via the `index` and `index<-` replacement method. The structure of the index internally is now a numeric value corresponding to seconds since the epoch (POSIXct converted to numeric). This change allows for near native-speed matrix subsetting, as well as nearly instantaneous speed subsets by time.

A call to `index` translates to the desired class on-the-fly. The desired index class is stored as an attribute within the xts object. Upon a standard `index` call, this is used to convert the numeric value to the desired class.

It is possible to view and set the class of the time-index of a given xts object via the `tclass` function.

To retrieve the raw numeric data a new accessor function (and replacement) has been added `.index`. This is primarily for internal use, but may be useful for end-users.

`.indexXXX` functions are useful to extract time components of the underlying time index. The `tc`lass' is virtual, and as such suitable conversions are made depending on the component requested.

The specified value for `tclass<-` must be a character string containing one of the following: Date, POSIXct, chron, yearmon, yearqtr or timeDate.

`tformat` only manages the manner in which the object is displayed via `print` (also called automatically when the object is returned) and in conversion to other classes such as `matrix`. The valid values for `tformat` are the same for `format.POSIXct`, as this is the function that does the conversion internally.

`convertIndex` returns a modified xts object, and does not alter the original.

Changing the index type may alter the behavior of xts functions expecting a different index, as well as the functionality of additional methods. Use with caution.

**Author(s)**

Jeffrey A. Ryan

**Examples**

```r
x <- timeBasedSeq('2010-01-01/2010-01-02 12:00')
x <- xts(1:length(x), x)
```
# all obs. in the first 6 and last 3 minutes of the
# 8th and 15th hours on each day
x[.indexhour(x) %in% c(8,15) & .indexmin(x) %in% c(0:5,57:59)]

# change the index format
tformat(x) <- "%Y-%b-%d \%H:\%M:\%S3"

head(x)

i <- 0:60000
focal_date <- as.numeric(as.POSIXct("2018-02-01", tz = "UTC"))
x <- .xts(i, c(focal_date + i * 15), tz = "UTC", dimnames = list(NULL, "value"))

# select all observations for the first minute of each hour:
x[.indexmin(x) == 0]

# Select all observations for Monday:
mon <- x[.indexwday(x) == 1]
head(mon); tail(mon)
unique(weekdays(index(mon))) # check

# Disjoint time of day selections

# Select all observations between 08:30 and 08:59:59.9999 or between 12:00 and 12:14:59.99999:
x[.indexhour(x) == 8 & .indexmin(x) >= 30 | .indexhour(x) == 12 & .indexmin(x) %in% 0:14]

### Compound selections

# Select all observations for Wednesdays or Fridays between 9am and 4pm (exclusive of 4pm):
x[.indexwday(x) %in% c(3, 5) & (.indexhour(x) %in% c(9:15))]

# Select all observations on Monday between 8:59:45 and 09:04:30:
x[.indexwday(x) == 1 & (.indexhour(x) == 8 & .indexmin(x) == 59 & .indexsec(x) >= 45 | .indexhour(x) == 9 & (.indexmin(x) < 4 | .indexmin(x) == 4 & .indexsec(x) <= 30))]

i <- 0:30000
u <- .xts(i, c(focal_date + i * 1800), tz = "UTC", dimnames = list(NULL, "value"))

# Select all observations for January or February:
u[.indexmon(u) %in% c(0, 1)]

# Select all data for the 28th to 31st of each month, excluding any Fridays:
u[.indexmday(u) %in% 28:31 & .indexwday(u) != 5]

# Subset by week since origin
unique(.indexweek(u))
origin <- xts(1, as.POSIXct("1970-01-01"))
unique(.indexweek(origin))

# e.g. select all observations in weeks 2515 to 2517.


```r
timeBased

u2 <- u[.indexweek(u) %in% 2515:2517]
head(u2); tail(u2)

# select all observations after 12pm for day 50 and 51 in each year
u[.indexyday(u) %in% 50:51 & .indexhour(u) >= 12]
```

---

### timeBased

**Check if Class is Time-Based**

**Description**

Used to verify that the object is one of the known time-based classes in R.

**Usage**

```r
is.timeBased(x)
timeBased(x)
```

**Arguments**

- `x` object to test

**Details**

Current time-based objects supported are `Date`, `POSIXct`, `chron`, `yearmon`, `yearqtr`, and `timeDate`.

**Value**

Logical

**Author(s)**

Jeffrey A. Ryan

**Examples**

```r
timeBased(Sys.time())
timeBased(Sys.Date())
timeBased(200701)
```
timeBasedSeq  

Create a Sequence or Range of Times

Description

A function to create a vector of time-based objects suitable for indexing an xts object, given a string conforming to the ISO 8601 time and date standard for range-based specification. The resultant series can be of any class supported by xts, including POSIXct, Date, chron, timeDate, yearmon, and yearqtr.

timeBasedRange creates a vector of length 1 or 2 as seconds since the epoch (1970-01-01) for use internally.

Usage

```r
timeBasedSeq(x, retclass = NULL, length.out = NULL)

timeBasedRange(x, ...)
```

Arguments

- **x**: a string representing the time-date range desired
- **retclass**: the return class desired
- **length.out**: passed to seq internally
- **...**: unused

Details

Designed to provide uniform creation of valid time-based objects for use within xts, the interface conforms (mostly) to the ISO recommended format for specifying ranges.

In general, the format is a string specifying a time and/or date from/to, and optionally by delineated by either "/" or "::".

The first argument need not be quoted, as it is converted internally if need be.

The general form is from/to/by or from::to::by, where to and by are optional if the length.out arg is specified.

The from and to elements of the string must be left-specified with respect to the standard CCYMM-DD HHMMSS form. All dates-times specified will be set to either the earliest point (from) or the latest (to), given the level of specificity.

For example ‘1999’ in the from field would set the start to the beginning of 1999. The opposite occurs in the to field.

The level of detail in the request is interpreted as the level of detail in the result. The maximum detail of either from or to is the basis of the sequence, unless the optional by element is specified, which will be covered later.

To request a yearly series, it is only necessary to use "1999/2008". Alternately, one could request a monthly series (returned by default as class yearmon) with "199901/2008" or "1999-01/2008".
or even "1999/2008-01". As the level of granularity increases, so does the resultant sequence granularity - as does its length.

Using the optional third by field (the third delimited element to the string), will override the granularity interpretation and return the requested periodicity. The acceptable arguments include Y for years, m for months, d for days, H for hours, M for minutes and S for seconds.

Value

A sequence or range of time-based objects.

If retclass is NULL, the result is a named list of from, to, by and length.out.

Author(s)

Jeffrey A. Ryan

References

International Organization for Standardization: ISO 8601 https://www.iso.org

See Also

timeBased, xts

Examples

timeBasedSeq('1999/2008')
timeBasedSeq('199901/2008')
timeBasedSeq('199901/2008/d')
timeBasedSeq('20080101 0830', length=100) # 100 minutes
timeBasedSeq('20080101 083000', length=100) # 100 seconds

---

**to.period**  
*Convert time series data to an OHLC series*

**Description**

Convert an OHLC or univariate object to a specified periodicity lower than the given data object. For example, convert a daily series to a monthly series, or a monthly series to a yearly one, or a one minute series to an hourly series.

The result will contain the open and close for the given period, as well as the maximum and minimum over the new period, reflected in the new high and low, respectively.

If volume for a period was available, the new volume will also be calculated.
Usage

to.minutes(x,k,name,...)
to.minutes3(x,name,...)
to.minutes5(x,name,...)
to.minutes10(x,name,...)
to.minutes15(x,name,...)
to.minutes30(x,name,...)
to.hourly(x,name,...)
to.daily(x,drop.time=TRUE,name,...)
to.weekly(x,drop.time=TRUE,name,...)
to.monthly(x,indexAt='yearmon',drop.time=TRUE,name,...)
to.quarterly(x,indexAt='yearqtr',drop.time=TRUE,name,...)
to.yearly(x,drop.time=TRUE,name,...)

to.period(x,
    period = 'months',
    k = 1,
    indexAt,
    name=NULL,
    OHLC = TRUE,
    ...)

Arguments

x a univariate or OHLC type time-series object
period period to convert to. See details.
indexAt convert final index to new class or date. See details
drop.time remove time component of POSIX datestamp (if any)
k number of sub periods to aggregate on (only for minutes and seconds)
name override column names
OHLC should an OHLC object be returned? (only OHLC=TRUE currently supported)
... additional arguments

Details

Essentially an easy and reliable way to convert one periodicity of data into any new periodicity. It is important to note that all dates will be aligned to the end of each period by default - with the exception of to.monthly and to.quarterly, which index by ‘yearmon’ and ‘yearqtr’ from the zoo package, respectively.

Valid period character strings include: “seconds”, “minutes”, “hours”, “days”, “weeks”, “months”, “quarters”, and “years”. These are calculated internally via endpoints. See that function’s help page for further details.

To adjust the final indexing style, it is possible to set indexAt to one of the following: ‘yearmon’, ‘yearqtr’, ‘firstof’, ‘lastof’, ‘startof’, or ‘endof’. The final index will then be yearmon, yearqtr,
the first time of the period, the last time of the period, the starting time in the data for that period,
or the ending time in the data for that period, respectively.

It is also possible to pass a single time series, such as a univariate exchange rate, and return an
OHLC object of lower frequency - e.g. the weekly OHLC of the daily series.

Setting drop.time to TRUE (the default) will convert a series that includes a time component into
one with just a date index, as the time index is often of little value in lower frequency series.

It is not possible to convert a series from a lower periodicity to a higher periodicity - e.g. weekly to
daily or daily to 5 minute bars, as that would require magic.

Value

An object of the original type, with new periodicity.

Note

In order for this function to work properly on OHLC data, it is necessary that the Open, High, Low
and Close columns be names as such; including the first letter capitalized and the full spelling found.
Internally a call is made to reorder the data into the correct column order, and then a verification
step to make sure that this ordering and naming has succeeded. All other data formats must be
aggregated with functions such as aggregate and period.apply.

This method should work on almost all time-series-like objects. Including ‘timeSeries’, ‘zoo’, ‘ts’,
and ‘irts’. It is even likely to work well for other data structures - including ‘data.frames’ and
‘matrix’ objects.

Internally a call to as.xts converts the original x into the universal xts format, and then re-converts
back to the original type.

A special note with respect to ‘ts’ objects. As these are strictly regular they may include NA values.
These are stripped for aggregation purposes, though replaced before returning. This inevitably leads
to many, many additional ‘NA’ values in the data. It is more beneficial to consider using an ‘xts’
object originally, or converting to one in the function call by means of as.xts.

Author(s)

Jeffrey A. Ryan

Examples

data(sample_matrix)

samplexts <- as.xts(sample_matrix)

to.monthly(samplexts)
to.monthly(sample_matrix)

str(to.monthly(samplexts))
str(to.monthly(sample_matrix))
Description
Method for extracting time windows from xts objects.

Usage
## S3 method for class 'xts'
window(x, index. = NULL, start = NULL, end = NULL, ...)

Arguments
x
an object.

index.
a user defined time index. This defaults to the xts index for the series via .index(x). When supplied, this is typically a subset of the dates in the full series. The index. must be a set of dates that are convertible to POSIXct. If you want fast lookups, then index. should be sorted and of class POSIXct. If an unsorted index. is passed in, window will sort it.

start
a start time. Extract xts rows where index. >= start. start may be any class that is convertible to POSIXct such as a character variable in the format 'YYYY-MM-DD'. If start is NULL then all index. dates are matched.

end
an end time. Extract xts rows where index. <= end. end must be convertible to POSIXct. If end is NULL then all index. dates are matched.

...currently not used.

Details
The point of having window in addition to the regular subset function is to have a fast way of extracting time ranges from an xts series. In particular, this method will convert start and end to POSIXct then do a binary lookup on the internal xts index to quickly return a range of matching dates. With a user supplied index., a similarly fast invocation of findInterval is used so that large sets of sorted dates can be retrieved quickly.

Value
The matching time window is extracted.

Author(s)
Corwin Joy
See Also

subset.xts, findInterval, xts

Examples

## xts example

```r
x.date <- as.Date(paste(2003, rep(1:4, 4:1), seq(1,19,2), sep = "-"))
x <- xts(matrix(rnorm(20), ncol = 2), x.date)
x

window(x, start = "2003-02-01", end = "2003-03-01")
window(x, start = as.Date("2003-02-01"), end = as.Date("2003-03-01"))
window(x, index = x.date[1:6], start = as.Date("2003-02-01"))
window(x, index = x.date[c(4, 8, 10)])

## Assign to subset
window(x, index = x.date[c(4, 8, 10)]) <- matrix(1:6, ncol = 2)
x
```

xts

Create Or Test For An xts Time-Series Object

Description

Constructor function for creating an extensible time-series object.

_xts_ is used to create an xts object from raw data inputs.

Usage

```r
xts(x = NULL,
    order.by = index(x),
    frequency = NULL,
    unique = TRUE,
    tzone = Sys.getenv("TZ"),
    ...
)

is.xts(x)
```

Arguments

- **x**: an object containing the time series data
- **order.by**: a corresponding vector of unique times/dates - must be of a known time-based class. See details.
- **frequency**: numeric indicating frequency of order.by. See details.
- **unique**: should index be checked for unique time-stamps?
- **tzone**: time zone of series. This is ignored for Date indices
- **...**: additional attributes to be added. See details.
Details

An xts object extends the S3 class zoo from the package of the same name.

Similar to zoo objects, xts objects must have an ordered index. While zoo indexes cannot contain duplicate values, xts objects have optionally supported duplicate index elements since version 0.5-0. The xts class has one additional requirement, the index must be a time-based class. Currently supported classes include: ‘Date’, ‘POSIXct’, ‘timeDate’, as well as ‘yearmon’ and ‘yearqtr’ where the index values remain unique.

The uniqueness requirement was relaxed in version 0.5-0, but is still enforced by default. Setting unique = FALSE skips the uniqueness check and only ensures that the index is ordered via the isOrdered function.

As of version 0.10-0, xts no longer allows missing values in the index. This is because many xts functions expect all index values to be finite. The most important of these is merge.xts, which is used ubiquitously. Missing values in the index are usually the result of a date-time conversion error (e.g. incorrect format, non-existent time due to daylight saving time, etc). Because of how non-finite numbers are represented, a missing timestamp will always be at the end of the index (except if it is -Inf, which will be first).

Another difference is that the object may now carry additional attributes that may be desired in individual time-series handling. This includes the ability to augment the objects data with metadata otherwise not cleanly attachable to a standard zoo object.

Examples of usage from finance may include the addition of data for keeping track of sources, last-update times, financial instrument descriptions or details, etc.

The idea behind xts is to offer the user the ability to utilize a standard zoo object, while providing an mechanism to customize the object’s meta-data, as well as create custom methods to handle the object in a manner required by the user.

Many xts-specific methods have been written to better handle the unique aspects of xts. These include, `"["`, merge, cbind, rbind, e, Ops, lag, diff, coredata, head and tail. Additionally there are xts specific methods for converting amongst R’s different time-series classes.

Subsetting via `"["` methods offers the ability to specify dates by range, if they are enclosed in quotes. The style borrows from python by creating ranges with a double colon `"::"` or `"/"` operator. Each side of the operator may be left blank, which would then default to the beginning and end of the data, respectively. To specify a subset of times, it is only required that the time specified be in standard ISO format, with some form of separation between the elements. The time must be ‘left-filled’, that is to specify a full year one needs only to provide the year, a month would require the full year and the integer of the month requested - e.g. '1999-01'. This format would extend all the way down to seconds - e.g. '1999-01-01 08:35:23'. Leading zeros are not necessary. See the examples for more detail.

Users may also extend the xts class to new classes to allow for method overloading.

Additional benefits derive from the use of as.xts and reclass, which allow for lossless two-way conversion between common R time-series classes and the xts object structure. See those functions for more detail.

Value

An S3 object of class xts. As it inherits and extends the zoo class, all zoo methods remain valid. Additional attributes may be assigned and extracted via xtsAttributes.
Note

Most users will benefit the most by using the as.xts and reclass functions to automagically handle all data objects as one would handle a zoo object.

Author(s)

Jeffrey A. Ryan and Joshua M. Ulrich

References

zoo:

See Also

as.xts, reclass, xtsAttributes

Examples

data(sample_matrix)
sample.xts <- as.xts(sample_matrix, descr='my new xts object')

class(sample.xts)
str(sample.xts)

head(sample.xts) # attribute 'descr' hidden from view
attr(sample.xts,'descr')

sample.xts[['2007']] # all of 2007
sample.xts[['2007-03/']] # March 2007 to the end of the data set
sample.xts[['2007-03/2007']] # March 2007 to the end of 2007
sample.xts['/'] # the whole data set
sample.xts['/2007'] # the beginning of the data through 2007
sample.xts['2007-01-03'] # just the 3rd of January 2007
Callable from other R packages:
SEXP xtsIsOrdered(SEXP x, SEXP increasing, SEXP strictly)
SEXP xtsNaCheck(SEXP x, SEXP check)
SEXP xtsTry(SEXP x)
SEXP xtsRBind(SEXP x, SEXP y, SEXP dup)
SEXP xtsCoredata(SEXP x)
SEXP xtsLag(SEXP x, SEXP k, SEXP pad)

Internal use functions:
SEXP isXts(SEXP x)
void copy_xtsAttributes(SEXP x, SEXP y)
void copy_xtsCoreAttributes(SEXP x, SEXP y)

Internal use macros:
xts_ATTRIB(x)
xts_COREATTRIB(x)
GET_xtsIndex(x)
SET_xtsIndex(x, value)
GET_xtsIndexFormat(x)
SET_xtsIndexFormat(x, value)
GET_xtsCLASS(x)
SET_xtsCLASS(x, value)

Internal use SYMBOLS:
xts_IndexSymbol
xts_ClassSymbol
xts_IndexFormatSymbol

Callable from R:
SEXP mergeXts(SEXP args)
SEXP rbindXts(SEXP args)
SEXP tryXts(SEXP x)

Author(s)
Jeffrey A. Ryan

Examples
## Not run:
# some example code to look at

file.show(system.file('api_example/README', package="xts"))
file.show(system.file('api_example/src/checkOrder.c', package="xts"))

## End(Not run)
xtsAttributes

Extract and Replace xts Attributes

Description

Extract and replace non-core xts attributes.

Usage

xtsAttributes(x, user=NULL)

xtsAttributes(x) <- value

Arguments

x an xts object
user logical: should user-defined attributes be returned? The default of NULL returns all xts attributes.
value a list of new name=value attributes

Details

Since xts objects are S3 objects with special attributes, a method is necessary to properly assign and view the user-added attributes.

A call to attributes from the base package will return all attributes, including those specific to the xts class.

Value

A named list of user settable attributes.

Author(s)

Jeffrey A. Ryan

See Also

attributes

Examples

x <- xts(matrix(1:(9*6),nc=6), order.by=as.Date(13000,origin="1970-01-01")+1:9, al='my attribute')

xtsAttributes(x)
xtsAttributes(x) <- list(a2=2020)
xtsAttributes(x)
xtsAttributes(x) <- list(a=NULL)
xtsAttributes(x)

---

\textbf{Description}

This help file is to help in development of xts, as well as provide some clarity and insight into its purpose and implementation.

Last modified: 2008-08-06 by Jeffrey A. Ryan
Version: 0.5-0 and above

The \texttt{xts} package xts designed as a drop-in replacement for the very popular \texttt{zoo} package. Most all functionality of zoo has been extended or carries into the xts package.

Notable changes in direction include the use of time-based indexing, at first explicitly, now implicitly.

An \texttt{xts} object consists of data in the form of a matrix, an index - ordered and increasing, either numeric or integer, and additional attributes for use internally, or for end-user purposes.

The current implementation enforces two major rules on the object. One is that the index must be coercible to numeric, by way of \texttt{as.POSIXct}. There are defined types that meet this criteria. See \texttt{timeBased} for details.

The second requirement is that the object cannot have rownames. The motivation from this comes in part from the work Matthew Doyle has done in his data.table class, in the package of the same name. Rownames in \texttt{R} must be character vectors, and as such are inefficient in both storage and conversion. By eliminating the rownames, and providing a numeric index of \texttt{R} internal type \texttt{REAL} or \texttt{INTEGER}, it is possible to maintain a connection to standard \texttt{R} date and time classes via the \texttt{POSIXct} functions, while at the same time maximizing efficiencies in data handling.

User level functions \texttt{index}, as well as conversion to other classes proceeds as if there were rownames. The code for \texttt{index} automatically converts time to numeric in both extraction and replacement functionality. This provides a level of abstraction to facilitate internal, and external package use and inter-operability.

There is also new work on providing a C-level API to some of the xts functionality to facilitate external package developers to utilize the fast utility routines such as subsetting and merges, without having to call only from \texttt{R}. Obviously this places far more burden on the developer to not only understand the internal xts implementation, but also to understand all of what is documented for R-internals (and much that isn’t). At present the functions and macros available can be found in the ‘xts.h’ file in the src directory.

There is no current documentation for this API. The adventure starts here. Future documentation is planned, not implemented.

\textbf{Author(s)}

Jeffrey A. Ryan
Description

Details on efficient subsetting of xts objects for maximum performance and compatibility.

Usage

```r
## S3 method for class 'xts'
x[i, j, drop = FALSE, which.i=FALSE, ...]
```

Arguments

- `x`: xts object
- `i`: the rows to extract. Numeric, timeBased or ISO-8601 style (see details)
- `j`: the columns to extract, numeric or by name
- `drop`: should dimension be dropped, if possible. See NOTE.
- `which.i`: return the ‘i’ values used for subsetting. No subset will be performed.
- `...`: additional arguments (unused)

Details

One of the primary motivations, and key points of differentiation of the time series class xts, is the ability to subset rows by specifying ISO-8601 compatible range strings. This allows for natural range-based time queries without requiring prior knowledge of the underlying time object used in construction.

When a raw character vector is used for the `i` subset argument, it is processed as if it was ISO-8601 compliant. This means that it is parsed from left to right, according to the following specification:

```
CCYYMMDD HH:MM:SS.ss+
```

A full description will be expanded from a left-specified truncated one.

Additionally, one may specify range-based queries by simply supplying two time descriptions separated by a forward slash:

```
CCYYMMDD HH:MM:SS.ss+/CCYYMMDD HH:MM:SS.ss
```

The algorithm to parse the above is `parseISO8601` from the `xts` package.

ISO-style subsetting, given a range type query, makes use of a custom binary search mechanism that allows for very fast subsetting as no linear search though the index is required. ISO-style character vectors may be longer than length one, allowing for multiple non-contiguous ranges to be selected in one subsetting call.

If a character `vector` representing time is used in place of numeric values, ISO-style queries, or timeBased objects, the above parsing will be carried out on each element of the i-vector. This overhead can be very costly. If the character approach is used when no ISO range querying is needed, it is recommended to wrap the ‘i’ character vector with the `I()` function call, to allow for
more efficient internal processing. Alternately converting character vectors to POSIXct objects will provide the most performance efficiency.

As `xts` uses POSIXct time representations of all user-level index classes internally, the fastest time-based subsetting will always be from POSIXct objects, regardless of the `tclass` of the original object. All non-POSIXct time classes are converted to character first to preserve consistent TZ behavior.

**Value**

An extraction of the original xts object. If `which.i` is `TRUE`, the corresponding integer ‘i’ values used to subset will be returned.

**Note**

By design, `drop=FALSE` in the default case. This preserves the basic underlying type of `matrix` and the `dim()` to be non-NULL. This is different from both matrix and zoo behavior as R uses `drop=TRUE`. Explicitly passing `drop=TRUE` may be required when performing certain matrix operations.

**Author(s)**

Jeffrey A. Ryan

**References**

ISO 8601: Date elements and interchange formats - Information interchange - Representation of dates and time [https://www.iso.org](https://www.iso.org)

**See Also**

`xts`, `.parseISO8601`, `.index`

**Examples**

```r
x <- xts(1:3, Sys.Date()+1:3)
xx <- cbind(x,x)

# drop=FALSE for xts, differs from zoo and matrix
z <- as.zoo(xx)
z/z[,1]

m <- as.matrix(xx)
m/m[,1]

# this will fail with non-conformable arrays (both retain dim)
tryCatch(
  xx/xx[,1],
  error=function(e) print("need to set drop=TRUE")
)

# correct way
```
\[ xx/xx[,1,drop=TRUE] \]

# or less efficiently
\[ xx/drop(xx[,1]) \]
# likewise
\[ xx/coredata(xx)[,1] \]

\[ x <- xts(1:1000, as.Date("2000-01-01") + 1:1000) \]
\[ y <- xts(1:1000, as.POSIXct(format(as.Date("2000-01-01") + 1:1000))) \]

\[ x[as.character(x.subset)] \] # by character string. Beware!
\[ x[as.character(x.subset)] \] # wrapped with I(), faster!

\[ x[\text{"200001\"}] \] # January 2000
\[ x[\text{"1999/2000\"}] \] # All of 2000 (note there is no need to use the exact start)
\[ x[\text{"1999/200001\"}] \] # January 2000

\[ y[\text{"1999/200005\"}] \] # 2000-01 to 2000-05
\[ x[\text{"2000/2000-04-01\"}] \] # through April 01, 2000
\[ y[\text{"2000/2000-04-01\"}] \] # through April 01, 2000 (using POSIXct series)

### Time of day subsetting

\[ i <- 0:60000 \]
\[ focal_date <- as.numeric(as.POSIXct("2018-02-01", tz = "UTC")) \]
\[ x <- .xts(i, c(focal_date + i * 15), tz = "UTC", dimnames = list(NULL, "value")) \]

# Select all observations between 9am and 15:59:59.9999:
\[ w1 \] <- \[ x[\text{"T09/T15\"}] \] # or \[ x[\text{"T9/T15\"}] \]

# timestring is of the form THH:MM:SS.ss/THH:MM:SS.ss

# Select all observations between 13:00:00 and 13:59:59.9999 in two ways:
\[ y1 \] <- \[ x[\text{"T13/T13\"}] \]

# Select all observations between 9:30am and 30 seconds, and 4.10pm:
\[ x[\text{"T09:30:30/T16:10\"}] \]

# It is possible to subset time of day overnight.
# e.g. This is useful for subsetting FX time series which trade 24 hours on week days

# Select all observations between 23:50 and 00:15 the following day, in the xts time zone
\[ z \] <- \[ x[\text{"T23:50/T00:14\"}] \]
z["2018-02-10 12:00/"] # check the last day

# Select all observations between 7pm and 8.30am the following day:
z2 <- x["T19:00/T08:29:59"]
head(z2); tail(z2)
Index

* chron
  align.time, 9
diff.xts, 19

* datasets
  sample_matrix, 44

* manip
  align.time, 9
as.environment.xts, 11
diff.xts, 19
merge.xts, 30

* misc
  align.time, 9
dimnames.xts, 20
indexTZ, 26
isOrdered, 27
na.locf.xts, 32

* package
  xts-package, 3

* ts
  align.time, 9
make.index.unique, 28
window.xts, 54

* utilities
  .parseISO8601, 3
  [.xts, 61
apply.monthly, 10
as.xts, 12
as.xts.methods, 14
axTicksByTime, 16
CLASS, 17
coredata.xts, 18
days, 22
first, 23
firstof, 25
merge.xts, 30
ndays, 33
period.apply, 34
period.max, 35
period.min, 36
period.prod, 37
period.sum, 38
periodicity, 39
rbind.xts, 43
split.xts, 45
tclass, 46
timeBased, 49
timeBasedSeq, 50
to.period, 51
xts, 55
xtsAPI, 57
xtsAttributes, 59
xtsInternals, 60
  .dimnames.xts(xtsInternals), 60
  .index, 62
  .index(tclass), 46
  .index<- (tclass), 46
  .indexDate (tclass), 46
  .indexday (tclass), 46
  .indexhour (tclass), 46
  .indexmday (tclass), 46
  .indexmin (tclass), 46
  .indexmon (tclass), 46
  .indexsec (tclass), 46
  .indexwday (tclass), 46
  .indexweek (tclass), 46
  .indexyday (tclass), 46
  .indexyear (tclass), 46
  .indexymon (tclass), 46
  .makeISO8601 (.parseISO8601), 3
  .parseISO8601, 3, 62
  .subset.xts([.xts), 61
  [.xts, 61

addEventLines, 5
addLegend, 6
addPanel, 7, 42
addPolygon, 8
addSeries, 9, 42
adj.time (align.time), 9
aggregate.zoo, 45
align.time, 9, 29
apply.daily (apply.monthly), 10
apply.monthly, 10, 35
apply.quarterly (apply.monthly), 10
apply.weekly (apply.monthly), 10
apply.yearly (apply.monthly), 10
as.environment.xts, 11
as.fts.xts (as.xts.methods), 14
as.timeSeries.xts (as.xts.methods), 14
as.xts, 3, 12, 17, 57
as.xts.data.frame (as.xts.methods), 14
as.xts.fts (as.xts.methods), 14
as.xts.matrix (as.xts.methods), 14
as.xts.methods, 14
as.xts.timeSeries (as.xts.methods), 14
as.xts.ts (as.xts.methods), 14
as.xts.xts (as.xts.methods), 14
as.xts.zoo (as.xts.methods), 14
attributes, 59
axTicksByTime, 16, 41
c.xts (rbind.xts), 43
cbind.xts (merge.xts), 30
CLASS, 17
CLASS<- (CLASS), 17
convertIndex (tclass), 46
coredata, 18
coredata.xts, 18
diff.xts, 19
difftime, 39
dimnames.xts, 20
dimnames.xts<- (xtsInternals), 60
dimnames<- .xts (dimnames.xts), 20
endpoints, 11, 17, 22, 34–38, 45
findInterval, 55
first, 23
firstof, 25
index.xts (tclass), 46
index<- .xts (tclass), 46
indexClass (tclass), 46
indexClass<- (tclass), 46
indexFormat (tclass), 46
indexFormat<- (tclass), 46
indexTZ, 26
indexTZ<- (indexTZ), 26
is.index.unique (make.index.unique), 28
is.time.unique (make.index.unique), 28
is.timeBased (timeBased), 49
is.unsorted, 28
is.xts (xts), 55
ISO8601 (.parseISO8601), 3
ISOdatetime, 25
isOrdered, 27
lag.xts (diff.xts), 19
lagts.xts (diff.xts), 19
last (first), 23
lastof (firstof), 25
legend, 6
lines.xts (plot.xts), 40
make.index.unique, 28
make.time.unique (make.index.unique), 28
makeISO8601 (.parseISO8601), 3
merge.xts, 30, 44
na.locf.xts, 32
ndays, 33
nhours (ndays), 33
nminutes (ndays), 33
nmonths (ndays), 33
nquarters (ndays), 33
nseconds (ndays), 33
nweeks (ndays), 33
nyears (ndays), 33
OHLC (to.period), 51
par, 5, 7–9, 40, 41
parseISO8601 (.parseISO8601), 3
period.apply, 11, 34
period.max, 35, 36–38
period.min, 35, 36, 37, 38
period.prod, 35, 36, 37, 38
period.sum, 35–37, 38
periodicity, 39
plot, 7, 9, 41
plot.xts, 40
points.xts (plot.xts), 40
POSIXt, 27
rbind, 44
rbind.xts, 43
Reclass (as.xts), 12
reclass, 3, 17, 57
reclass(as.xts), 12

sample_matrix, 44
shift.time (align.time), 9
split.xts, 45
split.zoo, 45
subset.xts, 55
subset.xts([., xts), 61

tclass, 46
tclass<- (tclass), 46
text, 5
tformat (tclass), 46
tformat<- (tclass), 46
timeBased, 49, 51
timeBasedRange (timeBasedSeq), 50
timeBasedSeq, 50
TimeZone (indexTZ), 26
to.daily (to.period), 51
to.hourly (to.period), 51
to.minutes (to.period), 51
to.minutes10 (to.period), 51
to.minutes15 (to.period), 51
to.minutes3 (to.period), 51
to.minutes30 (to.period), 51
to.minutes5 (to.period), 51
to.monthly, 11
to.monthly (to.period), 51
to.period, 10, 51
to.quarterly (to.period), 51
to.weekly (to.period), 51
to.yearly (to.period), 51
to_period (to.period), 51
try.xts (as.xts), 12
tzone (indexTZ), 26
tzone<- (indexTZ), 26

use.reclass (as.xts), 12
use.xts (as.xts), 12

window.xts, 54

xcoredata (coredata.xts), 18
xcoredata<- (coredata.xts), 18
xts, 3, 14, 15, 21, 40, 51, 55, 55, 62
xts-package, 3
xtsAPI, 57
xtsAttributes, 18, 57, 59