

# Package ‘XVector’

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**Title** Foundation of external vector representation and manipulation in Bioconductor

**Description** Provides memory efficient S4 classes for storing sequences ``externally" (e.g. behind an R external pointer, or on disk).

**biocViews** Infrastructure, DataRepresentation

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compact	<i>Object compaction</i>
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### Description

Compacting an object is modifying its internal representation in order to reduce its size in memory.

### Usage

```
compact(x, check=TRUE, ...)

## Internal compact() support function. Not intended to be called
## directly:
xvcopy(x, start=NA, end=NA, width=NA, lkup=NULL, reverse=FALSE)
```

### Arguments

x	For compact, the object to be compacted. compact accepts any R object. However, on most of them, compact won't do anything and will just return an object identical to x. See the Details section below. For xvcopy, a <a href="#">SharedVector</a> , <a href="#">XVector</a> , <a href="#">SharedVector_Pool</a> , or <a href="#">XRawList</a> vector.
check	After compacting the individual slots of an S4 object, this argument is passed to <code>~slot&lt;-`</code> when replacing the original value of a slot with the compacted value.
...	Arguments to be passed to or from other methods.
start, end, width, lkup, reverse	For internal use.

## Details

The internal reorganization of the object should be transparent to the user i.e. `compact(x)` should "look" the same as `x`, or, more precisely, `x` and `compact(x)` should be interchangeable anywhere in the user's code. However, because they have different internal representations, we generally don't expect `identical(x, compact(x))` to be `TRUE`, even though most of the times they will, because there are only very few types of objects that `compact` actually knows how to reorganize internally.

`compact` is a generic function.

Here is how the default method works. By default `compact(x)` is obtained by compacting all the "components" in `x`. Only 2 kinds of objects are considered to have "components": lists (the components are the list elements), and S4 objects (the components are the slots). The other objects are not considered to have components, so, by default, `compact` does nothing on them. In particular, it does nothing on environments. Also the attributes of an object (other than the slots of an S4 object) are not considered to be "components" and therefore are not compacted.

Note that, in the absence of specialized `compact` methods that actually know how to reorganize an object internally, the default method would visit the tree of all the components, sub-components, sub-sub-components etc of object `x` without actually modifying anything in `x`. So of course, specialized `compact` methods need to be defined for the objects that can \*effectively\* be compacted. Otherwise the `compact` function would be equivalent to the `identity` function!

At the moment, 2 specialized `compact` methods are defined (in addition to the default method): one for [XVector](#) objects, and one for [XVectorList](#) objects.

## Value

An object equivalent to `x` but eventually smaller in memory.

## Author(s)

H. Pagès

## See Also

[XVector-class](#), [XVectorList-class](#), [subseq](#), [object.size](#), [save](#)

## Examples

```
## We illustrate the use of compact() on an XInteger vector (XInteger
## is one of the 3 concrete subclasses of the XVector virtual class):
x <- XInteger(500000, sample(500000))

## subseq() does NOT copy the data stored in an XVector object:
y <- subseq(x, start=41, end=60)
x@shared
y@shared # same address
object.size(x)
object.size(y) # same size

## compact() copies the data, but only the data actually "used" by 'y':
y0 <- compact(y)
y0@shared # new address
object.size(y0) # much smaller now!

## Compaction is particularly relevant when saving an object with
## external references like 'y':
```

```

yfile <- file.path(tempdir(), "y.rda")
save(y, file=yfile)
file.info(yfile)$size

y0file <- file.path(tempdir(), "y0.rda")
save(y0, file=y0file)
file.info(y0file)$size

```

---

intra-range-methods     *Intra range transformations of an XVectorList object*

---

## Description

The *intra range transformations* are a set of generic functions defined in the **IRanges** package. Only 2 of them have methods for **XVectorList** objects: **narrow** and **threebands**. This man page describes those 2 methods only.

See `?`inter-range-methods`` for more information.

## Usage

```

## S4 method for signature 'XVectorList'
narrow(x, start=NA, end=NA, width=NA, use.names=TRUE)

## S4 method for signature 'XVectorList'
threebands(x, start=NA, end=NA, width=NA)

```

## Arguments

<code>x</code>	An <b>XVectorList</b> object.
<code>start, end, width</code>	Vectors of integers, possibly with NAs. See the SEW (Start/End/Width) interface in the <b>IRanges</b> package for the details ( <code>?solveUserSEW</code> ).
<code>use.names</code>	TRUE or FALSE. Should names be preserved?

## Details

`narrow` is equivalent to subset on an **XVectorList** object.

`threebands` extends the capability of `narrow` by returning the 3 **XVectorList** objects associated with the narrowing operation. The returned value `y` is a list of 3 **XVectorList** objects named "left", "middle" and "right". The middle component is obtained by calling `narrow` with the same arguments (except that names are dropped). The left and right components are also instances of the same class as `x` and they contain what has been removed on the left and right sides (respectively) of the original ranges during the narrowing.

## Author(s)

H. Pagès

**See Also**

- [intra-range-methods](#) in the **IRanges** package for intra range transformations.
- [solveUserSEW](#) in the **IRanges** package for the SEW (Start/End/Width) interface.
- The [XVectorList](#) class.

**Examples**

```
## -----
## narrow()
## -----

#TODO: show examples

## -----
## threebands()
## -----

#TODO: show examples
```

---

OnDiskRaw-class

*OnDiskRaw objects*


---

**Description**

THIS IS A WORK-IN-PROGRESS!

**Author(s)**

H. Pagès

---

reverse-methods

*Reverse an XVector or XVectorList object*


---

**Description**

Methods for reversing an [XVector](#) or [XVectorList](#) object.

**Usage**

```
## S4 method for signature 'XVector'
reverse(x, ...)
## S4 method for signature 'XVectorList'
reverse(x, ...)
```

**Arguments**

x            An [XVector](#) or [XVectorList](#) object.  
...           Additional arguments. Currently ignored.

**Details**

On an [XVector](#) object, `reverse` and `rev` are equivalent, i.e. they both reverse the order of their elements.

On an [XVectorList](#) object, `reverse` reverses each element individually, without modifying the top-level order of the elements. It's equivalent to, but more efficient than, doing `endoapply(x, rev)`.

**Value**

An object of the same class and length as the original object.

**See Also**

[XVector-class](#), [XVectorList-class](#), [endoapply](#), [rev](#)

**Examples**

```
## On an XInteger object:
x <- as(12:-2, "XInteger")
reverse(x)

## On an XIntegerViews object:
v <- successiveViews(x, 1:5)
v
reverse(v)

## On an XVectorList object:
if (require(Biostrings) && require(drosophila2probe)) {
  library(Biostrings)
  library(drosophila2probe)
  probes <- DNASTringSet(drosophila2probe)
  reverse(probes)
}
```

---

slice-methods

*Slice an XInteger or XDouble object*

---

**Description**

The `slice` methods for [XInteger](#) and [XDouble](#) objects create views corresponding to the indices where the data are within the specified bounds. The views are returned in a [XIntegerViews](#) or [XDoubleViews](#) object.

**Usage**

```
## S4 method for signature 'integer'
slice(x, lower=-.Machine$integer.max, upper=.Machine$integer.max)

## S4 method for signature 'XInteger'
slice(x, lower=-.Machine$integer.max, upper=.Machine$integer.max)

## S4 method for signature 'numeric'
slice(x, lower=-Inf, upper=Inf,
```

```

includeLower=TRUE, includeUpper=TRUE, rangesOnly=FALSE)

## S4 method for signature 'XDouble'
slice(x, lower=-.Machine$double.xmax, upper=.Machine$double.xmax,
      includeLower=TRUE, includeUpper=TRUE, rangesOnly=FALSE)

```

### Arguments

`x` An [XInteger](#) or [XDouble](#) object. Alternatively, it can also be an integer or numeric vector.

`lower, upper` The lower and upper bounds for the slice.

`includeLower, includeUpper` Logical indicating whether or not the specified boundary is open or closed.

`rangesOnly` A logical indicating whether or not to drop the original data from the output.

### Value

An [XIntegerViews](#) or [XDoubleViews](#) object if `rangesOnly=FALSE`.  
 An [IRanges](#) object if `rangesOnly=TRUE`.

### Author(s)

P. Aboyoun

### See Also

- [view-summarization-methods](#) for summarizing the views returned by `slice`.
- [slice-methods](#) in the `IRanges` package for more `slice` methods.
- The [XInteger](#), [XIntegerViews](#), [XDouble](#), and [XDoubleViews](#) classes.

### Examples

```

vec <- as.integer(c(19, 5, 0, 8, 5))
slice(vec, lower=5, upper=8)

set.seed(0)
vec <- sample(24)
slice(vec, lower=4, upper=16)

```

---

updateObject-methods *Update an object of a class defined in the XVector package to its current class definition*

---

### Description

The `XVector` package provides an extensive collection of `updateObject` methods for updating almost any instance of a class defined in the package.

**Usage**

```
## Showing usage of method defined for XVector objects only (usage
## is the same for all methods).
```

```
## S4 method for signature 'XVector'
updateObject(object, ..., verbose=FALSE)
```

**Arguments**

```
object          Object to be updated. Many (but not all) XVector classes are supported. If no
                 specific method is available for the object, then the default method (defined in
                 the BiocGenerics package) is used. See ?updateObject for a description of the
                 default method.
..., verbose    See ?updateObject.
```

**Value**

Returns a valid instance of object.

**See Also**

[updateObject](#)

---

view-summarization-methods

*Summarize views on an XInteger or XDouble object*

---

**Description**

The `viewMins`, `viewMaxs`, `viewSums`, and `viewMeans` methods described here calculate respectively the minima, maxima, sums, and means of the views in an [XIntegerViews](#) or [XDoubleViews](#) object.

**Usage**

```
## "viewMins" methods:
## -----

## S4 method for signature 'XIntegerViews'
viewMins(x, na.rm=FALSE)

## S4 method for signature 'XDoubleViews'
viewMins(x, na.rm=FALSE)

## "viewMaxs" methods:
## -----

## S4 method for signature 'XIntegerViews'
viewMaxs(x, na.rm=FALSE)

## S4 method for signature 'XDoubleViews'
```



```

viewMaxs(x, na.rm=FALSE)

## "viewSums" methods:
## -----

## S4 method for signature 'XIntegerViews'
viewSums(x, na.rm=FALSE)

## S4 method for signature 'XDoubleViews'
viewSums(x, na.rm=FALSE)

## "viewMeans" methods:
## -----

## S4 method for signature 'XIntegerViews'
viewMeans(x, na.rm=FALSE)

## S4 method for signature 'XDoubleViews'
viewMeans(x, na.rm=FALSE)

## "viewWhichMins" methods:
## -----

## S4 method for signature 'XIntegerViews'
viewWhichMins(x, na.rm=FALSE)

## S4 method for signature 'XDoubleViews'
viewWhichMins(x, na.rm=FALSE)

## "viewWhichMaxs" methods:
## -----

## S4 method for signature 'XIntegerViews'
viewWhichMaxs(x, na.rm=FALSE)

## S4 method for signature 'XDoubleViews'
viewWhichMaxs(x, na.rm=FALSE)

```

### Arguments

x	An <a href="#">XIntegerViews</a> or <a href="#">XDoubleViews</a> object.
na.rm	Logical indicating whether or not to include missing values in the results.

### Value

A numeric vector of the length of x.

**Note**

For convenience, methods for `min`, `max`, `sum`, `mean`, `which.min` and `which.max` are provided as wrappers around the corresponding `view*` functions (which might be deprecated at some point).

**Author(s)**

P. Aboyoun

**See Also**

- [slice-methods](#) for slicing an [XInteger](#) or [XDouble](#) object.
- [view-summarization-methods](#) in the `IRanges` package for the view summarization generics.
- The [XIntegerViews](#) and [XDoubleViews](#) classes.

**Examples**

```
set.seed(0)
vec <- sample(24)
vec_views <- slice(vec, lower=4, upper=16)
vec_views

viewApply(vec_views, function(x) diff(as.integer(x)))

viewMins(vec_views)
viewMaxs(vec_views)

viewSums(vec_views)
viewMeans(vec_views)

viewWhichMins(vec_views)
viewWhichMaxs(vec_views)
```

---

XDoubleViews-class      *The XDoubleViews class*

---

**Description**

The `XDoubleViews` class is the basic container for storing a set of views (start/end locations) on the same `XDouble` object.

**Details**

An `XDoubleViews` object contains a set of views (start/end locations) on the same [XDouble](#) object called "the subject numeric vector" or simply "the subject". Each view is defined by its start and end locations: both are integers such that `start <= end`. An `XDoubleViews` object is in fact a particular case of a [Views](#) object (the `XDoubleViews` class contains the [Views](#) class) so it can be manipulated in a similar manner: see [?Views](#) for more information. Note that two views can overlap and that a view can be "out of limits" i.e. it can start before the first element of the subject or/and end after its last element.

**Other methods**

In the code snippets below, `x`, `object`, `e1` and `e2` are `XDoubleViews` objects, and `i` can be a numeric or logical vector.

`x[[i]]`: Extract a view as an `XDouble` object. `i` must be a single numeric value (a numeric vector of length 1). Can't be used for extracting a view that is "out of limits" (raise an error). The returned object has the same `XDouble` subtype as `subject(x)`.

`e1 == e2`: A vector of logicals indicating the result of the view by view comparison. The views in the shorter of the two `XDoubleViews` object being compared are recycled as necessary.

`e1 != e2`: Equivalent to `!(e1 == e2)`.

**Author(s)**

P. Aboyoun for the `XIntegerViews*` code, which was adapted to work over `XDouble`'s by S. Lianoglou

**See Also**

[view-summarization-methods](#), [Views-class](#), [XDouble-class](#), [XIntegerViews-class](#)

**Examples**

```
## One standard way to create an XDoubleViews object is to use
## the Views() constructor:
subject <- as(rnorm(6), "XDouble")
v4 <- Views(subject, start=3:0, end=5:8)
v4
subject(v4)
length(v4)
start(v4)
end(v4)
width(v4)

## Attach a comment to views #3 and #4:
names(v4)[3:4] <- "out of limits"
names(v4)

## A more programatical way to "tag" the "out of limits" views:
idx <- start(v4) < 1 | end(v4) > length(subject(v4))
names(v4)[idx] <- "out of limits"

## Extract a view as an XDouble object:
v4[[2]]

## It is an error to try to extract an "out of limits" view:
## Not run:
v4[[3]] # Error!

## End(Not run)

## Here the first view doesn't even overlap with the subject:
subject <- as(c(97, 97, 97, 45, 45, 98), "XDouble")
Views(subject, start=-3:4, end=-3:4 + c(3:6, 6:3))

## Some fast view* functionalities:
```

```
x <- rnorm(55)
bounds <- IRanges(c(1, 11, 35, 20), width=c(5, 10, 15, 28))
v <- Views(x, bounds)
val <- viewMins(v)
expect <- sapply(1:length(bounds), function(i) {
  min(x[start(bounds)[i]:end(bounds[i])])
})
stopifnot(all(val == expect))
```

---

XIntegerViews-class    *The XIntegerViews class*

---

## Description

The XIntegerViews class is the basic container for storing a set of views (start/end locations) on the same XInteger object.

## Details

An XIntegerViews object contains a set of views (start/end locations) on the same [XInteger](#) object called "the subject integer vector" or simply "the subject". Each view is defined by its start and end locations: both are integers such that start <= end. An XIntegerViews object is in fact a particular case of a [Views](#) object (the XIntegerViews class contains the [Views](#) class) so it can be manipulated in a similar manner: see [?Views](#) for more information. Note that two views can overlap and that a view can be "out of limits" i.e. it can start before the first element of the subject or/and end after its last element.

## Other methods

In the code snippets below, x, object, e1 and e2 are XIntegerViews objects, and i can be a numeric or logical vector.

`x[[i]]`: Extract a view as an [XInteger](#) object. i must be a single numeric value (a numeric vector of length 1). Can't be used for extracting a view that is "out of limits" (raise an error). The returned object has the same [XInteger](#) subtype as `subject(x)`.

`e1 == e2`: A vector of logicals indicating the result of the view by view comparison. The views in the shorter of the two XIntegerViews object being compared are recycled as necessary.

`e1 != e2`: Equivalent to `!(e1 == e2)`.

## Author(s)

P. Aboyoun

## See Also

[view-summarization-methods](#), [Views-class](#), [XInteger-class](#), [XDoubleViews-class](#)

**Examples**

```

## One standard way to create an XIntegerViews object is to use
## the Views() constructor:
subject <- as(c(45, 67, 84, 67, 45, 78), "XInteger")
v4 <- Views(subject, start=3:0, end=5:8)
v4
subject(v4)
length(v4)
start(v4)
end(v4)
width(v4)

## Attach a comment to views #3 and #4:
names(v4)[3:4] <- "out of limits"
names(v4)

## A more programatical way to "tag" the "out of limits" views:
idx <- start(v4) < 1 | end(v4) > length(subject(v4))
names(v4)[idx] <- "out of limits"

## Extract a view as an XInteger object:
v4[[2]]

## It is an error to try to extract an "out of limits" view:
## Not run:
v4[[3]] # Error!

## End(Not run)

## Here the first view doesn't even overlap with the subject:
subject <- as(c(97, 97, 97, 45, 45, 98), "XInteger")
Views(subject, start=-3:4, end=-3:4 + c(3:6, 6:3))

## Views on a big XInteger subject:
subject <- XInteger(99999, sample(99, 99999, replace=TRUE) - 50)
v5 <- Views(subject, start=1:99*1000, end=1:99*1001)
v5
v5[-1]
v5[[5]]

## 31 adjacent views:
successiveViews(subject, 40:10)

```

---

XRawList-class

*XRawList objects*


---

**Description**

THIS IS A WORK-IN-PROGRESS!

An XRawList object is *\*conceptually\** a list of [XRaw](#) objects.

**Author(s)**

H. Pagès

**See Also**

[XRaw-class](#), [XVectorList-class](#)

---

XRawList-comparison     *Comparing and ordering the list elements of XRawList objects*

---

**Description**

Methods for comparing and ordering the elements in one or more [XRawList](#) objects.

**Usage**

```
## Element-wise (aka "parallel") comparison of 2 XRawList objects
## -----

## S4 method for signature 'XRawList,XRawList'
e1 == e2

## S4 method for signature 'XRawList,XRawList'
e1 <= e2

## duplicated()
## -----

## S4 method for signature 'XRawList'
duplicated(x, incomparables=FALSE, ...)

## match()
## -----

## S4 method for signature 'XRawList,XRawList'
match(x, table, nomatch=NA_integer_, incomparables=NULL)

## order() and related methods
## -----

## S4 method for signature 'XRawList'
is.unsorted(x, na.rm=FALSE, strictly=FALSE)

## S4 method for signature 'XRawList'
order(..., na.last=TRUE, decreasing=FALSE,
       method=c("auto", "shell", "radix"))

## S4 method for signature 'XRawList'
rank(x, na.last=TRUE,
     ties.method=c("average", "first", "random", "max", "min"))

## Generalized element-wise (aka "parallel") comparison of 2 XRawList objects
## -----

## S4 method for signature 'XRawList,XRawList'
pcompare(x, y)
```

## Arguments

e1, e2, x, table, y	<a href="#">XRawList</a> objects.
incomparables	Not supported.
...	For duplicated: currently no additional arguments are allowed. For order: additional <a href="#">XRawList</a> objects used for breaking ties.
nomatch	The value to be returned in the case when no match is found. It is coerced to an integer.
na.rm, na.last, method	Ignored.
strictly	TRUE or FALSE. Should the check be for <i>strictly</i> increasing values?
decreasing	TRUE or FALSE.
ties.method	A character string specifying how ties are treated. Only "first" and "min" are supported for now.

## Details

[TODO]

## Author(s)

H. Pagès

## See Also

- The [XRawList](#) class.
- [Ranges-comparison](#) in the IRanges package for comparing and ordering ranges.
- [==](#), [duplicated](#), [unique](#), [match](#), [%in%](#), [order](#), [sort](#), [rank](#) for general information about those functions.

## Examples

```
## TODO
```

---

XVector internals      *XVector internals*

---

## Description

Objects, classes and methods defined in the XVector package that are not intended to be used directly.

---

XVector-class

*XVector objects*

---

## Description

The XVector virtual class is a general container for storing an "external vector". It inherits from the [Vector](#) class, which has a rich interface.

The following classes derive directly from the XVector class:

The XRaw class is a container for storing an "external raw vector" i.e. an external sequence of bytes (stored as char values at the C level).

The XInteger class is a container for storing an "external integer vector" i.e. an external sequence of integer values (stored as int values at the C level).

The XDouble class is a container for storing an "external double vector" i.e. an external sequence of numeric values (stored as double values at the C level).

Also the [XString](#) class defined in the Biostrings package.

The purpose of the X\* containers is to provide a "pass by address" semantic and also to avoid the overhead of copying the sequence data when a linear subsequence needs to be extracted.

## Additional Subsetting operations on XVector objects

In the code snippets below, x is an XVector object.

`subseq(x, start=NA, end=NA, width=NA)`: Extract the subsequence from x specified by start, end and width. The supplied start/end/width values are solved by a call to `solveUserSEW(length(x), start=start, end=end, width=width)` and therefore must be compliant with the rules of the SEW (Start/End/Width) interface (see `?solveUserSEW` for the details).

A note about performance: `subseq` does NOT copy the sequence data of an XVector object. Hence it's very efficient and is therefore the recommended way to extract a linear subsequence (i.e. a set of consecutive elements) from an XVector object. For example, extracting a 100Mb subsequence from Human chromosome 1 (a 250Mb [DNAString](#) object) with `subseq` is (almost) instantaneous and has (almost) no memory footprint (the cost in time and memory does not depend on the length of the original sequence or on the length of the subsequence to extract).

`subseq(x, start=NA, end=NA, width=NA) <- value`: Replace the subsequence specified on the left (i.e. the subsequence in x specified by start, end and width) by value. value must belong to the same class as x, or to one of its subclasses, or must be NULL. This replacement method can modify the length of x, depending on how the length of the left subsequence compares to the length of value. It can be used for inserting elements in x (specify an empty left subsequence for this) or deleting elements from x (use a NULL right value for this). Unlike the extraction method above, this replacement method always copies the sequence data of x (even for XVector objects). NOTE: Only works for XRaw (and derived) objects for now.

## Author(s)

H. Pagès

## See Also

[Vector-class](#), [DNAString-class](#), [XVectorList-class](#), [Views-class](#), [solveUserSEW](#), [compact](#)



**Examples**

```
## -----
## A. XRaw OBJECTS
## -----

x1 <- XRaw(4) # values are not initialized
x1
x2 <- as(c(255, 255, 199), "XRaw")
x2
y <- c(x1, x2, NULL, x1) # NULLs are ignored
y
subseq(y, start=-4)
subseq(y, start=-4) <- x2
y

## -----
## B. XInteger OBJECTS
## -----

x3 <- XInteger(12, val=c(-1:10))
x3
length(x3)

## Subsetting
x4 <- XInteger(99999, val=sample(99, 99999, replace=TRUE) - 50)
x4
subseq(x4, start=10)
subseq(x4, start=-10)
subseq(x4, start=-20, end=-10)
subseq(x4, start=10, width=5)
subseq(x4, end=10, width=5)
subseq(x4, end=10, width=0)

x3[length(x3):1]
x3[length(x3):1, drop=FALSE]
```

---

XVectorList-class      *XVectorList* objects

---

**Description**

THIS IS A WORK-IN-PROGRESS!!

An XVectorList object is *conceptually* a list of [XVector](#) objects.

**Author(s)**

H. Pagès

**See Also**

[XVector-class](#), [XRawList-class](#), [compact](#)

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