

# Package ‘bit’

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**Type** Package

**Title** Classes and Methods for Fast Memory-Efficient Boolean Selections

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**Description** Provided are classes for boolean and skewed boolean vectors,  
fast boolean methods, fast unique and non-unique integer sorting,  
fast set operations on sorted and unsorted sets of integers, and  
foundations for ff (range index, compression, chunked processing).

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bit-package *bit: Classes and methods for fast memory-efficient boolean selections*

**Description**

Provided are classes for boolean and skewed boolean vectors, fast boolean methods, fast unique and non-unique integer sorting, fast set operations on sorted and unsorted sets of integers, and foundations for ff (range indices, compression, chunked processing).

**Details**

For details view the vignettes [../doc/bit-usage.pdf](#) and [../doc/bit-performance.pdf](#)

.BITS *Initializing bit masks*

**Description**

Functions to allocate (and de-allocate) bit masks

**Usage**

- .BITS
- bit\_init()
- bit\_done()

**Format**

An object of class integer of length 1.

**Details**

The C-code operates with bit masks. The memory for these is allocated dynamically. `bit_init` is called by `.First.lib` and `bit_done` is called by `.Last.lib`. You don't need to care about these under normal circumstances.

**Author(s)**

Jens Oehlschlägel

**See Also**

[bit](#)

**Examples**

```
bit_done()
bit_init()
```

---

as.bit.NULL

*Coercing to bit*

---

**Description**

Coercing to bit vector

**Usage**

```
## S3 method for class ``NULL``
as.bit(x, ...)

## S3 method for class 'bit'
as.bit(x, ...)

## S3 method for class 'logical'
as.bit(x, ...)

## S3 method for class 'integer'
as.bit(x, ...)

## S3 method for class 'double'
as.bit(x, ...)
```

```
## S3 method for class 'bitwhich'
as.bit(x, ...)

## S3 method for class 'which'
as.bit(x, length = attr(x, "maxindex"), ...)

## S3 method for class 'ri'
as.bit(x, ...)

as.bit(x = NULL, ...)
```

### Arguments

x	an object of class <code>bit</code> , <code>logical</code> , <code>integer</code> , <code>bitwhich</code> or an integer from <code>as.which</code> or a boolean <code>ff</code>
...	further arguments
length	the length of the new bit vector

### Details

Coercing to bit is quite fast because we use a double loop that fixes each word in a processor register

### Value

`is.bit` returns FALSE or TRUE, `as.bit` returns a vector of class 'bit'

### Methods (by class)

- `as.bit(~NULL~)`: method to coerce to `bit` (zero length) from `NULL`
- `as.bit(bit)`: method to coerce to `bit` from `bit`
- `as.bit(logical)`: method to coerce to `bit` from `logical`
- `as.bit(integer)`: method to coerce to `bit` from `integer` (`0L` and `NA` become FALSE, everything else becomes TRUE)
- `as.bit(double)`: method to coerce to `bit` from `double` (`0` and `NA` become FALSE, everything else becomes TRUE)
- `as.bit(bitwhich)`: method to coerce to `bit` from `bitwhich`
- `as.bit(which)`: method to coerce to `bit` from `which`
- `as.bit(ri)`: method to coerce to `bit` from `ri`

### Note

Zero is coerced to FALSE, all other numbers including NA are coerced to TRUE. This differs from the NA-to-FALSE coercion in package `ff` and may change in the future.

### Author(s)

Jens Oehlschlägel

**See Also**

[CoercionToStandard](#), [as.booltype](#), [as.bit](#), [as.bitwhich](#), [as.which](#), [as.ri](#), [as.hi](#), [as.ff](#)

**Examples**

```
as.bit(c(0L,1L,2L,-2L,NA))
as.bit(c(0,1,2,-2,NA))

as.bit(c(FALSE, NA, TRUE))
```

---

as.bitwhich.NULL      *Coercing to bitwhich*

---

**Description**

Functions to coerce to bitwhich

**Usage**

```
## S3 method for class ``NULL``
as.bitwhich(x, ...)

## S3 method for class 'bitwhich'
as.bitwhich(x, ...)

## S3 method for class 'which'
as.bitwhich(x, maxindex = attr(x, "maxindex"), ...)

## S3 method for class 'ri'
as.bitwhich(x, ...)

## S3 method for class 'integer'
as.bitwhich(x, poslength = NULL, ...)

## S3 method for class 'double'
as.bitwhich(x, poslength = NULL, ...)

## S3 method for class 'logical'
as.bitwhich(x, poslength = NULL, ...)

## S3 method for class 'bit'
as.bitwhich(x, range = NULL, poslength = NULL, ...)

as.bitwhich(x = NULL, ...)
```

**Arguments**

x	An object of class 'bitwhich', 'integer', 'logical' or 'bit' or an integer vector as resulting from 'which'
...	further arguments
maxindex	the length of the new bitwhich vector
poslength	the number of selected elements
range	a <i>ri</i> or an integer vector of length==2 giving a range restriction for chunked processing

**Value**

a value of class `bitwhich`

**Methods (by class)**

- `as.bitwhich(~NULL~)`: method to coerce to `bitwhich` (zero length) from `NULL`
- `as.bitwhich(bitwhich)`: method to coerce to `bitwhich` from `bitwhich`
- `as.bitwhich(which)`: method to coerce to `bitwhich` from `which`
- `as.bitwhich(ri)`: method to coerce to `bitwhich` from `ri`
- `as.bitwhich(integer)`: method to coerce to `bitwhich` from `integer` (0 and NA become FALSE, everthing else becomes TRUE)
- `as.bitwhich(double)`: method to coerce to `bitwhich` from `double` (0 and NA become FALSE, everthing else becomes TRUE)
- `as.bitwhich(logical)`: method to coerce to `bitwhich` from `logical`
- `as.bitwhich(bit)`: method to coerce to `bitwhich` from `bit`

**Author(s)**

Jens Oehlschlägel

**See Also**

`CoercionToStandard`, `as.booltype`, `as.bit`, `as.bitwhich`, `as.which`, `as.ri`, `as.hi`, `as.ff`

**Examples**

```
as.bitwhich(c(0L,1L,2L,-2L,NA))
as.bitwhich(c(0,1,2,-2,NA))

as.bitwhich(c(NA,NA,NA))
as.bitwhich(c(FALSE, FALSE, FALSE))
as.bitwhich(c(FALSE, FALSE, TRUE))
as.bitwhich(c(FALSE, TRUE, TRUE))
as.bitwhich(c(TRUE, TRUE, TRUE))
```

---

as.booltype.default    *Coerce to booltype (generic)*

---

### Description

Coerce to booltype (generic)

### Usage

```
## Default S3 method:  
as.booltype(x, booltype = "logical", ...)  
  
as.booltype(x, booltype, ...)
```

### Arguments

x	object to coerce
booltype	target <a href="#">booltype</a> given as integer or as character
...	further arguments

### Value

x coerced to booltype

### Methods (by class)

- `as.booltype(default)`: default method for `as.booltype`

### See Also

[CoercionToStandard](#), [booltypes](#), [booltype](#), [is.booltype](#)

### Examples

```
as.booltype(0:1)  
as.booltype(0:1, "logical")  
as.booltype(0:1, "bit")  
as.booltype(0:1, "bitwhich")  
as.booltype(0:1, "which", maxindex=2)  
as.booltype(0:1, "ri")
```



---

as.character.bit      *Coerce bit to character*

---

**Description**

Coerce bit to character

**Usage**

```
## S3 method for class 'bit'  
as.character(x, ...)
```

**Arguments**

x	a <b>bit</b> vector
...	ignored

**Value**

a character vector of zeroes and ones

**Examples**

```
as.character(bit(12))
```

---

as.character.bitwhich      *Coerce bitwhich to character*

---

**Description**

Coerce bitwhich to character

**Usage**

```
## S3 method for class 'bitwhich'  
as.character(x, ...)
```

**Arguments**

x	a <b>bitwhich</b> vector
...	ignored

**Value**

a character vector of zeroes and ones

**Examples**

```
as.character(bitwhich(12))
```

---

as.ri.ri

*Coerce to ri*

---

**Description**

Coerce to ri

**Usage**

```
## S3 method for class 'ri'  
as.ri(x, ...)  
  
## Default S3 method:  
as.ri(x, ...)  
  
as.ri(x, ...)
```

**Arguments**

x	object to coerce
...	further arguments

**Value**

an [ri](#) object

**Methods (by class)**

- `as.ri(ri)`: method to coerce [ri](#) to [ri](#)
- `as.ri(default)`: default method to coerce to [ri](#)

**Author(s)**

Jens Oehlschlägel

**See Also**

[CoercionToStandard](#), [as.booltype](#), [as.bit](#), [as.bitwhich](#), [as.which](#), [as.ri](#), [as.hi](#), [as.ff](#)

**Examples**

```
as.ri(c(FALSE, TRUE, FALSE, TRUE))
```

---

as.which.which                    *Coercion to (positive) integer positions*


---

**Description**

Coercing to something like the result of which [which](#)

**Usage**

```
## S3 method for class 'which'
as.which(x, maxindex = NA_integer_, ...)

## S3 method for class '`NULL`'
as.which(x, ...)

## S3 method for class 'numeric'
as.which(x, maxindex = NA_integer_, ...)

## S3 method for class 'integer'
as.which(x, maxindex = NA_integer_, is.unsorted = TRUE, has.dup = TRUE, ...)

## S3 method for class 'logical'
as.which(x, ...)

## S3 method for class 'ri'
as.which(x, ...)

## S3 method for class 'bit'
as.which(x, range = NULL, ...)

## S3 method for class 'bitwhich'
as.which(x, ...)

as.which(x, ...)
```

**Arguments**

x	an object of classes <a href="#">bit</a> , <a href="#">bitwhich</a> , <a href="#">ri</a> or something on which <a href="#">which</a> works
maxindex	the length of the boolean vector which is represented
...	further arguments (passed to <a href="#">which</a> for the default method, ignored otherwise)
is.unsorted	a logical scalar indicating whether the data may be unsorted
has.dup	a logical scalar indicating whether the data may have duplicates
range	a <a href="#">ri</a> or an integer vector of length==2 giving a range restriction for chunked processing

**Details**

as.which.bit returns a vector of subscripts with class 'which'

**Value**

a vector of class 'logical' or 'integer'

**Methods (by class)**

- as.which(which): method to coerce to [which](#) from [which](#)
- as.which(`^NULL`): method to coerce to zero length [which](#) from [NULL](#)
- as.which(numeric): method to coerce to [which](#) from [numeric](#)
- as.which(integer): method to coerce to [which](#) from [integer](#)
- as.which(logical): method to coerce to [which](#) from [logical](#)
- as.which(ri): method to coerce to [which](#) from [ri](#)
- as.which(bit): method to coerce to [which](#) from [bit](#)
- as.which(bitwhich): method to coerce to [which](#) from [bitwhich](#)

**Author(s)**

Jens Oehlschlägel

**See Also**

[CoercionToStandard](#), [as.booltype](#), [as.bit](#), [as.bitwhich](#), [as.which](#), [as.ri](#), [as.hi](#), [as.ff](#)

**Examples**

```
r <- ri(5, 20, 100)
x <- as.which(r)
x

stopifnot(identical(x, as.which(as.logical(r))))
stopifnot(identical(x, as.which(as.bitwhich(r))))
stopifnot(identical(x, as.which(as.bit(r))))
```

---

bbatch	<i>Balanced Batch sizes</i>
--------	-----------------------------

---

**Description**

bbatch calculates batch sizes in 1..N so that they have rather balanced sizes than very different sizes.

**Usage**

```
bbatch(N, B)
```

**Arguments**

N	total size in 0..integer_max
B	desired batch size in 1..integer_max

**Details**

Tries to have  $rb=0$  or  $rb$  as close to  $b$  as possible while guaranteeing that  $rb < b$  &&  $(b - rb) \leq \min(nb, b)$

**Value**

a list with components

b	the batch size
nb	the number of batches
rb	the size of the rest

**Author(s)**

Jens Oehlschlägel

**See Also**

[repsfromto](#), [ffvecapply](#)

**Examples**

```
bbatch(100, 24)
```

---

bit	<i>Create empty bit vector</i>
-----	--------------------------------

---

**Description**

Bit vectors are a boolean type without NA that requires by factor 32 less RAM than [logical](#). For details on usage see the [usage-vignette](#) and for details on performance see [performance-vignette](#)

**Usage**

```
bit(length = 0L)
```

**Arguments**

length	length in bits
--------	----------------

**Value**

bit returns a vector of integer sufficiently long to store 'length' bits

**See Also**

[booltype](#), [bitwhich](#), [logical](#)

**Examples**

```
bit(12)
!bit(12)
str(bit(128))
```

---

bitsort	<i>Low-level sorting: bit sort</i>
---------	------------------------------------

---

**Description**

In one pass over the vector NAs are handled according to parameter `na.last` by [range\\_sortna](#), then, if the vector is unsorted, bit sort is invoked.

**Usage**

```
bitsort(x, na.last = NA, depth = 1)
```

**Arguments**

x	an integer vector
na.last	NA removes NAs, FALSE puts NAs at the beginning, TRUE puts NAs at the end
depth	an integer scalar giving the number of bit-passed before switching to quicksort

**Value**

a sorted vector

**Examples**

```
bitsort(c(2L,0L,1L,NA,2L))
bitsort(c(2L,0L,1L,NA,2L), na.last=TRUE)
bitsort(c(2L,0L,1L,NA,2L), na.last=FALSE)
```

---

bitwhich

---

*Create bitwhich vector (skewed boolean)*


---

**Description**

A bitwhich object represents a boolean filter like a `bit` object (NAs are not allowed) but uses a sparse representation suitable for very skewed (asymmetric) selections. Three extreme cases are represented with logical values, no length via `logical()`, all TRUE with TRUE and all FALSE with FALSE. All other selections are represented with positive or negative integers, whatever is shorter. This needs less RAM compared to `logical` (and often less than `bit` or `which`). Logical operations are fast if the selection is asymmetric (only few or almost all selected).

**Usage**

```
bitwhich(
  maxindex = 0L,
  x = NULL,
  xempty = FALSE,
  poslength = NULL,
  is.unsorted = TRUE,
  has.dup = TRUE
)
```

**Arguments**

<code>maxindex</code>	length of the vector
<code>x</code>	Information about which positions are FALSE or TRUE: either <code>logical()</code> or TRUE or FALSE or a integer vector of positive or of negative subscripts.
<code>xempty</code>	what to assume about parameter x if <code>x=integer(0)</code> , typically TRUE or FALSE.
<code>poslength</code>	tuning: <code>poslength</code> is calculated automatically, you can give <code>poslength</code> explicitly, in this case it must be correct and x must be sorted and not have duplicates.
<code>is.unsorted</code>	tuning: FALSE implies that x is already sorted and sorting is skipped
<code>has.dup</code>	tuning: FALSE implies that x has no duplicates

**Value**

an object of class 'bitwhich' carrying two attributes

**maxindex** see above

**poslength** see above

**See Also**

[bitwhich\\_representation](#), [as.bitwhich](#), [bit](#)

**Examples**

```
bitwhich()  
bitwhich(12)  
bitwhich(12, x=TRUE)  
bitwhich(12, x=3)  
bitwhich(12, x=-3)  
bitwhich(12, x=integer())  
bitwhich(12, x=integer(), xempty=TRUE)
```

---

bitwhich\_representation

*Diagnose representation of bitwhich*

---

**Description**

Diagnose representation of bitwhich

**Usage**

```
bitwhich_representation(x)
```

**Arguments**

x                    a [bitwhich](#) object

**Value**

a scalar, one of `logical()`, `FALSE`, `TRUE`, `-1` or `1`

**Examples**

```
bitwhich_representation(bitwhich())  
bitwhich_representation(bitwhich(12,FALSE))  
bitwhich_representation(bitwhich(12,TRUE))  
bitwhich_representation(bitwhich(12, -3))  
bitwhich_representation(bitwhich(12, 3))
```



---

bit_in	<i>bit %in%</i>
--------	-----------------

---

## Description

fast [%in%](#) for integers

## Usage

```
bit_in(x, table, retFUN = as.bit)
```

## Arguments

x	an integer vector of values to be looked-up
table	an integer vector used as lookup-table
retFUN	a function that coerces <a href="#">bit</a> and <a href="#">logical</a> vectors

## Details

determines the range of the integers and checks if the density justifies use of a bit vector; if yes, maps x or table – whatever is smaller – into a bit vector and searches the other of table or x in the it vector; if no, falls back to [%in%](#)

## Value

a boolean vector coerced to retFUN

## See Also

[%in%](#)

## Examples

```
bit_in(1:2, 2:3)
bit_in(1:2, 2:3, retFUN=as.logical)
```

---

bit_rangediff	<i>bit range difference</i>
---------------	-----------------------------

---

### Description

Fast version of `setdiff(rx[1]:rx[2], y)`.

### Usage

```
bit_rangediff(rx, y, revx = FALSE, revy = FALSE)
```

### Arguments

<code>rx</code>	range of integers given as <a href="#">ri</a> or as a two-element <a href="#">integer</a>
<code>y</code>	an integer vector of elements to exclude
<code>revx</code>	FALSE as is, TRUE to reverse the direction and sign of <code>rx</code>
<code>revy</code>	FALSE as is, TRUE to reverse the direction and sign of <code>y</code>

### Details

determines the range of the integers `y` and checks if the density justifies use of a bit vector; if yes, uses a bit vector for the set operation; if no, falls back to a quicksort and [merge\\_rangediff](#)

### Value

an integer vector

### See Also

[bit\\_setdiff](#), [merge\\_rangediff](#)

### Examples

```
bit_rangediff(c(1L,6L), c(3L,4L))
bit_rangediff(c(6L,1L), c(3L,4L))
bit_rangediff(c(6L,1L), c(3L,4L), revx=TRUE)
bit_rangediff(c(6L,1L), c(3L,4L), revx=TRUE, revy=TRUE)
```

---

bit_setops	<i>bit set operations</i>
------------	---------------------------

---

## Description

Fast versions of [union](#), [intersect](#), [setdiff](#), symmetric difference and [setequal](#) for integers.

## Usage

```
bit_union(x, y)
```

```
bit_intersect(x, y)
```

```
bit_setdiff(x, y)
```

```
bit_syndiff(x, y)
```

```
bit_setequal(x, y)
```

## Arguments

x                    an integer vector

y                    an integer vector

## Details

determines the range of the integers and checks if the density justifies use of a bit vector; if yes, uses a bit vector for finding duplicates; if no, falls back to [union](#), [intersect](#), [setdiff](#), [union\(setdiff\(x,y\),setdiff\(y,x\)\)](#) and [setequal](#)

## Value

an integer vector

## Functions

- [bit\\_union\(\)](#): union
- [bit\\_intersect\(\)](#): intersection
- [bit\\_setdiff\(\)](#): asymmetric difference
- [bit\\_syndiff\(\)](#): symmetric difference
- [bit\\_setequal\(\)](#): equality

## See Also

[bit\\_in](#), [bit\\_rangediff](#)

## Examples

```
bit_union(1:2, 2:3)
bit_intersect(1:2, 2:3)
bit_setdiff(1:2, 2:3)
bit_symdiff(1:2, 2:3)
bit_setequal(1:2, 2:3)
bit_setequal(1:2, 2:1)
```

---

bit\_sort

*bit sort*

---

## Description

fast sorting of integers

## Usage

```
bit_sort(x, decreasing = FALSE, na.last = NA, has.dup = TRUE)
```

## Arguments

x	an integer vector
decreasing	(currently only FALSE is supported)
na.last	NA removes NAs, FALSE puts NAs at the beginning, TRUE puts NAs at the end
has.dup	TRUE (the default) assumes that x might have duplicates, set to FALSE if duplicates are impossible

## Details

determines the range of the integers and checks if the density justifies use of a bit vector; if yes, sorts the first occurrences of each integer in the range using a bit vector, sorts the rest and merges; if no, falls back to quicksort.

## Value

a sorted vector

## See Also

[sort](#), [ramsort](#), [bit\\_sort\\_unique](#)

**Examples**

```

bit_sort(c(2L,1L,NA,NA,1L,2L))
bit_sort(c(2L,1L,NA,NA,1L,2L), na.last=FALSE)
bit_sort(c(2L,1L,NA,NA,1L,2L), na.last=TRUE)

## Not run:
x <- sample(1e7, replace=TRUE)
system.time(bit_sort(x))
system.time(sort(x))

## End(Not run)

```

---

bit_sort_unique	<i>bit sort unique</i>
-----------------	------------------------

---

**Description**

fast combination of [sort](#) and [unique](#) for integers

**Usage**

```

bit_sort_unique(
  x,
  decreasing = FALSE,
  na.last = NA,
  has.dup = TRUE,
  range_na = NULL
)

```

**Arguments**

x	an integer vector
decreasing	FALSE (ascending) or TRUE (descending)
na.last	NA removes NAs, FALSE puts NAs at the beginning, TRUE puts NAs at the end
has.dup	TRUE (the default) assumes that x might have duplicates, set to FALSE if duplicates are impossible
range_na	NULL calls <a href="#">range_na</a> , optionally the result of <a href="#">range_na</a> can be given here to avoid calling it again

**Details**

determines the range of the integers and checks if the density justifies use of a bit vector; if yes, creates the result using a bit vector; if no, falls back to `sort(unique())`

**Value**

a sorted unique integer vector

**See Also**

[sort](#), [unique](#), [bit\\_sort](#), [bit\\_unique](#)

**Examples**

```
bit_sort_unique(c(2L,1L,NA,NA,1L,2L))
bit_sort_unique(c(2L,1L,NA,NA,1L,2L), na.last=FALSE)
bit_sort_unique(c(2L,1L,NA,NA,1L,2L), na.last=TRUE)
bit_sort_unique(c(2L,1L,NA,NA,1L,2L), decreasing = TRUE)
bit_sort_unique(c(2L,1L,NA,NA,1L,2L), decreasing = TRUE, na.last=FALSE)
bit_sort_unique(c(2L,1L,NA,NA,1L,2L), decreasing = TRUE, na.last=TRUE)

## Not run:
x <- sample(1e7, replace=TRUE)
system.time(bit_sort_unique(x))
system.time(sort(unique(x)))
x <- sample(1e7)
system.time(bit_sort_unique(x))
system.time(sort(x))

## End(Not run)
```

---

bit\_unidup

*bit unique and duplicated*


---

**Description**

Fast versions of [unique](#), [duplicated](#), [anyDuplicated](#) and `sum(duplicated(x))` for integers.

**Usage**

```
bit_unique(x, na.rm = NA, range_na = NULL)

bit_duplicated(x, na.rm = NA, range_na = NULL, retFUN = as.bit)

bit_anyDuplicated(x, na.rm = NA, range_na = NULL)

bit_sumDuplicated(x, na.rm = NA, range_na = NULL)
```

**Arguments**

x	an integer vector
na.rm	NA treats NAs like other integers, TRUE treats <i>all</i> NAs as duplicates, FALSE treats <i>no</i> NAs as duplicates
range_na	NULL calls <a href="#">range_na</a> , optionally the result of <a href="#">range_na</a> can be given here to avoid calling it again
retFUN	a function that coerces <a href="#">bit</a> and <a href="#">logical</a> vectors

## Details

determines the range of the integers and checks if the density justifies use of a bit vector; if yes, uses a bit vector for finding duplicates; if no, falls back to [unique](#), [duplicated](#), [anyDuplicated](#) and [sum\(duplicated\(x\)\)](#)

## Value

`bit_unique` returns a vector of unique integers,  
`bit_duplicated` returns a boolean vector coerced to `retFUN`,  
`bit_anyDuplicated` returns the position of the first duplicate (or zero if no duplicates)  
`bit_sumDuplicated` returns the number of duplicated values (as.integer)

## Functions

- `bit_unique()`: extracts unique elements
- `bit_duplicated()`: determines duplicate elements
- `bit_anyDuplicated()`: checks for existence of duplicate elements
- `bit_sumDuplicated()`: counts duplicate elements

## See Also

[bit\\_sort\\_unique](#)

## Examples

```
bit_unique(c(2L, 1L, NA, NA, 1L, 2L))
bit_unique(c(2L, 1L, NA, NA, 1L, 2L), na.rm=FALSE)
bit_unique(c(2L, 1L, NA, NA, 1L, 2L), na.rm=TRUE)

bit_duplicated(c(2L, 1L, NA, NA, 1L, 2L))
bit_duplicated(c(2L, 1L, NA, NA, 1L, 2L), na.rm=FALSE)
bit_duplicated(c(2L, 1L, NA, NA, 1L, 2L), na.rm=TRUE)

bit_anyDuplicated(c(2L, 1L, NA, NA, 1L, 2L))
bit_anyDuplicated(c(2L, 1L, NA, NA, 1L, 2L), na.rm=FALSE)
bit_anyDuplicated(c(2L, 1L, NA, NA, 1L, 2L), na.rm=TRUE)

bit_sumDuplicated(c(2L, 1L, NA, NA, 1L, 2L))
bit_sumDuplicated(c(2L, 1L, NA, NA, 1L, 2L), na.rm=FALSE)
bit_sumDuplicated(c(2L, 1L, NA, NA, 1L, 2L), na.rm=TRUE)
```

## Description

Specific methods for `booltype` are required, where non-unary methods can combine multiple boolean types, particularly boolean binary operators.

**Usage**

```
booltype(x)
```

**Arguments**

x                    an R object

**Details**

Function `booltype` returns the boolean type of its argument. There are currently six boolean types, `booltypes` is an [ordered](#) vector with the following ordinal [levels](#)

**nobool** non-boolean types

[logical](#) for representing any boolean data including NA

[bit](#) for representing dense boolean data

[bitwhich](#) for representing sparse (skewed) boolean data

[which](#) for representing sparse boolean data with few TRUE

[ri](#) range-indexing, for representing sparse boolean data with a single range of TRUE

**Value**

one scalar element of [booltypes](#) in case of 'nobool' it carries a name attribute with the data type.

**Note**

do not rely on the internal integer codes of these levels, we might add-in [hi](#) later

**See Also**

[booltypes](#), [is.booltype](#), [as.booltype](#)

**Examples**

```
unname(booltypes)
str(booltypes)
sapply(list(double(), integer(), logical(), bit(), bitwhich(), as.which(), ri(1,2,3)), booltype)
```



---

`booltypes`*Boolean types*

---

**Description**

The `ordered` factor `booltypes` ranks the boolean types.

**Usage**

```
booltypes
```

**Format**

An object of class `ordered` (inherits from `factor`) of length 6.

**Details**

There are currently six boolean types, `booltypes` is an `ordered` vector with the following ordinal [levels](#)

**nobool** non-boolean types

`logical` for representing any boolean data including NA

`bit` for representing dense boolean data

`bitwhich` for representing sparse (skewed) boolean data

`which` for representing sparse boolean data with few TRUE

`ri` range-indexing, for representing sparse boolean data with a single range of TRUE

`booltypes` has a `names` attribute such that elements can be selected by name.

**Note**

do not rely on the internal integer codes of these levels, we might add-in `hi` later

**See Also**

[booltype](#), [is.booltype](#), [as.booltype](#)

---

`c.booltype`*Concatenating booltype vectors*

---

**Description**

Creating new boolean vectors by concatenating boolean vectors

**Usage**

```
## S3 method for class 'booltype'  
c(...)  
  
## S3 method for class 'bit'  
c(...)  
  
## S3 method for class 'bitwhich'  
c(...)
```

**Arguments**

... [booltype](#) vectors

**Value**

a vector with the lowest input [booltype](#) (but not lower than [logical](#))

**Author(s)**

Jens Oehlschlägel

**See Also**

[c](#), [bit](#), [bitwhich](#), [which](#)

**Examples**

```
c(bit(4), !bit(4))  
c(bit(4), !bitwhich(4))  
c(bitwhich(4), !bit(4))  
c(ri(1,2,4), !bit(4))  
c(bit(4), !logical(4))  
message("logical in first argument does not dispatch: c(logical(4), bit(4))")  
c.booltype(logical(4), !bit(4))
```

---

chunk *Methods for chunked range index*

---

### Description

Calls [chunks](#) to create a sequence of range indexes along the object which causes the method dispatch.

### Usage

```
chunk(x = NULL, ...)
```

```
## Default S3 method:
```

```
chunk(x = NULL, ..., RECORDBYTES = NULL, BATCHBYTES = NULL)
```

### Arguments

x	the object along we want chunks
...	further arguments passed to <a href="#">chunks</a>
RECORDBYTES	integer scalar representing the bytes needed to process a single element of the boolean vector (default 4 bytes for logical)
BATCHBYTES	integer scalar limiting the number of bytes to be processed in one chunk, default from <code>getOption("ffbatchbytes")</code> if not null, otherwise 16777216

### Details

chunk is generic, the default method is described here, other methods that automatically consider RAM needs are provided with package 'ff', see for example [chunk.ffdf](#)

### Value

returns a named list of [ri](#) objects representing chunks of subscripts

### Methods (by class)

- `chunk(default)`: default vector method

### available methods

`chunk.default`, [chunk.ff\\_vector](#), [chunk.ffdf](#)

### Author(s)

Jens Oehlschlägel

### See Also

[chunks](#), [ri](#), [seq](#), [bbatch](#)

**Examples**

```

chunk(complex(1e7))
chunk(raw(1e7))
chunk(raw(1e7), length=3)

chunks(1,10,3)
# no longer do
chunk(1,100,10)
# but for backward compatibility this works
chunk(from=1,to=100,by=10)

```

---

chunks

*Function for chunked range index*


---

**Description**

creates a sequence of range indexes using a syntax not completely unlike 'seq'

**Usage**

```

chunks(
  from = NULL,
  to = NULL,
  by = NULL,
  length.out = NULL,
  along.with = NULL,
  overlap = 0L,
  method = c("bbatch", "seq"),
  maxindex = NA
)

```

**Arguments**

from	the starting value of the sequence.
to	the (maximal) end value of the sequence.
by	increment of the sequence
length.out	desired length of the sequence.
along.with	take the length from the length of this argument.
overlap	number of values to overlap (will lower the starting value of the sequence, the first range becomes smaller)
method	default 'bbatch' will try to balance the chunk size, see <a href="#">bbatch</a> , 'seq' will create chunks like <a href="#">seq</a>
maxindex	passed to <a href="#">ri</a>

**Value**

returns a named list of `ri` objects representing chunks of subscripts

**Author(s)**

Jens Oehlschlägel

**See Also**

generic `chunk`, `ri`, `seq`, `bbatch`

**Examples**

```

chunks(1, 100, by=30)
chunks(1, 100, by=30, method="seq")
## Not run:
require(foreach)
m <- 10000
k <- 1000
n <- m*k
message("Four ways to loop from 1 to n. Slowest foreach to fastest chunk is 1700:1
on a dual core notebook with 3GB RAM\n")
z <- 0L;
print(k*system.time({it <- icount(m); foreach (i = it) %do% { z <- i; NULL }}))
z

z <- 0L
print(system.time({i <- 0L; while (i<n) {i <- i + 1L; z <- i}}))
z

z <- 0L
print(system.time(for (i in 1:n) z <- i))
z

z <- 0L; n <- m*k;
print(system.time(for (ch in chunks(1, n, by=m)){for (i in ch[1]:ch[2])z <- i}))
z

message("Seven ways to calculate sum(1:n).
Slowest foreach to fastest chunk is 61000:1 on a dual core notebook with 3GB RAM\n")
print(k*system.time({it <- icount(m); foreach (i = it, .combine="+") %do% { i }}))

z <- 0;
print(k*system.time({it <- icount(m); foreach (i = it) %do% { z <- z + i; NULL }}))
z

z <- 0; print(system.time({i <- 0L;while (i<n) {i <- i + 1L; z <- z + i}})); z

z <- 0; print(system.time(for (i in 1:n) z <- z + i)); z

print(system.time(sum(as.double(1:n))))

```

```
z <- 0; n <- m*k
print(system.time(for (ch in chunks(1, n, by=m)){for (i in ch[1]:ch[2])z <- z + i}))
z

z <- 0; n <- m*k
print(system.time(for (ch in chunks(1, n, by=m)){z <- z+sum(as.double(ch[1]:ch[2]))}))
z

## End(Not run)
```

---

clone

*Cloning ff and ram objects*

---

## Description

clone physically duplicates objects and can additionally change some features, e.g. length.

## Usage

```
clone(x, ...)
```

## Default S3 method:

```
clone(x, ...)
```

## Arguments

x                    x an R object

...                    further arguments to the generic

## Details

clone is generic. clone.default handles ram objects. Further methods are provided in package 'ff'. still.identical returns TRUE if the two atomic arguments still point to the same memory.

## Value

an object that is a deep copy of x

## Methods (by class)

- clone(default): default method uses R's C-API 'duplicate()'

## Author(s)

Jens Oehlschlägel

**See Also**

`clone.ff`, [copy\\_vector](#)

**Examples**

```
x <- 1:12
y <- x
still.identical(x,y)
y[1] <- y[1]
still.identical(x,y)
y <- clone(x)
still.identical(x,y)
rm(x,y); gc()
```

---

CoercionToStandard

*Coercion from bit, bitwhich, which and ri to logical, integer, double*

---

**Description**

Coercion from bit is quite fast because we use a double loop that fixes each word in a processor register.

**Usage**

```
## S3 method for class 'bit'
as.logical(x, ...)

## S3 method for class 'bit'
as.integer(x, ...)

## S3 method for class 'bit'
as.double(x, ...)

## S3 method for class 'bitwhich'
as.integer(x, ...)

## S3 method for class 'bitwhich'
as.double(x, ...)

## S3 method for class 'bitwhich'
as.logical(x, ...)

## S3 method for class 'ri'
as.logical(x, ...)

## S3 method for class 'ri'
```

```

as.integer(x, ...)

## S3 method for class 'ri'
as.double(x, ...)

## S3 method for class 'which'
as.logical(x, length = attr(x, "maxindex"), ...)

```

### Arguments

x	an object of class <a href="#">bit</a> , <a href="#">bitwhich</a> or <a href="#">ri</a>
...	ignored
length	length of the boolean vector (required for <code>as.logical.which</code> )

### Value

[as.logical](#) returns a vector of FALSE, TRUE, [as.integer](#) and [as.double](#) return a vector of 0, 1.

### Author(s)

Jens Oehlschlägel

### See Also

[CoercionToStandard](#), [as.booltype](#), [as.bit](#), [as.bitwhich](#), [as.which](#), [as.ri](#), [as.hi](#), [as.ff](#)

### Examples

```

x <- ri(2, 5, 10)
y <- as.logical(x)
y
stopifnot(identical(y, as.logical(as.bit(x))))
stopifnot(identical(y, as.logical(as.bitwhich(x))))

y <- as.integer(x)
y
stopifnot(identical(y, as.integer(as.logical(x))))
stopifnot(identical(y, as.integer(as.bit(x))))
stopifnot(identical(y, as.integer(as.bitwhich(x))))

y <- as.double(x)
y
stopifnot(identical(y, as.double(as.logical(x))))
stopifnot(identical(y, as.double(as.bit(x))))
stopifnot(identical(y, as.double(as.bitwhich(x))))

```



---

copy_vector	<i>Copy atomic R vector</i>
-------------	-----------------------------

---

### Description

Creates a true copy of the underlying C-vector – dropping all attributes – and optionally reverses the direction of the elements.

### Usage

```
copy_vector(x, revx = FALSE)
```

### Arguments

x	an R vector
revx	default FALSE, set to TRUE to reverse the elements in 'x'

### Details

This can be substantially faster than `duplicate(as.vector(unclass(x)))`

### Value

copied R vector

### See Also

[clone](#), [still.identical](#), [reverse\\_vector](#)

### Examples

```
x <- factor(letters)
y <- x
z <- copy_vector(x)
still.identical(x,y)
still.identical(x,z)
str(x)
str(y)
str(z)
```

---

countsort	<i>Low-level sorting: counting sort</i>
-----------	---

---

**Description**

In one pass over the vector NAs are handled according to parameter `na.last` by `range_sortna`, then, if the vector is unsorted, counting sort is invoked.

**Usage**

```
countsort(x, na.last = NA)
```

**Arguments**

<code>x</code>	an integer vector
<code>na.last</code>	NA removes NAs, FALSE puts NAs at the beginning, TRUE puts NAs at the end

**Value**

a sorted vector

**Examples**

```
countsort(c(2L,0L,1L,NA,2L))
countsort(c(2L,0L,1L,NA,2L), na.last=TRUE)
countsort(c(2L,0L,1L,NA,2L), na.last=FALSE)
```

---

Extract	<i>Extract or replace part of an boolean vector</i>
---------	---

---

**Description**

Operators acting on `bit` or `bitwhich` objects to extract or replace parts.

**Usage**

```
## S3 method for class 'bit'
x[[i]]

## S3 replacement method for class 'bit'
x[[i]] <- value

## S3 method for class 'bit'
x[i]

## S3 replacement method for class 'bit'
```

```
x[i] <- value

## S3 method for class 'bitwhich'
x[[i]]

## S3 replacement method for class 'bitwhich'
x[[i]] <- value

## S3 method for class 'bitwhich'
x[i]

## S3 replacement method for class 'bitwhich'
x[i] <- value
```

### Arguments

x	a <a href="#">bit</a> or <a href="#">bitwhich</a> object
i	preferably a positive integer subscript or a <a href="#">ri</a> , see text
value	new logical or integer values

### Details

The typical usecase for for '[' and '[<-' is subscripting with positive integers, negative integers are allowed but slower, as logical subscripts only scalars are allowed. The subscript can be given as a [bitwhich](#) object. Also [ri](#) can be used as subscript.

Extracting from [bit](#) and [bitwhich](#) is faster than from [logical](#) if positive subscripts are used. integer subscripts make sense. Negative subscripts are converted to positive ones, beware the RAM consumption.

### Value

The extractors [[ and [ return a logical scalar or vector. The replacment functions return an object of class(x).

### Author(s)

Jens Oehlschlägel

### See Also

[bit](#), [Extract](#)

### Examples

```
x <- as.bit(c(FALSE, NA, TRUE))
x[] <- c(FALSE, NA, TRUE)
x[1:2]
x[-3]
x[ri(1,2)]
```

```
x[as.bitwhich(c(TRUE,TRUE,FALSE))]
x[[1]]
x[] <- TRUE
x[1:2] <- FALSE
x[[1]] <- TRUE
```

---

firstNA

*Position of first NA*

---

### Description

This is substantially faster than `which.max(is.na(x))`

### Usage

```
firstNA(x)
```

### Arguments

`x` an R vector

### Value

a reversed vector

### See Also

[which.max](#), [is.na](#), [anyNA](#), [anyDuplicated](#), [bit\\_anyDuplicated](#)

### Examples

```
x <- c(FALSE,NA,TRUE)
firstNA(x)
reverse_vector(x)
## Not run:
x <- 1:1e7
system.time(rev(x))
system.time(reverse_vector(x))

## End(Not run)
```

---

`getsetattr`*Attribute setting by reference*

---

**Description**

Function `setattr` sets a single attribute and function `setattributes` sets a list of attributes.

**Usage**

```
getsetattr(x, which, value)
```

```
setattr(x, which, value)
```

```
setattributes(x, attributes)
```

**Arguments**

<code>x</code>	an R object
<code>which</code>	name of the attribute
<code>value</code>	value of the attribute, use <code>NULL</code> to remove this attribute
<code>attributes</code>	a named list of attribute values

**Details**

The attributes of `'x'` are changed in place without copying `x`. function `setattributes` does only change the named attributes, it does not delete the non-names attributes like `attributes` does.

**Value**

`invisible()`, we do not return the changed object to remind you of the fact that this function is called for its side-effect of changing its input object.

**Functions**

- `setattr()`:
- `setattributes()`:

**Author(s)**

Jens Oehlschlägel

**References**

Writing R extensions – System and foreign language interfaces – Handling R objects in C – Attributes (Version 2.11.1 (2010-06-03) R Development)

**See Also**[attr unattr](#)**Examples**

```

x <- as.single(runif(10))
attr(x, "Csingle")

f <- function(x)attr(x, "Csingle") <- NULL
g <- function(x)setattr(x, "Csingle", NULL)

f(x)
x
g(x)
x

## Not run:

# restart R
library(bit)

mysingle <- function(length = 0){
  ret <- double(length)
  setattr(ret, "Csingle", TRUE)
  ret
}

# show that mysinge gives exactly the same result as single
identical(single(10), mysingle(10))

# look at the speedup and memory-savings of mysingle compared to single
system.time(mysingle(1e7))
memory.size(max=TRUE)
system.time(single(1e7))
memory.size(max=TRUE)

# look at the memory limits
# on my win32 machine the first line fails because of not enough RAM, the second works
x <- single(1e8)
x <- mysingle(1e8)

# .g. performance with factors
x <- rep(factor(letters), length.out=1e7)
x[1:10]
# look how fast one can do this
system.time(setattr(x, "levels", rev(letters)))
x[1:10]
# look at the performance loss in time caused by the non-needed copying
system.time(levels(x) <- letters)
x[1:10]

```

```
# restart R
library(bit)

simplefactor <- function(n){
  factor(rep(1:2, length.out=n))
}

mysimplefactor <- function(n){
  ret <- rep(1:2, length.out=n)
  setattr(ret, "levels", as.character(1:2))
  setattr(ret, "class", "factor")
  ret
}

identical(simplefactor(10), mysimplefactor(10))

system.time(x <- mysimplefactor(1e7))
memory.size(max=TRUE)
system.time(setattr(x, "levels", c("a", "b")))
memory.size(max=TRUE)
x[1:4]
memory.size(max=TRUE)
rm(x)
gc()

system.time(x <- simplefactor(1e7))
memory.size(max=TRUE)
system.time(levels(x) <- c("x", "y"))
memory.size(max=TRUE)
x[1:4]
memory.size(max=TRUE)
rm(x)
gc()

## End(Not run)
```

---

get\_length

*Get C length of a vector*

---

### **Description**

Gets C length of a vector ignoring any length-methods dispatched by classes

### **Usage**

```
get_length(x)
```

**Arguments**

x                    a vector

**Details**

Queries the vector length using C-macro LENGTH, this can be substantially faster than `length(unclass(x))`

**Value**

integer scalar

**Examples**

```
length(bit(12))
get_length(bit(12))
```

---

in.bitwhich

*Check existence of integers in table*

---

**Description**

If the table is sorted, this can be much faster than `%in%`

**Usage**

```
in.bitwhich(x, table, is.unsorted = NULL)
```

**Arguments**

x                    a vector of integer  
table                a `bitwhich` object or a vector of integer  
is.unsorted        logical telling the function whether the table is (un)sorted. With the default NULL FALSE is assumed for `bitwhich` tables, otherwise TRUE

**Value**

logical vector

**See Also**

`%in%`

**Examples**

```
x <- bitwhich(100)
x[3] <- TRUE
in.bitwhich(c(NA,2,3), x)
```



---

intrle *Hybrid Index, C-coded utilities*

---

### Description

These C-coded utilities speed up index preprocessing considerably.

### Usage

```
intrle(x)
```

```
intisasc(x, na.method = c("none", "break", "skip")[2])
```

```
intisdesc(x, na.method = c("none", "break", "skip")[1])
```

### Arguments

x	an integer vector
na.method	one of "none","break","skip", see details. The strange defaults stem from the initial usage.

### Details

intrle is by factor 50 faster and needs less RAM (2x its input vector) compared to [rle](#) which needs 9x the RAM of its input vector. This is achieved because we allow the C-code of intrle to break when it turns out, that rle-packing will not achieve a compression factor of 3 or better.

intisasc is a faster version of [is.unsorted](#): it checks whether x is sorted.

intisdesc checks for being sorted descending and by default default assumes that the input x contains no NAs. na.method="none" treats NAs (the smallest integer) like every other integer and hence returns either TRUE or FALSE na.method="break" checks for NAs and returns either NA as soon as NA is encountered. na.method="skip" checks for NAs and skips over them, hence decides the return value only on the basis of non-NA values.

### Value

intrle returns an object of class [rle](#) or NULL, if rle-compression is not efficient (compression factor <3 or length(x)<3).

intisasc returns one of FALSE, NA, TRUE

intisdesc returns one of FALSE, TRUE (if the input contains NAs, the output is undefined)

### Functions

- `intisasc()`: check whether integer vector is ascending
- `intisdesc()`: check whether integer vector is descending

### Author(s)

Jens Oehlschlägel

**See Also**

[hi](#), [rle](#), [is.unsorted](#), [is.sorted](#)

**Examples**

```
intrle(sample(1:10))
intrle(diff(1:10))
intisasc(1:10)
intisasc(10:1)
intisasc(c(NA, 1:10))
intisdesc(1:10)
intisdesc(c(10:1, NA))
intisdesc(c(10:6, NA, 5:1))
intisdesc(c(10:6, NA, 5:1), na.method="skip")
intisdesc(c(10:6, NA, 5:1), na.method="break")
```

---

is.booltype

*Testing for boolean types*

---

**Description**

All [booltypes](#) including [logical](#) except 'nbool' types are considered 'is.booltype'.

**Usage**

```
is.booltype(x)
```

```
is.bit(x)
```

```
is.bitwhich(x)
```

```
is.which(x)
```

```
is.hi(x)
```

```
is.ri(x)
```

**Arguments**

x                    an R object

**Value**

logical scalar

**Functions**

- `is.bit()`: tests for `bit`
- `is.bitwhich()`: tests for `bitwhich`
- `is.which()`: tests for `which`
- `is.hi()`: tests for `hi`
- `is.ri()`: tests for `ri`

**See Also**

[booltypes](#), [booltype](#), [as.booltype](#)

**Examples**

```
sapply(list(double(),integer(),logical(),bit(),bitwhich(),as.which(),ri(1,2,3)), is.booltype)
```

---

<code>is.na.bit</code>	<i>Test for NA in bit and bitwhich</i>
------------------------	--

---

**Description**

Test for NA in bit and bitwhich

**Usage**

```
## S3 method for class 'bit'  
is.na(x)  
  
## S3 method for class 'bitwhich'  
is.na(x)
```

**Arguments**

`x` a `bit` or `bitwhich` vector

**Value**

vector of same type with all elements FALSE

**Functions**

- `is.na(bitwhich)`: method for `is.na` from `bitwhich`

**See Also**

[is.na](#)

**Examples**

```
is.na(bit(6))
is.na(bitwhich(6))
```

---

length.bit

*Getting and setting length of bit, bitwhich and ri objects*


---

**Description**

Query the number of bits in a [bit](#) vector or change the number of bits in a bit vector.

Query the number of bits in a [bitwhich](#) vector or change the number of bits in a bit vector.

**Usage**

```
## S3 method for class 'bit'
length(x)

## S3 replacement method for class 'bit'
length(x) <- value

## S3 method for class 'bitwhich'
length(x)

## S3 replacement method for class 'bitwhich'
length(x) <- value

## S3 method for class 'ri'
length(x)
```

**Arguments**

x	a <a href="#">bit</a> , <a href="#">bitwhich</a> or <a href="#">ri</a> object
value	the new number of bits

**Details**

NOTE that the length does NOT reflect the number of selected (TRUE) bits, it reflects the sum of both, TRUE and FALSE bits. Increasing the length of a [bit](#) object will set new bits to FALSE. The behaviour of increasing the length of a [bitwhich](#) object is different and depends on the content of the object:

- TRUE – all included, new bits are set to TRUE
- positive integers – some included, new bits are set to FALSE
- negative integers – some excluded, new bits are set to TRUE
- FALSE – all excluded:, new bits are set to FALSE

Decreasing the length of bit or bitwhich removes any previous information about the status bits above the new length.

**Value**

the length A bit vector with the new length

**Author(s)**

Jens Oehlschlägel

**See Also**

[length](#), [sum](#), [poslength](#), [maxindex](#)

**Examples**

```
stopifnot(length(ri(1, 1, 32))==32)
```

```
x <- as.bit(ri(32, 32, 32))
stopifnot(length(x)==32)
stopifnot(sum(x)==1)
length(x) <- 16
stopifnot(length(x)==16)
stopifnot(sum(x)==0)
length(x) <- 32
stopifnot(length(x)==32)
stopifnot(sum(x)==0)
```

```
x <- as.bit(ri(1, 1, 32))
stopifnot(length(x)==32)
stopifnot(sum(x)==1)
length(x) <- 16
stopifnot(length(x)==16)
stopifnot(sum(x)==1)
length(x) <- 32
stopifnot(length(x)==32)
stopifnot(sum(x)==1)
```

```
x <- as.bitwhich(bit(32))
stopifnot(length(x)==32)
stopifnot(sum(x)==0)
length(x) <- 16
stopifnot(length(x)==16)
stopifnot(sum(x)==0)
length(x) <- 32
stopifnot(length(x)==32)
stopifnot(sum(x)==0)
```

```
x <- as.bitwhich(!bit(32))
stopifnot(length(x)==32)
stopifnot(sum(x)==32)
length(x) <- 16
stopifnot(length(x)==16)
stopifnot(sum(x)==16)
length(x) <- 32
```

```

stopifnot(length(x)==32)
stopifnot(sum(x)==32)

x <- as.bitwhich(ri(32, 32, 32))
stopifnot(length(x)==32)
stopifnot(sum(x)==1)
length(x) <- 16
stopifnot(length(x)==16)
stopifnot(sum(x)==0)
length(x) <- 32
stopifnot(length(x)==32)
stopifnot(sum(x)==0)

x <- as.bitwhich(ri(2, 32, 32))
stopifnot(length(x)==32)
stopifnot(sum(x)==31)
length(x) <- 16
stopifnot(length(x)==16)
stopifnot(sum(x)==15)
length(x) <- 32
stopifnot(length(x)==32)
stopifnot(sum(x)==31)

x <- as.bitwhich(ri(1, 1, 32))
stopifnot(length(x)==32)
stopifnot(sum(x)==1)
length(x) <- 16
stopifnot(length(x)==16)
stopifnot(sum(x)==1)
length(x) <- 32
stopifnot(length(x)==32)
stopifnot(sum(x)==1)

x <- as.bitwhich(ri(1, 31, 32))
stopifnot(length(x)==32)
stopifnot(sum(x)==31)
message("NOTE the change from 'some excluded' to 'all excluded' here")
length(x) <- 16
stopifnot(length(x)==16)
stopifnot(sum(x)==16)
length(x) <- 32
stopifnot(length(x)==32)
stopifnot(sum(x)==32)

```

## Description

For `is.booltype` objects the term `length` is ambiguous. For example the length of `which` corresponds to the sum of `logical`. The generic `maxindex` gives `length(logical)` for all `booltypes`. The generic `poslength` gives the number of positively selected elements, i.e. `sum(logical)` for all `booltypes` (and gives NA if NAs are present).

## Usage

```
## Default S3 method:
maxindex(x, ...)

## Default S3 method:
poslength(x, ...)

## S3 method for class 'logical'
maxindex(x, ...)

## S3 method for class 'logical'
poslength(x, ...)

## S3 method for class 'bit'
maxindex(x, ...)

## S3 method for class 'bit'
poslength(x, ...)

## S3 method for class 'bitwhich'
maxindex(x, ...)

## S3 method for class 'bitwhich'
poslength(x, ...)

## S3 method for class 'which'
maxindex(x, ...)

## S3 method for class 'which'
poslength(x, ...)

## S3 method for class 'ri'
maxindex(x, ...)

## S3 method for class 'ri'
poslength(x, ...)

maxindex(x, ...)

poslength(x, ...)
```

**Arguments**

`x` an R object, typically a `is.booltype` object.  
`...` further arguments (ignored)

**Value**

an integer scalar

**Methods (by class)**

- `maxindex(default)`: default method for `maxindex`
- `maxindex(logical)`: `maxindex` method for class `logical`
- `maxindex(bit)`: `maxindex` method for class `bit`
- `maxindex(bitwhich)`: `maxindex` method for class `bitwhich`
- `maxindex(which)`: `maxindex` method for class `which`
- `maxindex(ri)`: `maxindex` method for class `ri`

**Functions**

- `poslength(default)`: default method for `poslength`
- `poslength(logical)`: `poslength` method for class `logical`
- `poslength(bit)`: `poslength` method for class `bit`
- `poslength(bitwhich)`: `poslength` method for class `bitwhich`
- `poslength(which)`: `poslength` method for class `which`
- `poslength(ri)`: `poslength` method for class `ri`

**Examples**

```
r <- ri(1,2,12)
i <- as.which(r)
w <- as.bitwhich(r)
b <- as.bit(r)
l <- as.logical(r)
u <- which(l)      # unclassed which

sapply(list(r=r,u=u,i=i,w=w,b=b,l=l), function(x){
  c(length=length(x), sum=sum(x), maxindex=maxindex(x), poslength=poslength(x))
})
```



**Description**

The `merge_` functions allow unary and binary operations on (ascending) sorted vectors of `link{integer}`. `merge_rev(x)` will do in one scan what costs two scans in `-rev(x)`, see also `reverse_vector(x)`. Many of these `merge_` can optionally scan their input in reverse order (and switch the sign), which again saves extra scans for calling `merge_rev(x)` first.

**Usage**

```
merge_rev(x)

merge_match(x, y, revx = FALSE, revy = FALSE, nomatch = NA_integer_)

merge_in(x, y, revx = FALSE, revy = FALSE)

merge_notin(x, y, revx = FALSE, revy = FALSE)

merge_duplicated(x, revx = FALSE)

merge_anyDuplicated(x, revx = FALSE)

merge_sumDuplicated(x, revx = FALSE)

merge_unique(x, revx = FALSE)

merge_union(
  x,
  y,
  revx = FALSE,
  revy = FALSE,
  method = c("unique", "exact", "all")
)

merge_setdiff(x, y, revx = FALSE, revy = FALSE, method = c("unique", "exact"))

merge_syndiff(x, y, revx = FALSE, revy = FALSE, method = c("unique", "exact"))

merge_intersect(
  x,
  y,
  revx = FALSE,
  revy = FALSE,
  method = c("unique", "exact")
)
```

```

merge_setequal(x, y, revx = FALSE, revy = FALSE, method = c("unique", "exact"))
merge_rangein(rx, y, revx = FALSE, revy = FALSE)
merge_rangenotin(rx, y, revx = FALSE, revy = FALSE)
merge_rangesect(rx, y, revx = FALSE, revy = FALSE)
merge_rangediff(rx, y, revx = FALSE, revy = FALSE)
merge_first(x, revx = FALSE)
merge_last(x, revx = FALSE)
merge_firstin(rx, y, revx = FALSE, revy = FALSE)
merge_lastin(rx, y, revx = FALSE, revy = FALSE)
merge_firstnotin(rx, y, revx = FALSE, revy = FALSE)
merge_lastnotin(rx, y, revx = FALSE, revy = FALSE)

```

### Arguments

x	a sorted set
y	a sorted set
revx	default FALSE, set to TRUE to reverse scan parameter 'x'
revy	default FALSE, set to TRUE to reverse scan parameter 'y'
nomatch	integer value returned for non-matched elements, see <a href="#">match</a>
method	one of "unique", "exact" (or "all") which governs how to treat ties, see the function descriptions
rx	range of integers given as <a href="#">ri</a> or as a two-element <a href="#">integer</a>

### Details

These are low-level functions and hence do not check whether the set is actually sorted. Note that the 'merge\_\*' and 'merge\_range\*' functions have no special treatment for 'NA'. If vectors with 'NA' are sorted with 'NA' in the first positions ('na.last=FALSE') and arguments 'revx=' or 'revy=' have not been used, then 'NAs' are treated like ordinary integers. 'NA' sorted elsewhere or using 'revx=' or 'revy=' can cause unexpected results (note for example that 'revx=' switches the sign on all integers but 'NAs').

The *binary* 'merge\_\*' functions have a 'method="exact"' which in both sets treats consecutive occurrences of the same value as if they were different values, more precisely they are handled as if the identity of ties were tuples of ties, `rank(ties)`. `method="exact"` delivers unique output if the input is unique, and in this case works faster than `method="unique"`.

**Value**

merge\_rev(x) returns  $-\text{rev}(x)$  for [integer](#) and [double](#) and  $!\text{rev}(x)$  for [logical](#)

**Functions**

- merge\_match(): returns integer positions of sorted set x in sorted set y, see [match\(x, y, ...\)](#)
- merge\_in(): returns logical existence of sorted set x in sorted set y, see  $x \%in\% y$
- merge\_notin(): returns logical in-existence of sorted set x in sorted set y, see  $!(x \%in\% y)$
- merge\_duplicated(): returns the duplicated status of a sorted set x, see [duplicated](#)
- merge\_anyDuplicated(): returns the anyDuplicated status of a sorted set x, see [anyDuplicated](#)
- merge\_sumDuplicated(): returns the sumDuplicated status of a sorted set x, see [bit\\_sumDuplicated](#)
- merge\_unique(): returns unique elements of sorted set x, see [unique](#)
- merge\_union(): returns union of two sorted sets. Default method='unique' returns a unique sorted set, see [union](#); method='exact' returns a sorted set with the maximum number of ties in either input set; method='all' returns a sorted set with the sum of ties in both input sets.
- merge\_setdiff(): returns sorted set x minus sorted set y Default method='unique' returns a unique sorted set, see [setdiff](#); method='exact' returns a sorted set with sum(x ties) minus sum(y ties);
- merge\_symdiff(): returns those elements that are in sorted set x **xor** in sorted set y Default method='unique' returns the sorted unique set complement, see [symdiff](#); method='exact' returns a sorted set set complement with  $\text{abs}(\text{sum}(x \text{ ties}) - \text{sum}(y \text{ ties}))$ ;
- merge\_intersect(): returns the intersection of two sorted sets x and y Default method='unique' returns the sorted unique intersect, see [intersect](#); method='exact' returns the intersect with the minimum number of ties in either set;
- merge\_setequal(): returns TRUE for equal sorted sets and FALSE otherwise Default method='unique' compares the sets after removing ties, see [setequal](#); method='exact' compares the sets without removing ties;
- merge\_rangein(): returns logical existence of range rx in sorted set y, see [merge\\_in](#)
- merge\_rangenotin(): returns logical in-existence of range rx in sorted set y, see [merge\\_notin](#)
- merge\_rangesect(): returns the intersection of range rx and sorted set y, see [merge\\_intersect](#)
- merge\_rangediff(): returns range rx minus sorted set y, see [merge\\_setdiff](#)
- merge\_first(): quickly returns the first element of a sorted set x (or NA if x is empty), hence  $x[1]$  or  $\text{merge\_rev}(x)[1]$
- merge\_last(): quickly returns the last element of a sorted set x, (or NA if x is empty), hence  $x[n]$  or  $\text{merge\_rev}(x)[n]$
- merge\_firstin(): quickly returns the first common element of a range rx and a sorted set y, (or NA if the intersection is empty), hence  $\text{merge\_first}(\text{merge\_rangesect}(rx, y))$
- merge\_lastin(): quickly returns the last common element of a range rx and a sorted set y, (or NA if the intersection is empty), hence  $\text{merge\_last}(\text{merge\_rangesect}(rx, y))$
- merge\_firstnotin(): quickly returns the first element of a range rx which is not in a sorted set y (or NA if all rx are in y), hence  $\text{merge\_first}(\text{merge\_rangediff}(rx, y))$
- merge\_lastnotin(): quickly returns the last element of a range rx which is not in a sorted set y (or NA if all rx are in y), hence  $\text{merge\_last}(\text{merge\_rangediff}(rx, y))$

**Note**

xx OPTIMIZATION OPPORTUNITY These are low-level functions could be optimized with initial binary search (not findInterval, which coerces to double).

**Examples**

```
merge_rev(1:9)

merge_match(1:7, 3:9)
#' merge_match(merge_rev(1:7), 3:9)
merge_match(merge_rev(1:7), 3:9, revx=TRUE)
merge_match(merge_rev(1:7), 3:9, revy=TRUE)
merge_match(merge_rev(1:7), merge_rev(3:9))

merge_in(1:7, 3:9)
merge_notin(1:7, 3:9)

merge_anyDuplicated(c(1L,1L,2L,3L))
merge_duplicated(c(1L,1L,2L,3L))
merge_unique(c(1L,1L,2L,3L))

merge_union(c(1L,2L,2L,2L), c(2L,2L,3L))
merge_union(c(1L,2L,2L,2L), c(2L,2L,3L), method="exact")
merge_union(c(1L,2L,2L,2L), c(2L,2L,3L), method="all")

merge_setdiff(c(1L,2L,2L,2L), c(2L,2L,3L))
merge_setdiff(c(1L,2L,2L,2L), c(2L,2L,3L), method="exact")
merge_setdiff(c(1L,2L,2L), c(2L,2L,2L,3L), method="exact")

merge_symdiff(c(1L,2L,2L,2L), c(2L,2L,3L))
merge_symdiff(c(1L,2L,2L,2L), c(2L,2L,3L), method="exact")
merge_symdiff(c(1L,2L,2L), c(2L,2L,2L,3L), method="exact")

merge_intersect(c(1L,2L,2L,2L), c(2L,2L,3L))
merge_intersect(c(1L,2L,2L,2L), c(2L,2L,3L), method="exact")

merge_setequal(c(1L,2L,2L), c(1L,2L))
merge_setequal(c(1L,2L,2L), c(1L,2L,2L))
merge_setequal(c(1L,2L,2L), c(1L,2L), method="exact")
merge_setequal(c(1L,2L,2L), c(1L,2L,2L), method="exact")
```

---

Metadata

*Generics related to cache access*


---

**Description**

These generics are packaged here for methods in packages bit64 and ff.

**Usage**

```
is.sorted(x, ...)  
  
is.sorted(x, ...) <- value  
  
na.count(x, ...)  
  
na.count(x, ...) <- value  
  
nvalid(x, ...)  
  
nunique(x, ...)  
  
nunique(x, ...) <- value  
  
nties(x, ...)  
  
nties(x, ...) <- value
```

**Arguments**

x	some object
...	ignored
value	value assigned on responsibility of the user

**Details**

see help of the available methods

**Value**

see help of the available methods

**Author(s)**

Jens Oehlschlägel <Jens.Oehlschlaegel@truecluster.com>

**See Also**

[is.sorted.integer64](#), [na.count.integer64](#), [nvalid.integer64](#), [nunique.integer64](#), [nties.integer64](#)

**Examples**

```
methods("na.count")
```

---

physical.default      *Physical and virtual attributes*

---

### Description

Compatibility functions (to package ff) for getting and setting physical and virtual attributes.

### Usage

```
## Default S3 method:
physical(x)

## Default S3 replacement method:
physical(x) <- value

## Default S3 method:
virtual(x)

## Default S3 replacement method:
virtual(x) <- value

## S3 method for class 'physical'
print(x, ...)

## S3 method for class 'virtual'
print(x, ...)

physical(x)

physical(x) <- value

virtual(x)

virtual(x) <- value
```

### Arguments

x	a ff or ram object
value	a list with named elements
...	further arguments

### Details

ff objects have physical and virtual attributes, which have different copying semantics: physical attributes are shared between copies of ff objects while virtual attributes might differ between copies. [as.ram](#) will retain some physical and virtual attributes in the ram clone, such that [as.ff](#) can restore an ff object with the same attributes.

**Value**

physical and virtual returns a list with named elements

**Author(s)**

Jens Oehlschlägel

**See Also**

[physical.ff](#), [physical.ffdf](#)

**Examples**

```
physical(bit(12))
virtual(bit(12))
```

---

print.bit

*Print method for bit*

---

**Description**

Print method for bit

**Usage**

```
## S3 method for class 'bit'
print(x, ...)
```

**Arguments**

x	a bit vector
...	passed to print

**Value**

a character vector showing first and last elements of the bit vector

**Examples**

```
print(bit(120))
```

---

print.bitwhich	<i>Print method for bitwhich</i>
----------------	----------------------------------

---

**Description**

Print method for bitwhich

**Usage**

```
## S3 method for class 'bitwhich'
print(x, ...)
```

**Arguments**

x	a <code>bitwhich</code> object
...	ignored

---

quicksort2	<i>Low-level sorting: binary quicksort</i>
------------	--

---

**Description**

In one pass over the vector NAs are handled according to parameter `na.last` by `range_sortna`, then, if the vector is unsorted, binary quicksort is invoked.

**Usage**

```
quicksort2(x, na.last = NA)
```

**Arguments**

x	an integer vector
na.last	NA removes NAs, FALSE puts NAs at the beginning, TRUE puts NAs at the end

**Value**

a sorted vector

**Examples**

```
quicksort2(c(2L,0L,1L,NA,2L))
quicksort2(c(2L,0L,1L,NA,2L), na.last=TRUE)
quicksort2(c(2L,0L,1L,NA,2L), na.last=FALSE)
```



---

quicksort3	<i>Low-level sorting: threeway quicksort</i>
------------	--

---

**Description**

In one pass over the vector NAs are handled according to parameter `na.last` by `range_sortna`, then, if the vector is unsorted, threeway quicksort is invoked.

**Usage**

```
quicksort3(x, na.last = NA)
```

**Arguments**

<code>x</code>	an integer vector
<code>na.last</code>	NA removes NAs, FALSE puts NAs at the beginning, TRUE puts NAs at the end

**Value**

a sorted vector

**Examples**

```
countsort(c(2L,0L,1L,NA,2L))  
countsort(c(2L,0L,1L,NA,2L), na.last=TRUE)  
countsort(c(2L,0L,1L,NA,2L), na.last=FALSE)
```

---

range_na	<i>Get range and number of NAs</i>
----------	------------------------------------

---

**Description**

Get range and number of NAs

**Usage**

```
range_na(x)
```

**Arguments**

<code>x</code>	an integer vector
----------------	-------------------

**Value**

an integer vector with three elements

- 1 min integer
- 2 max integer
- 3 number of NAs

**See Also**

[range\\_nanozero](#) and [range\\_sortna](#)

**Examples**

```
range_na(c(0L, 1L, 2L, NA))
```

---

range_nanozero	<i>Remove zeros and get range and number of NAs</i>
----------------	---

---

**Description**

Remove zeros and get range and number of NAs

**Usage**

```
range_nanozero(x)
```

**Arguments**

x                    an integer vector

**Value**

an integer vector without zeros and with an attribute [range\\_na](#) with three elements

- 1 min integer
- 2 max integer
- 3 number of NAs

**See Also**

[range\\_na](#) and [range\\_sortna](#)

**Examples**

```
range_nanozero(c(0L, 1L, 2L, NA))
```

---

range_sortna	<i>Prepare for sorting and get range, number of NAs and unsortedness</i>
--------------	--

---

### Description

In one pass over the vector NAs are treated according to parameter `na.last` exactly like [sort](#) does, the [range](#), number of NAs and unsortedness is determined.

### Usage

```
range_sortna(x, decreasing = FALSE, na.last = NA)
```

### Arguments

<code>x</code>	an integer vector
<code>decreasing</code>	(currently only FALSE is supported)
<code>na.last</code>	NA removes NAs, FALSE puts NAs at the beginning, TRUE puts NAs at the end

### Value

an integer vector with NAs are treated and an attribute [range\\_na](#) with four elements

- 1 min integer
- 2 max integer
- 3 number of NAs
- 3 0 for sorted vector and 1 for [is.unsorted](#)

### See Also

[range\\_na](#) and [range\\_nanozero](#)

### Examples

```
range_sortna(c(0L, 1L, NA, 2L))
range_sortna(c(2L, NA, 1L, 0L))
range_sortna(c(0L, 1L, NA, 2L), na.last=TRUE)
range_sortna(c(2L, NA, 1L, 0L), na.last=TRUE)
range_sortna(c(0L, 1L, NA, 2L), na.last=FALSE)
range_sortna(c(2L, NA, 1L, 0L), na.last=FALSE)
```

---

rep.booltype                      *Replicating bit and bitwhich vectors*

---

### Description

Creating new bit or bitwhich by recycling such vectors

### Usage

```
## S3 method for class 'bit'  
rep(x, times = 1L, length.out = NA, ...)
```

```
## S3 method for class 'bitwhich'  
rep(x, times = 1L, length.out = NA, ...)
```

### Arguments

x	bit or bitwhich object
times	number of replications
length.out	final length of replicated vector (dominates times)
...	not used

### Value

An object of class 'bit' or 'bitwhich'

### Author(s)

Jens Oehlschlägel

### See Also

[rep](#), [bit](#), [bitwhich](#)

### Examples

```
rep(as.bit(c(FALSE,TRUE)), 2)  
rep(as.bit(c(FALSE,TRUE)), length.out=7)  
rep(as.bitwhich(c(FALSE,TRUE)), 2)  
rep(as.bitwhich(c(FALSE,TRUE)), length.out=1)
```

---

repeat.time	<i>Adaptive timer</i>
-------------	-----------------------

---

### Description

Repeats timing expr until minSec is reached

### Usage

```
repeat.time(expr, gcFirst = TRUE, minSec = 0.5, envir = parent.frame())
```

### Arguments

expr	Valid expression to be timed.
gcFirst	Logical - should a garbage collection be performed immediately before the timing? Default is TRUE.
minSec	number of seconds to repeat at least
envir	the environment in which to evaluate expr (by default the calling frame)

### Value

A object of class "proc\_time": see [proc.time](#) for details.

### Author(s)

Jens Oehlschlägel <Jens.Oehlschlaegel@truecluster.com>

### See Also

[system.time](#)

### Examples

```
system.time(1+1)
repeat.time(1+1)
system.time(sort(runif(1e6)))
repeat.time(sort(runif(1e6)))
```

---

`repfromto`*Virtual recycling*

---

**Description**

`repfromto` virtually recycles object `x` and cuts out positions from `..` to

**Usage**

```
repfromto(x, from, to)
```

```
repfromto(x, from, to) <- value
```

**Arguments**

<code>x</code>	an object from which to recycle
<code>from</code>	first position to return
<code>to</code>	last position to return
<code>value</code>	value to assign

**Details**

`repfromto` is a generalization of [rep](#), where `rep(x, n) == repfromto(x, 1, n)`. You can see this as an R-side (vector) solution of the `mod_iterate` macro in `arithmetic.c`

**Value**

a vector of length `from - to + 1`

**Author(s)**

Jens Oehlschlägel

**See Also**

[rep](#), [ffvecapply](#)

**Examples**

```
message("a simple example")
repfromto(0:9, 11, 20)
```

---

rev.booltype	<i>Reversing bit and bitwhich vectors</i>
--------------	---

---

**Description**

Creating new bit or bitwhich by reversing such vectors

**Usage**

```
## S3 method for class 'bit'  
rev(x)  
  
## S3 method for class 'bitwhich'  
rev(x)
```

**Arguments**

x                    bit or bitwhich object

**Value**

An object of class 'bit' or 'bitwhich'

**Author(s)**

Jens Oehlschlägel

**See Also**

[rev](#), [bit](#), [bitwhich](#)

**Examples**

```
rev(as.bit(c(FALSE,TRUE)))  
rev(as.bitwhich(c(FALSE,TRUE)))
```

---

reverse_vector	<i>Reverse atomic vector</i>
----------------	------------------------------

---

**Description**

Returns a reversed copy – with attributes retained.

**Usage**

```
reverse_vector(x)
```

**Arguments**

x                    an R vector

**Details**

This is substantially faster than [rev](#)

**Value**

a reversed vector

**See Also**

[rev](#), [copy\\_vector](#)

**Examples**

```
x <- factor(letters)
rev(x)
reverse_vector(x)
## Not run:
x <- 1:1e7
system.time(rev(x))
system.time(reverse_vector(x))

## End(Not run)
```

---

 ri

*Range index*


---

**Description**

A range index can be used to extract or replace a continuous ascending part of the data

**Usage**

```
ri(from, to = NULL, maxindex = NA)

## S3 method for class 'ri'
print(x, ...)
```

**Arguments**

from                first position  
 to                  last position  
 maxindex          the maximal length of the object-to-be-subscripted (if known)  
 x                   an object of class 'ri'  
 ...                further arguments



**Value**

A two element integer vector with class 'ri'

**Author(s)**

Jens Oehlschlägel

**See Also**

[as.hi](#)

**Examples**

```
bit(12)[ri(1,6)]
```

---

rlepack

*Hybrid Index, rle-pack utilities*

---

**Description**

Basic utilities for rle packing and unpacking and appropriate methods for [rev](#) and [unique](#).

**Usage**

```
rlepack(x, ...)  
  
## S3 method for class 'integer'  
rlepack(x, pack = TRUE, ...)  
  
rleunpack(x)  
  
## S3 method for class 'rlepack'  
rleunpack(x)  
  
## S3 method for class 'rlepack'  
rev(x)  
  
## S3 method for class 'rlepack'  
unique(x, incomparables = FALSE, ...)  
  
## S3 method for class 'rlepack'  
anyDuplicated(x, incomparables = FALSE, ...)
```

**Arguments**

`x` in 'rlepack' an integer vector, in the other functions an object of class 'rlepack'  
`...` just to keep R CMD CHECK quiet (not used)  
`pack` FALSE to suppress packing  
`incomparables` just to keep R CMD CHECK quiet (not used)

**Value**

A list with components

`first` the first element of the packed sequence  
`dat` either an object of class `rle` or the complete input vector `x` if rle-packing is not efficient  
`last` the last element of the packed sequence

**Author(s)**

Jens Oehlschlägel

**See Also**

[hi](#), [intrle](#), [rle](#), [rev](#), [unique](#)

**Examples**

```
x <- rlepack(rep(0L, 10))
```

---

Sorting

*Generics for in-RAM sorting and ordering*

---

**Description**

These are generic stubs for low-level sorting and ordering methods implemented in packages 'bit64' and 'ff'. The `..sortorder` methods do sorting and ordering at once, which requires more RAM than ordering but is (almost) as fast as as sorting.

**Usage**

```
ramsort(x, ...)
```

```
ramorder(x, i, ...)
```

```
ramsortorder(x, i, ...)
```

```
mergesort(x, ...)  
mergeorder(x, i, ...)  
mergesortorder(x, i, ...)  
quicksort(x, ...)  
quickorder(x, i, ...)  
quicksortorder(x, i, ...)  
shellsort(x, ...)  
shellorder(x, i, ...)  
shellsortorder(x, i, ...)  
radixsort(x, ...)  
radixorder(x, i, ...)  
radixsortorder(x, i, ...)  
keysort(x, ...)  
keyorder(x, i, ...)  
keysortorder(x, i, ...)
```

### Arguments

x	a vector to be sorted by <a href="#">ramsort</a> and <a href="#">ramsortorder</a> , i.e. the output of <a href="#">sort</a>
...	further arguments to the sorting methods
i	integer positions to be modified by <a href="#">ramorder</a> and <a href="#">ramsortorder</a> , default is 1:n, in this case the output is similar to <a href="#">order</a>

### Details

The `sort` generics do sort their argument 'x', some methods need temporary RAM of the same size as 'x'. The `order` generics do order their argument 'i' leaving 'x' as it was, some methods need temporary RAM of the same size as 'i'. The `sortorder` generics do sort their argument 'x' and order their argument 'i', this way of ordering is much faster at the price of requiring temporary RAM for both, 'x' and 'i', if the method requires temporary RAM. The `ram` generics are high-level functions containing an optimizer that chooses the 'best' algorithms given some context.

### Value

These functions return the number of NAs found or assumed during sorting

**Index of implemented methods**

<b>generic</b>	<b>ff</b>	<b>bit64</b>
ramsort	ramsort.default	ramsort.integer64
shellsort	shellsort.default	shellsort.integer64
quicksort		quicksort.integer64
mergesort	mergesort.default	mergesort.integer64
radixsort	radixsort.default	radixsort.integer64
keysort	keysort.default	
<b>generic</b>	<b>ff</b>	<b>bit64</b>
ramorder	ramorder.default	ramorder.integer64
shellorder	shellorder.default	shellorder.integer64
quickorder		quickorder.integer64
mergeorder	mergeorder.default	mergeorder.integer64
radixorder	radixorder.default	radixorder.integer64
keyorder	keyorder.default	
<b>generic</b>	<b>ff</b>	<b>bit64</b>
ramsortorder		ramsortorder.integer64
shellsortorder		shellsortorder.integer64
quicksortorder		quicksortorder.integer64
mergesortorder		mergesortorder.integer64
radixsortorder		radixsortorder.integer64
keysortorder		

**Note**

Note that these methods purposely violate the functional programming paradigm: they are called for the side-effect of changing some of their arguments. The rationale behind this is that sorting is very RAM-intensive and in certain situations we might not want to allocate additional memory if not necessary to do so. The `sort`-methods change `x`, the `order`-methods change `i`, and the `sortorder`-methods change both `x` and `i`. You as the user are responsible to create copies of the input data `'x'` and `'i'` if you need non-modified versions.

**Author(s)**

Jens Oehlschlägel <Jens.Oehlschlaegel@truecluster.com>

**See Also**

[sort](#) and [order](#) in base R, [bitsort](#) for faster integer sorting

---

still.identical	<i>Test for C-level identity of two atomic vectors</i>
-----------------	--

---

**Description**

Test for C-level identity of two atomic vectors

**Usage**

```
still.identical(x, y)
```

**Arguments**

x	an atomic vector
y	an atomic vector

**Value**

logical scalar

**Examples**

```
x <- 1:2
y <- x
z <- copy_vector(x)
still.identical(y,x)
still.identical(z,x)
```

---

str.bit	<i>Str method for bit</i>
---------	---------------------------

---

**Description**

To actually view the internal structure use `str(unclass(bit))`

**Usage**

```
## S3 method for class 'bit'
str(
  object,
  vec.len = str0$vec.len,
  give.head = TRUE,
  give.length = give.head,
  ...
)
```

**Arguments**

object	any R object about which you want to have some information.
vec.len	numeric ( $\geq 0$ ) indicating how many ‘first few’ elements are displayed of each vector. The number is multiplied by different factors (from .5 to 3) depending on the kind of vector. Defaults to the <code>vec.len</code> component of option "str" (see <a href="#">options</a> ) which defaults to 4.
give.head	logical; if TRUE (default), give (possibly abbreviated) mode/class and length (as <code>type[1:...]</code> ).
give.length	logical; if TRUE (default), indicate length (as <code>[1:...]</code> ).
...	potential further arguments (required for Method/Generic reasons).

**Value**

[invisible](#)

**Examples**

```
str(bit(120))
```

---

str.bitwhich	<i>Str method for bitwhich</i>
--------------	--------------------------------

---

**Description**

To actually view the internal structure use `str(unclass(bitwhich))`

**Usage**

```
## S3 method for class 'bitwhich'
str(
  object,
  vec.len = str0$vec.len,
  give.head = TRUE,
  give.length = give.head,
  ...
)
```

**Arguments**

object	any R object about which you want to have some information.
vec.len	numeric ( $\geq 0$ ) indicating how many ‘first few’ elements are displayed of each vector. The number is multiplied by different factors (from .5 to 3) depending on the kind of vector. Defaults to the <code>vec.len</code> component of option "str" (see <a href="#">options</a> ) which defaults to 4.
give.head	logical; if TRUE (default), give (possibly abbreviated) mode/class and length (as <code>type[1:...]</code> ).

give.length      logical; if TRUE (default), indicate length (as [1:...]).  
 ...              potential further arguments (required for Method/Generic reasons).

**Value**

`invisible`

**Examples**

```
str(bitwhich(120))
```

---

 Summaries

*Summaries of boolean vectors*


---

**Description**

Fast aggregation functions for `booltype` vectors. namely `bit`, `all`, `any`, `anyNA`, `min`, `max`, `range`, `sum` and `summary`. Now all boolean summaries (except for `anyNA` because the generic does not allow it) have an optional range argument to restrict the range of evaluation. Note that the boolean summaries have meaning and return values differing from logical aggregation functions: they treat NA as FALSE, `min`, `max` and `range` give the minimum and maximum positions of TRUE, `summary` returns counts of FALSE, TRUE and the range. Note that you can force the boolean interpretation by calling the `booltype` method explicitly on any `booltypes` input, e.g. `min.booltype()`, see the examples.

**Usage**

```
## S3 method for class 'bit'
all(x, range = NULL, ...)

## S3 method for class 'bit'
any(x, range = NULL, ...)

## S3 method for class 'bit'
anyNA(x, recursive = FALSE)

## S3 method for class 'bit'
sum(x, range = NULL, ...)

## S3 method for class 'bit'
min(x, range = NULL, ...)

## S3 method for class 'bit'
max(x, range = NULL, ...)

## S3 method for class 'bit'
range(x, range = NULL, ...)
```

```
## S3 method for class 'bit'  
summary(object, range = NULL, ...)  
  
## S3 method for class 'bitwhich'  
all(x, range = NULL, ...)  
  
## S3 method for class 'bitwhich'  
any(x, range = NULL, ...)  
  
## S3 method for class 'bitwhich'  
anyNA(x, recursive = FALSE)  
  
## S3 method for class 'bitwhich'  
sum(x, range = NULL, ...)  
  
## S3 method for class 'bitwhich'  
min(x, range = NULL, ...)  
  
## S3 method for class 'bitwhich'  
max(x, range = NULL, ...)  
  
## S3 method for class 'bitwhich'  
range(x, range = NULL, ...)  
  
## S3 method for class 'bitwhich'  
summary(object, range = NULL, ...)  
  
## S3 method for class 'which'  
all(x, range = NULL, ...)  
  
## S3 method for class 'which'  
any(x, range = NULL, ...)  
  
## S3 method for class 'which'  
anyNA(x, recursive = FALSE)  
  
## S3 method for class 'which'  
sum(x, range = NULL, ...)  
  
## S3 method for class 'which'  
min(x, range = NULL, ...)  
  
## S3 method for class 'which'  
max(x, range = NULL, ...)  
  
## S3 method for class 'which'  
range(x, range = NULL, ...)
```



```
## S3 method for class 'which'  
summary(object, range = NULL, ...)  
  
## S3 method for class 'booltype'  
all(x, range = NULL, ...)  
  
## S3 method for class 'booltype'  
any(x, range = NULL, ...)  
  
## S3 method for class 'booltype'  
anyNA(x, ...)  
  
## S3 method for class 'booltype'  
sum(x, range = NULL, ...)  
  
## S3 method for class 'booltype'  
min(x, range = NULL, ...)  
  
## S3 method for class 'booltype'  
max(x, range = NULL, ...)  
  
## S3 method for class 'booltype'  
range(x, range = NULL, ...)  
  
## S3 method for class 'booltype'  
summary(object, range = NULL, ...)  
  
## S3 method for class 'ri'  
all(x, range = NULL, ...)  
  
## S3 method for class 'ri'  
any(x, range = NULL, ...)  
  
## S3 method for class 'ri'  
anyNA(x, recursive = FALSE)  
  
## S3 method for class 'ri'  
sum(x, ...)  
  
## S3 method for class 'ri'  
min(x, ...)  
  
## S3 method for class 'ri'  
max(x, ...)  
  
## S3 method for class 'ri'  
range(x, ...)
```

```
## S3 method for class 'ri'
summary(object, ...)
```

### Arguments

x	an object of class bit or bitwhich
range	a <a href="#">ri</a> or an integer vector of length==2 giving a range restriction for chunked processing
...	formally required but not used
recursive	formally required but not used
object	an object of class bit

### Details

Summaries of [bit](#) vectors are quite fast because we use a double loop that fixes each word in a processor register. Furthermore we break out of looping as soon as possible. Summaries of [bitwhich](#) vectors are even faster, if the selection is very skewed.

### Value

as expected

### Author(s)

Jens Oehlschlägel

### See Also

[length](#)

### Examples

```
l <- c(NA, FALSE, TRUE)
b <- as.bit(l)

all(l)
all(b)
all(b, range=c(3,3))
all.booltype(l, range=c(3,3))

min(l)
min(b)

sum(l)
sum(b)

summary(l)
summary(b)
summary.booltype(l)
```

---

symdiff	<i>Symmetric set complement</i>
---------	---------------------------------

---

**Description**

Symmetric set complement

**Usage**

```
symdiff(x, y)
```

**Arguments**

x	a vector
y	a vector

**Value**

```
union(setdiff(x,y), setdiff(y,x))
```

**Note**

that `symdiff(x,y)` is not [identical](#) as `symdiff(y,x)` without applying [sort](#) to the result

**See Also**

[merge\\_symdiff](#) and [xor](#)

**Examples**

```
symdiff(c(1L,2L,2L), c(2L,3L))  
symdiff(c(2L,3L), c(1L,2L,2L))
```

---

unattr	<i>Attribute removal</i>
--------	--------------------------

---

**Description**

Returns object with attributes removed

**Usage**

```
unattr(x)
```

**Arguments**

x	any R object
---	--------------

**Details**

attribute removal copies the object as usual

**Value**

a similar object with attributes removed

**Author(s)**

Jens Oehlschlägel

**See Also**

[attributes](#), [setattrributes](#), [unclass](#)

**Examples**

```
bit(2)[]  
unattr(bit(2)[])
```

---

vecseq

*Vectorized Sequences*

---

**Description**

vecseq returns concatenated multiple sequences

**Usage**

```
vecseq(x, y = NULL, concat = TRUE, eval = TRUE)
```

**Arguments**

x	vector of sequence start points
y	vector of sequence end points (if <code>is.null(y)</code> then x are taken as endpoints, all starting at 1)
concat	vector of sequence end points (if <code>is.null(y)</code> then x are taken as endpoints, all starting at 1)
eval	vector of sequence end points (if <code>is.null(y)</code> then x are taken as endpoints, all starting at 1)

**Details**

This is a generalization of [sequence](#) in that you can choose sequence starts other than 1 and also have options to no concat and/or return a call instead of the evaluated sequence.

**Value**

if `concat==FALSE` and `eval==FALSE` a list with `n` calls that generate sequences  
 if `concat==FALSE` and `eval==TRUE` a list with `n` sequences  
 if `concat==TRUE` and `eval==FALSE` a single call generating the concatenated sequences  
 if `concat==TRUE` and `eval==TRUE` an integer vector of concatenated sequences

**Author(s)**

Angelo Canty, Jens Oehlschlägel

**See Also**

[:](#), [seq](#), [sequence](#)

**Examples**

```
sequence(c(3,4))
vecseq(c(3,4))
vecseq(c(1,11), c(5, 15))
vecseq(c(1,11), c(5, 15), concat=FALSE, eval=FALSE)
vecseq(c(1,11), c(5, 15), concat=FALSE, eval=TRUE)
vecseq(c(1,11), c(5, 15), concat=TRUE, eval=FALSE)
vecseq(c(1,11), c(5, 15), concat=TRUE, eval=TRUE)
```

---

xor.default

*Boolean operators and functions*

---

**Description**

Boolean NEGATION '!', AND '&', OR '|' and EXCLUSIVE OR xor', see [Logic](#).

**Usage**

```
## Default S3 method:
xor(x, y)

## S3 method for class 'logical'
xor(x, y)

## S3 method for class 'bit'
!x

## S3 method for class 'bit'
e1 & e2

## S3 method for class 'bit'
e1 | e2
```

```
## S3 method for class 'bit'  
e1 == e2  
  
## S3 method for class 'bit'  
e1 != e2  
  
## S3 method for class 'bit'  
xor(x, y)  
  
## S3 method for class 'bitwhich'  
!x  
  
## S3 method for class 'bitwhich'  
e1 & e2  
  
## S3 method for class 'bitwhich'  
e1 | e2  
  
## S3 method for class 'bitwhich'  
e1 == e2  
  
## S3 method for class 'bitwhich'  
e1 != e2  
  
## S3 method for class 'bitwhich'  
xor(x, y)  
  
## S3 method for class 'booltype'  
e1 & e2  
  
## S3 method for class 'booltype'  
e1 | e2  
  
## S3 method for class 'booltype'  
e1 == e2  
  
## S3 method for class 'booltype'  
e1 != e2  
  
## S3 method for class 'booltype'  
xor(x, y)  
  
xor(x, y)
```

### Arguments

x                    a `is.booltype` vector

y	a <code>is.booltype</code> vector
e1	a <code>is.booltype</code> vector
e2	a <code>is.booltype</code> vector

### Details

The binary operators and function `xor` can now combine any `is.booltype` vectors. They now recycle if vectors have different length. If the two arguments have different `booltypes` the return value corresponds to the lower `booltype` of the two.

Boolean operations on `bit` vectors are extremely fast because they are implemented using C's bitwise operators. Boolean operations on or `bitwhich` vectors are even faster, if they represent very skewed selections.

The `xor` function has been made generic and `xor.default` has been implemented much faster than R's standard `xor`. This was possible because actually boolean function `xor` and comparison operator `!=` do the same (even with NAs), and `!=` is much faster than the multiple calls in  $(x | y) \& !(x \& y)$

### Value

An object of class `booltype` or `logical`

### Methods (by class)

- `xor(default)`: default method for `xor`
- `xor(logical)`: `logical` method for `xor`
- `xor(bit)`: `bit` method for `xor`
- `xor(bitwhich)`: `bitwhich` method for `xor`
- `xor(booltype)`: `booltype` method for `xor`

### Functions

- ``!` (bit)`: `bit` method for `!`
- `&`: `bit` method for `&`
- `|`: `bit` method for `|`
- `==`: `bit` method for `==`
- `!=`: `bit` method for `!=`
- ``!` (bitwhich)`: `bitwhich` method for `!`
- `&`: `bitwhich` method for `&`
- `|`: `bitwhich` method for `|`
- `==`: `bitwhich` method for `==`
- `!=`: `bitwhich` method for `!=`
- `&`: `booltype` method for `&`
- `|`: `booltype` method for `|`
- `==`: `booltype` method for `==`
- `!=`: `booltype` method for `!=`

**Author(s)**

Jens Oehlschlägel

**See Also**

[booltypes](#), [Logic](#)

**Examples**

```
x <- c(FALSE, FALSE, FALSE, NA, NA, NA, TRUE, TRUE, TRUE)
y <- c(FALSE, NA, TRUE, FALSE, NA, TRUE, FALSE, NA, TRUE)

x|y
x|as.bit(y)
x|as.bitwhich(y)
x|as.which(y)
x|ri(1,1,9)
```



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