

# Package 'bit'

February 14, 2012

**Type** Package

**Title** A class for vectors of 1-bit booleans

**Version** 1.1-8

**Date** 2010-09-13

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**Depends** R (>= 2.9.2)

**Description** bitmapped vectors of booleans (no NAs), coercion from and to logicals, integers and integer subscripts; fast boolean operators and fast summary statistics. With 'bit' vectors you can store true binary booleans {FALSE,TRUE} at the expense of 1 bit only, on a 32 bit architecture this means factor 32 less RAM and ~ factor 32 more speed on boolean operations. Due to overhead of R calls, actual speed gain depends on the size of the vector: expect gains for vectors of size > 10000 elements. Even for one-time boolean operations it can pay-off to convert to bit, the pay-off is obvious, when such components are used more than once. Reading from and writing to bit is approximately as fast as accessing standard logicals - mostly due to R's time for memory allocation. The package allows to work with pre-allocated memory for return values by calling .Call() directly: when evaluating the speed of C-access with pre-allocated vector memory, coping from bit to logical requires only 70% of the time for copying from logical to logical; and copying from logical to bit comes at a performance penalty of 150%. the package now contains further classes for representing logical selections: 'bitwhich' for very skewed selections and 'ri' for selecting ranges of values for chunked processing. All three index classes can be used for subsetting 'ff' objects (ff-2.1-0 and higher).

**License** GPL-2

**LazyLoad** yes

**ByteCompile** yes

**URL** <http://ff.r-forge.r-project.org/>

**Encoding** latin1

**Repository** CRAN

**Repository/R-Forge/Project** ff

**Repository/R-Forge/Revision** 85

**Date/Publication** 2012-01-15 17:01:08

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## Description

Package 'bit' provides bitmapped vectors of booleans (no NAs), coercion from and to logicals, integers and integer subscripts; fast boolean operators and fast summary statistics.

With bit vectors you can store true binary booleans {FALSE,TRUE} at the expense of 1 bit only, on a 32 bit architecture this means factor 32 less RAM and factor 32 more speed on boolean operations. With this speed gain it even pays-off to convert to bit in order to avoid a single boolean operation on logicals or a single set operation on (longer) integer subscripts, the pay-off is dramatic when such components are used more than once.

Reading from and writing to bit is approximately as fast as accessing standard logicals - mostly due to R's time for memory allocation. The package allows to work with pre-allocated memory for return values by calling `.Call()` directly: when evaluating the speed of C-access with pre-allocated vector memory, coping from bit to logical requires only 70% of the time for copying from logical to logical; and copying from logical to bit comes at a performance penalty of 150%.

Since bit objects cannot be used as subscripts in R, a second class 'bitwhich' allows to store selections as efficiently as possible with standard R types. This is usefull either to represent parts of bit objects or to represent very asymmetric selections.

Class 'ri' (range index) allows to select ranges of positions for chunked processing: all three classes 'bit', 'bitwhich' and 'ri' can be used for subsetting 'ff' objects (ff-2.1.0 and higher).

## Usage

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

## Arguments

length	length of vector in bits
x	a bit vector
...	further arguments to print

## Details

Package:	bit
Type:	Package
Version:	1.1.0
Date:	2009-07-07

License: GPL-2  
 LazyLoad: yes  
 Encoding: latin1

## Index:

bit function	bitwhich function	ri function	see also	description
.BITS			globalenv	variable holding number of bits on
bit_init			.First.lib	initially allocate bit-masks (done in
bit_done			.Last.lib	finally de-allocate bit-masks (done in
bit	bitwhich	ri	logical	create bit object
print.bit	print.bitwhich	print.ri	print	print bit vector
length.bit	length.bitwhich	length.ri	length	get length of bit vector
length<-.bit	length<-.bitwhich		length<-	change length of bit vector
c.bit	c.bitwhich		c	concatenate bit vectors
is.bit	is.bitwhich	is.ri	is.logical	test for bit class
as.bit	as.bitwhich		as.logical	generically coerce to bit or bitwhich
as.bit.logical	as.bitwhich.logical		logical	coerce logical to bit vector (FALSE to 0)
as.bit.integer	as.bitwhich.integer		integer	coerce integer to bit vector (0 => FALSE)
as.bit.double	as.bitwhich.double		double	coerce double to bit vector (0 => FALSE)
as.double.bit	as.double.bitwhich	as.double.ri	as.double	coerce bit vector to double (0/1)
as.integer.bit	as.integer.bitwhich	as.integer.ri	as.integer	coerce bit vector to integer (0L/1L)
as.logical.bit	as.logical.bitwhich	as.logical.ri	as.logical	coerce bit vector to logical (FALSE/TRUE)
as.which.bit	as.which.bitwhich	as.which.ri	as.which	coerce bit vector to positive integer
as.bit.which	as.bitwhich.which		bitwhich	coerce integer subscripts to bit vector
as.bit.bitwhich	as.bitwhich.bitwhich		UseMethod	coerce from bitwhich
as.bit.bit	as.bitwhich.bit			coerce from bit
as.bit.ri	as.bitwhich.ri			coerce from range index
as.bit.ff			ff	coerce ff boolean to bit vector
as.ff.bit			as.ff	coerce bit vector to ff boolean
as.hi.bit	as.hi.bitwhich	as.hi.ri	as.hi	coerce to hybrid index (requires package)
as.bit.hi	as.bitwhich.hi			coerce from hybrid index (requires package)
[[.bit			[[	get single bit (index checked)
[[<-.bit			[[<-	set single bit (index checked)
[.bit			[	get vector of bits (unchecked)
[<-.bit			[<-	set vector of bits (unchecked)
!.bit	!.bitwhich	(works as second arg in bit and bitwhich ops)	!	boolean NOT on bit
&.bit	&.bitwhich		&	boolean AND on bit
.bit	.bitwhich			boolean OR on bit
xor.bit	xor.bitwhich		xor	boolean XOR on bit
!=.bit	!=.bitwhich		!=	boolean inequality (same as XOR)
==.bit	==.bitwhich		==	boolean equality
all.bit	all.bitwhich	all.ri	all	aggregate AND
any.bit	any.bitwhich	any.ri	any	aggregate OR
min.bit	min.bitwhich	min.ri	min	aggregate MIN (first TRUE position)
max.bit	max.bitwhich	max.ri	max	aggregate MAX (last TRUE position)
range.bit	range.bitwhich	range.ri	range	aggregate [MIN,MAX]

<a href="#">sum.bit</a>	<a href="#">sum.bitwhich</a>	<a href="#">sum.ri</a>	<a href="#">sum</a>	aggregate SUM (count of TRUE)
<a href="#">summary.bit</a>	<a href="#">summary.bitwhich</a>	<a href="#">summary.ri</a>	<a href="#">tabulate</a>	aggregate c(nFALSE, nTRUE, min)
<a href="#">regtest.bit</a>				regressiontests for the package

**Value**

`bit` returns a vector of integer sufficiently long to store 'length' bits (but not longer) with an attribute 'n' and class 'bit'

**Note**

Currently operations on bit objects have some overhead from R-calls. Do expect speed gains for vectors of length ~ 10000 or longer.

Since this package was created for high performance purposes, only positive integer subscripts are allowed: The `'[.bit'` and `'[<-.bit'` methods don't check whether the subscripts are positive integers in the allowed range. All R-functions behave as expected - i.e. they do not change their arguments and create new return values. If you want to save the time for return value memory allocation, you must use `.Call` directly (see the dontrun example in [sum.bit](#)). Note that the package has not been tested under 64 bit. Note also that the mapping of NAs to TRUE differs from the mapping of NAs to FALSE in `vmode="boolean"` in package `ff` (and one of the two may change in the future).

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**See Also**

[logical](#) in base R and [vmode](#) in package 'ff'

**Examples**

```
x <- bit(12)
x
length(x) <- 16
length(x)
x[[2]]
x[[2]] <- TRUE
x[1:2]
x[1:2] <- TRUE
as.which(x)
x <- as.bit.which(3:4, 4)
as.logical(x)
y <- as.bit(c(FALSE, TRUE, FALSE, TRUE))
is.bit(y)
!x
x & y
x | y
xor(x, y)
# create bit vector
# autoprint bit vector
# change length
# get length
# extract single element
# replace single element
# extract parts of bit vector
# replace parts of bit vector
# coerce bit to subscripts
# coerce subscripts to bit
# coerce bit to logical
# coerce logical to bit
# test for bit
# boolean NOT
# boolean AND
# boolean OR
# boolean Exclusive OR
```

```

x != y          # boolean inequality (same as xor)
x == y          # boolean equality
all(x)          # aggregate AND
any(x)          # aggregate OR
min(x)          # aggregate MIN (integer version of ALL)
max(x)          # aggregate MAX (integer version of ANY)
range(x)        # aggregate [MIN,MAX]
sum(x)          # aggregate SUM (count of TRUE)
summary(x)      # aggregate count of FALSE and TRUE

## Not run:
message("\nEven for a single boolean operation transforming logical to bit pays off")
n <- 10000000
x <- sample(c(FALSE, TRUE), n, TRUE)
y <- sample(c(FALSE, TRUE), n, TRUE)
system.time(x|y)
system.time({
  x <- as.bit(x)
  y <- as.bit(y)
})
system.time( z <- x | y )
system.time( as.logical(z) )
message("Even more so if multiple operations are needed :-)")

message("\nEven for a single set operation transforming subscripts to bit pays off\n")
n <- 10000000
x <- sample(n, n/2)
y <- sample(n, n/2)
system.time( union(x,y) )
system.time({
  x <- as.bit.which(x, n)
  y <- as.bit.which(y, n)
})
system.time( as.which.bit( x | y ) )
message("Even more so if multiple operations are needed :-)")

message("\nSome timings WITH memory allocation")
n <- 2000000
l <- sample(c(FALSE, TRUE), n, TRUE)
# copy logical to logical
system.time(for(i in 1:100){ # 0.0112
  l2 <- l
  l2[1] <- TRUE # force new memory allocation (copy on modify)
  rm(l2)
})/100
# copy logical to bit
system.time(for(i in 1:100){ # 0.0123
  b <- as.bit(l)
  rm(b)
})/100
# copy bit to logical
b <- as.bit(l)
system.time(for(i in 1:100){ # 0.009

```

```

    l2 <- as.logical(b)
    rm(l2)
  }}/100
# copy bit to bit
b <- as.bit(1)
system.time(for(i in 1:100){ # 0.009
  b2 <- b
  b2[1] <- TRUE # force new memory allocation (copy on modify)
  rm(b2)
})/100

```

```

l2 <- 1
# replace logical by TRUE
system.time(for(i in 1:100){
  l[] <- TRUE
})/100
# replace bit by TRUE (NOTE that we recycle the assignment value on R side == memory allocation and assignment fir
system.time(for(i in 1:100){
  b[] <- TRUE
})/100
# THUS the following is faster
system.time(for(i in 1:100){
  b <- !bit(n)
})/100

```

```

# replace logical by logical
system.time(for(i in 1:100){
  l[] <- l2
})/100
# replace bit by logical
system.time(for(i in 1:100){
  b[] <- l2
})/100
# extract logical
system.time(for(i in 1:100){
  l2[]
})/100
# extract bit
system.time(for(i in 1:100){
  b[]
})/100

```

```

message("\nSome timings WITHOUT memory allocation (Serge, that's for you)")
n <- 2000000L
l <- sample(c(FALSE, TRUE), n, TRUE)
b <- as.bit(1)
# read from logical, write to logical
l2 <- logical(n)
system.time(for(i in 1:100).Call("R_filter_getset", l, l2, PACKAGE="bit")) / 100
# read from bit, write to logical
l2 <- logical(n)
system.time(for(i in 1:100).Call("R_bit_get", b, l2, c(1L, n), PACKAGE="bit")) / 100

```

```
# read from logical, write to bit
system.time(for(i in 1:100).Call("R_bit_set", b, l2, c(1L, n), PACKAGE="bit")) / 100

## End(Not run)
```

---

as.bit

*Coercing to bit*


---

## Description

Coercing to bit vector

## Usage

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

## 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>
length	the length of the new bit vector
...	further arguments

## 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'

## 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**[bit](#), [as.logical](#)**Examples**

```
x <- as.bit(c(FALSE, NA, TRUE))
as.bit(x)
as.bit.which(c(1,3,4), 12)
```

as.bitwhich

*Coercing to bitwhich***Description**

Functions to coerce to bitwhich

**Usage**

```
as.bitwhich(x, ...)
## S3 method for class 'bitwhich'
as.bitwhich(x, ...)
## S3 method for class 'ri'
as.bitwhich(x, ...)
## S3 method for class 'bit'
as.bitwhich(x, range=NULL, ...)
## S3 method for class 'which'
as.bitwhich(x, maxindex, ...)
## S3 method for class 'integer'
as.bitwhich(x, ...)
## S3 method for class 'double'
as.bitwhich(x, ...)
## S3 method for class 'logical'
as.bitwhich(x, ...)
```

**Arguments**

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

**Value**

a value of class `bitwhich`

**Author(s)**

Jens Oehlschlägel

**See Also**

`bitwhich`, `as.bit`

**Examples**

```
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.logical.bit

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

---

**Description**

Coercing from bit to logical, integer, which.

**Usage**

```
## S3 method for class 'bit'
as.logical(x, ...)
## S3 method for class 'bitwhich'
as.logical(x, ...)
## S3 method for class 'ri'
as.logical(x, ...)
## S3 method for class 'bit'
as.integer(x, ...)
## S3 method for class 'bitwhich'
as.integer(x, ...)
## S3 method for class 'ri'
as.integer(x, ...)
## S3 method for class 'bit'
as.double(x, ...)
## S3 method for class 'bitwhich'
as.double(x, ...)
## S3 method for class 'ri'
as.double(x, ...)
```

**Arguments**

x                    an object of class `bit`, `bitwhich` or `ri`  
 ...                  ignored

**Details**

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

**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**

`as.bit`, `as.which`, `as.bitwhich`, `as.ff`, `as.hi`

**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))))
```

---

as.which

*Coercion to (positive) integer positions*


---

**Description**

Coercing to something like the result of which `which`

**Usage**

```

as.which(x, ...)
## Default S3 method:
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, ...)

```

**Arguments**

x	an object of classes <code>bit</code> , <code>bitwhich</code> , <code>ri</code> or something on which <code>which</code> works
range	a <code>ri</code> or an integer vector of length==2 giving a range restriction for chunked processing
...	further arguments (passed to <code>which</code> for the default method, ignored otherwise)

**Details**

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

**Value**

a vector of class 'logical' or 'integer'

**Author(s)**

Jens Oehlschlägel

**See Also**

[as.bit](#), [as.logical](#), [as.integer](#), [as.which](#), [as.bitwhich](#), [as.ff](#), [as.hi](#)

**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 so that they have rather balanced sizes than very different sizes

**Usage**

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

**Arguments**

N	total size
B	desired batch size

**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)
```

bitwhich

*A class for vectors representing asymmetric selections*

---

**Description**

A bitwhich object like the result of [which](#) and [as.which](#) does represent integer subscript positions, but bitwhich objects represent some subscripts rather with negative integers, if this needs less space. The extreme cases of selecting all/none subscripts are represented by TRUE/FALSE. This needs less RAM compared to [logical](#) (and often less than [as.which](#)). Logical operations are fast if the selection is asymmetric (only few or almost all selected).

**Usage**

```
bitwhich(maxindex, poslength = NULL, x = NULL)
```

**Arguments**

maxindex	the length of the vector (sum of all TRUEs and FALSEs)
poslength	Only use if x is not NULL: the sum of all TRUEs
x	Default NULL or FALSE or unique negative integers or unique positive integers or TRUE

**Details**

class 'bitwhich' represents a boolean selection in one of the following ways

- FALSE to select nothing
- TRUE to select everything
- unique positive integers to select those
- unique negative integers to exclude those

**Value**

An object of class 'bitwhich' carrying two attributes

maxindex	see above
poslength	see above

**Author(s)**

Jens Oehlschlägel

**See Also**

[as.bitwhich](#), [as.which](#), [bit](#)

**Examples**

```
bitwhich(12, x=c(1,3), poslength=2)
bitwhich(12, x=-c(1,3), poslength=10)
```

---

`bit_init`*Initializing bit masks*

---

**Description**

Functions to allocate (and de-allocate) bit masks

**Usage**

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

**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.

**Value**

NULL

**Author(s)**

Jens Oehlschlägel

**See Also**

[bit](#)

**Examples**

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

---

 c.bit

*Concatenating bit and bitwhich vectors*


---

**Description**

Creating new bit by concatenating bit vectors

**Usage**

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

**Arguments**

... bit objects

**Value**

An object of class 'bit'

**Author(s)**

Jens Oehlschlägel

**See Also**

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

**Examples**

```
c(bit(4), bit(4))
```

---

chunk

*Chunked range index*


---

**Description**

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

**Usage**

```
chunk(...)
## Default S3 method:
chunk(from = NULL, to = NULL, by = NULL, length.out = NULL, along.with = NULL, overlap = 0L, method = c("b
```

**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>
...	ignored

**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**

chunk.default returns a list of [ri](#) objects representing chunks of subscripts

**available methods**

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

**Author(s)**

Jens Oehlschlägel

**See Also**

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

**Examples**

```
chunk(1, 100, by=30)
chunk(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 3
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 chunk(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 w
  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 chunk(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 chunk(1, n, by=m)){z <- z + sum(as.double(ch[1]:ch[2]))})); z

## End(Not run)

```

---

 Extract

---

*Extract or replace part of an bit vector*


---

## Description

Operators acting on bit 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

```

## Arguments

x	a bit object
i	positive integer subscript
value	new logical or integer values

## Details

Since this package was created for high performance purposes, only positive integer subscripts make sense. Negative subscripts are converted to positive ones, beware the RAM consumption. Further subscript classes allowed for '[' and '[<-' are range indices [ri](#) and [bitwhich](#). The '[' and '[<-' methods don't check whether the subscripts are positive integers in the allowed range.

## Value

The extractors [[ and [ return a logical scalar or vector. The replacment functions return a bit object.

**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
```

---

**intrle***Hybrid Index, C-coded utilities*

---

**Description**

These C-coded utilities speed up index preprocessing considerably

**Usage**

```
intrle(x)
intisasc(x)
intisdesc(x)
```

**Arguments**

x                    an integer vector

**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 and returns NA if x contains NAs.

`intisdesc` checks for being sorted descending and assumes that the input x contains no NAs (is used after `intisasc` and does not check for NAs).

**Value**

`intrle` returns an object of class `rle` or `NULL`, if rle-compression is not efficient (compression factor  $< 3$  or  $\text{length}(x) < 3$ ).

`intisasc` returns one of `FALSE`, `NA`, `TRUE`

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

**Author(s)**

Jens Oehlschlägel

**See Also**

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

**Examples**

```
intrle(sample(1:100))
intrle(diff(1:100))
intisasc(1:100)
intisasc(100:1)
intisasc(c(NA, 1:100))
intisdesc(1:100)
intisdesc(100:1)
```

---

is.bit

*Testing for bit, bitwhich and ri selection classes*

---

**Description**

Test whether an object inherits from `'ri'`, `'bit'` or `'bitwhich'`

**Usage**

```
is.ri(x)
is.bit(x)
is.bitwhich(x)
```

**Arguments**

`x` an R object of unknown type

**Value**

`TRUE` or `FALSE`

**Author(s)**

Jens Oehlschlägel

**See Also**

[is.logical](#), [bit](#), [bitwhich](#)

**Examples**

```
is.ri(TRUE)
is.ri(ri(1,4,12))
is.bit(TRUE)
is.bitwhich(TRUE)
is.bit(as.bit(TRUE))
is.bitwhich(as.bitwhich(TRUE))
```

---

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

**Arguments**

x                    a [bit](#), [bitwhich](#) or [ri](#) 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:

- TRUEall 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**

Boolean 'negation', 'and', 'or' and 'exclusive or'.

**Usage**

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

**Arguments**

x	a bit vector (or one logical vector in binary operators)
y	a bit vector or an logical vector
e1	a bit vector or an logical vector
e2	a bit vector or an logical vector

**Details**

Binary operators and function `xor` can combine 'bit' objects and 'logical' vectors. They do not recycle, thus the lengths of objects must match. Boolean operations on bit vectors are extremely fast because they are implemented using C's bitwise operators. If one argument is 'logical' it is converted to 'bit'.

Binary operators and function `xor` can combine 'bitwhich' objects and other vectors. They do not recycle, thus the lengths of objects must match. Boolean operations on bitwhich vectors are fast if the distribution of TRUE and FALSE is very asymmetric. If one argument is not 'bitwhich' it is converted to 'bitwhich'.

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 'bit' (or 'bitwhich')

**Author(s)**

Jens Oehlschlägel

**See Also**

[bit](#), [Logic](#)

**Examples**

```
x <- as.bit(c(FALSE, FALSE, FALSE, NA, NA, NA, TRUE, TRUE, TRUE))
y1 <- c(FALSE, NA, TRUE, FALSE, NA, TRUE, FALSE, NA, TRUE)
y <- as.bit(y1)
!x
x & y
x | y
xor(x, y)
x != y
x == y
x & y1
x | y1
xor(x, y1)
x != y1
x == y1

x <- as.bitwhich(c(FALSE, FALSE, FALSE, NA, NA, NA, TRUE, TRUE, TRUE))
y1 <- c(FALSE, NA, TRUE, FALSE, NA, TRUE, FALSE, NA, TRUE)
y <- as.bitwhich(y1)
!x
x & y
```

```
x | y
xor(x, y)
x != y
x == y
x & y1
x | y1
xor(x, y1)
x != y1
x == y1
```

---

physical

*Physical and virtual attributes*

---

## Description

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

## Usage

```
physical(x)
virtual(x)
physical(x) <- value
virtual(x) <- value
## Default S3 method:
physical(x)
## Default S3 method:
virtual(x)
## Default S3 replacement method:
physical(x) <- value
## Default S3 replacement method:
virtual(x) <- value
## S3 method for class 'physical'
print(x, ...)
## S3 method for class 'virtual'
print(x, ...)
```

## 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))
```

---

regtest.bit

*Regressiontests for bit*

---

**Description**

Test package bit for correctness

**Usage**

```
regtest.bit(N = 100)
```

**Arguments**

N                    number of random test runs

**Details**

random data of random length are generated and correctness of package functions tested on these

**Value**

a vector of class 'logical' or 'integer'

**Author(s)**

Jens Oehlschlägel

**See Also**

[bit](#), [as.bit](#), [as.logical](#), [as.integer](#), [which](#)

**Examples**

```
if (regtest.bit()){
  message("regtest.bit is OK")
}else{
  message("regtest.bit failed")
}

## Not run:
regtest.bit(10000)

## End(Not run)
```

---

repsfromto

*Virtual recycling*

---

**Description**

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

**Usage**

```
repsfromto(x, from, to)
repsfromto(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**

repsfromto is a generalization of [rep](#), where `rep(x, n) == repsfromto(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)
```

---

ri	<i>Range index</i>
----	--------------------

---

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

**Value**

A two element integer vector with class 'ri'

**Author(s)**

Jens Oehlschlägel

**See Also**

[as.hi.ri](#)

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

### Arguments

x	an integer vector
pack	FALSE to suppress packing
incomparables	just to keep R CMD CHECK quiet (not used)
...	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 <a href="#">rle</a> or the complete input vector x if rle-packing is not efficient
last	the last element of the packed sequence

### Note

Only for sorted input `unique.rlepack(rlepack(x))` will be the same as `rlepack(unique(x))`, furthermore `rlepack(unique(x))` is faster. Therefore we only use `unique.rlepack` only where we have rlepack format from [hi](#)

### Author(s)

Jens Oehlschlägel

### See Also

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

**Examples**

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

---

setattributes	<i>Attribute setting by reference</i>
---------------	---------------------------------------

---

**Description**

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

**Usage**

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

**Arguments**

<code>x</code>	
<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.

**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 beause 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=n))
  }

mysimplefactor <- function(n){
  ret <- rep(1:2, length=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)

```

---

 Summary

*Summaries of bit vectors*


---

## Description

Fast aggregation functions for bit vectors.

## Usage

```

## S3 method for class 'bit'
all(x, range = NULL, ...)
## S3 method for class 'bit'
any(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'
sum(x, range = NULL, ...)
## S3 method for class 'bit'
summary(object, range = NULL, ...)
## S3 method for class 'bitwhich'
all(x, ...)
## S3 method for class 'bitwhich'
any(x, ...)
## S3 method for class 'bitwhich'
min(x, ...)
## S3 method for class 'bitwhich'
max(x, ...)
## S3 method for class 'bitwhich'
range(x, ...)
## S3 method for class 'bitwhich'
sum(x, ...)
## S3 method for class 'bitwhich'
summary(object, ...)
## S3 method for class 'ri'
all(x, ...)
## S3 method for class 'ri'
any(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'
sum(x, ...)
## S3 method for class 'ri'
summary(object, ...)

```

### Arguments

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

### Details

Bit summaries 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.

**Value**

as expected

**Author(s)**

Jens Oehlschlägel

**See Also**

[bit](#), [all](#), [any](#), [min](#), [max](#), [range](#), [sum](#), [summary](#)

**Examples**

```
x <- as.bit(c(TRUE, TRUE))
all(x)
any(x)
min(x)
max(x)
range(x)
sum(x)
summary(x)
```

```
x <- as.bitwhich(c(TRUE, TRUE))
all(x)
any(x)
min(x)
max(x)
range(x)
sum(x)
summary(x)
```

```
## Not run:
```

```
n <- .Machine$integer.max
x <- !bit(n)
N <- 1000000L # batchsize
B <- n %% N # number of batches
R <- n %% N # rest
```

```
message("Batched sum (52.5 sec on Centrino duo)")
system.time({
  s <- 0L
  for (b in 1:B){
    s <- s + sum(x[((b-1L)*N+1L):(b*N)])
  }
  if (R)
    s <- s + sum(x[(n-R+1L):n])
})
```

```
message("Batched sum saving repeated memory allocation for the return vector (44.4 sec on Centrino duo)")
system.time({
  s <- 0L
  l <- logical(N)
```

```
for (b in 1:B){
  .Call("R_bit_extract", x, ((b-1L)*N+1L):(b*N), 1, PACKAGE = "bit")
  s <- s + sum(l)
}
if (R)
  s <- s + sum(x[(n-R+1L):n])
})

message("C-coded sum (3.1 sec on Centrino duo)")
system.time(sum(x))

## End(Not run)
```

---

unattr

*Attribute removal*

---

### 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](#), [setattributes](#), [unclass](#)

### Examples

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

---

vecseq	<i>Vectorized Sequences</i>
--------	-----------------------------

---

**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)
```

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