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            and size-recycling, and are in turn connected to ideas of type- and
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data_frame Construct a data frame

Description
data_frame() constructs a data frame. It is similar to base::data.frame(), but there are a few notable differences that make it more in line with vctrs principles. The Properties section outlines these.
data_frame

Usage
data_frame(  
  ...,  
  .size = NULL,  
  .name_repair = c("check_unique", "unique", "universal", "minimal")  
)

Arguments
  ...
  Vectors to become columns in the data frame. When inputs are named, those names are used for column names.
  .size
  The number of rows in the data frame. If NULL, this will be computed as the common size of the inputs.
  .name_repair
  One of "check_unique", "unique", "universal" or "minimal". See vec_as_names() for the meaning of these options.

Details
If no column names are supplied, "" will be used as a default for all columns. This is applied before name repair occurs, so the default name repair of "check_unique" will error if any unnamed inputs are supplied and "unique" will repair the empty string column names appropriately. If the column names don’t matter, use a "minimal" name repair for convenience and performance.

Properties
  • Inputs are recycled to a common size with vec_recycle_common().
  • With the exception of data frames, inputs are not modified in any way. Character vectors are never converted to factors, and lists are stored as-is for easy creation of list-columns.
  • Unnamed data frame inputs are automatically spliced. Named data frame inputs are stored unmodified as data frame columns.
  • NULL inputs are completely ignored.
  • The dots are dynamic, allowing for splicing of lists with !!! and unquoting.

See Also
df_list() for safely creating a data frame’s underlying data structure from individual columns. new_data_frame() for constructing the actual data frame from that underlying data structure. Together, these can be useful for developers when creating new data frame subclasses supporting standard evaluation.

Examples
data_frame(x = 1, y = 2)

  # Inputs are recycled using tidyverse recycling rules
data_frame(x = 1, y = 1:3)

  # Strings are never converted to factors
class(data_frame(x = "foo")$x)

  # List columns can be easily created
df <- data_frame(x = list(1:2, 2, 3:4), y = 3:1)
df_list

df_list() constructs the data structure underlying a data frame, a named list of equal-length vectors. It is often used in combination with `new_data_frame()` to safely and consistently create a helper function for data frame subclasses.

**Usage**

```r
df_list(
  ..., 
  .size = NULL, 
  .name_repair = c("check_unique", "unique", "universal", "minimal")
)
```

**Arguments**

- `...` Vectors of equal-length. When inputs are named, those names are used for names of the resulting list.
- `.size` The common size of vectors supplied in `.size`. If NULL, this will be computed as the common size of the inputs.
- `.name_repair` One of "check_unique", "unique", "universal" or "minimal". See `vec_as_names()` for the meaning of these options.

**Properties**

- Inputs are recycled to a common size with `vec_recycle_common()`.
• With the exception of data frames, inputs are not modified in any way. Character vectors are never converted to factors, and lists are stored as-is for easy creation of list-columns.

• Unnamed data frame inputs are automatically spliced. Named data frame inputs are stored unmodified as data frame columns.

• NULL inputs are completely ignored.

• The dots are dynamic, allowing for splicing of lists with !!! and unquoting.

See Also

`new_data_frame()` for constructing data frame subclasses from a validated input. `data_frame()` for a fast data frame creation helper.

Examples

```r
# `new_data_frame()` can be used to create custom data frame constructors
new_fancy_df <- function(x = list(), n = NULL, ..., class = NULL) {
  new_data_frame(x, n = n, ..., class = c(class, "fancy_df"))
}

# Combine this constructor with `df_list()` to create a safe, consistent helper function for your data frame subclass
fancy_df <- function(...) {
  data <- df_list(...) 
  new_fancy_df(data)
}

df <- fancy_df(x = 1)
class(df)
```

---

**df_ptype2**

*Coercion between two data frames*

**Description**

df_ptype2() and df_cast() are the two functions you need to call from vec_ptype2() and vec_cast() methods for data frame subclasses. See `?howto-faq-coercion-data-frame`. Their main job is to determine the common type of two data frames, adding and coercing columns as needed, or throwing an incompatible type error when the columns are not compatible.

**Usage**

df_ptype2(x, y, ..., x_arg = "", y_arg = "")

df_cast(x, to, ..., x_arg = "", to_arg = "")

tib_ptype2(x, y, ..., x_arg = "", y_arg = "")

tib_cast(x, to, ..., x_arg = "", to_arg = ")
Arguments

- **x, y, to**: Subclasses of data frame.
- **...**: If you call `df_ptype2()` or `df_cast()` from a vec_ptype2() or vec_cast() method, you must forward the dots passed to your method on to df_ptype2() or df_cast().
- **x_arg**: Argument names for x and y. These are used in error messages to inform the user about the locations of incompatible types (see `stop_incompatible_type()`).
- **y_arg**: Argument names for x and y. These are used in error messages to inform the user about the locations of incompatible types (see `stop_incompatible_type()`).
- **to_arg**: Argument names for x and to. These are used in error messages to inform the user about the locations of incompatible types (see `stop_incompatible_type()`).

Value

- When x and y are not compatible, an error of class `vctrs_error_incompatible_type` is thrown.
- When x and y are compatible, `df_ptype2()` returns the common type as a bare data frame. `tib_ptype2()` returns the common type as a bare tibble.

Description

Two vectors are **compatible** when you can safely:

- Combine them into one larger vector.
- Assign values from one of the vectors into the other vector.

Examples of compatible types are integer and double vectors. On the other hand, integer and character vectors are not compatible.

Common type of multiple vectors

There are two possible outcomes when multiple vectors of different types are combined into a larger vector:

- An incompatible type error is thrown because some of the types are not compatible:
  ```r
df1 <- data.frame(x = 1:3)
df2 <- data.frame(x = "foo")
dplyr::bind_rows(df1, df2)
#> Error: Can’t combine `..1$x` <integer> and `..2$x` <character>.
```
- The vectors are combined into a vector that has the common type of all inputs. In this example, the common type of integer and logical is integer:
In general, the common type is the richer type, in other words the type that can represent the most values. Logical vectors are at the bottom of the hierarchy of numeric types because they can only represent two values (not counting missing values). Then come integer vectors, and then doubles. Here is the vctrs type hierarchy for the fundamental vectors:

```
df1 <- data.frame(x = 1:3)
df2 <- data.frame(x = FALSE)
dplyr::bind_rows(df1, df2)
#> x
#> 1 1
#> 2 2
#> 3 3
#> 4 0
```

**Type conversion and lossy cast errors**

Type compatibility does not necessarily mean that you can convert one type to the other type. That's because one of the types might support a larger set of possible values. For instance, integer and double vectors are compatible, but double vectors can't be converted to integer if they contain fractional values.

When vctrs can't convert a vector because the target type is not as rich as the source type, it throws a lossy cast error. Assigning a fractional number to an integer vector is a typical example of a lossy cast error:

```
int_vector <- 1:3
vec_assign(int_vector, 2, 0.001)
#> Error: Can't convert from <double> to <integer> due to loss of precision.
#> * Locations: 1
```

**How to make two vector classes compatible?**

If you encounter two vector types that you think should be compatible, they might need to implement coercion methods. Reach out to the author(s) of the classes and ask them if it makes sense for their classes to be compatible.

These developer FAQ items provide guides for implementing coercion methods:
FAQ - Error/Warning: Some attributes are incompatible

Description

This error occurs when `vec_ptype2()` or `vec_cast()` are supplied vectors of the same classes with different attributes. In this case, vctrs doesn’t know how to combine the inputs.

To fix this error, the maintainer of the class should implement self-to-self coercion methods for `vec_ptype2()` and `vec_cast()`.

Implementing coercion methods

- For an overview of how these generics work and their roles in vctrs, see `?theory-faq-coercion`.
- For an example of implementing coercion methods for simple vectors, see `?howto-faq-coercion`.
- For an example of implementing coercion methods for data frame subclasses, see `?howto-faq-coercion-data-frame`.
- For a tutorial about implementing vctrs classes from scratch, see vignette("s3-vector").

FAQ - Error: Input must be a vector

Description

This error occurs when a function expects a vector and gets a scalar object instead. This commonly happens when some code attempts to assign a scalar object as column in a data frame:

```r
fn <- function() NULL
tibble::tibble(x = fn)
#> Error: All columns in a tibble must be vectors.
#> x Column `x` is a function.

fit <- lm(1:3 ~ 1)
tibble::tibble(x = fit)
#> Error: All columns in a tibble must be vectors.
#> x Column `x` is a `lm` object.
```

Vectorness in base R and in the tidyverse

In base R, almost everything is a vector or behaves like a vector. In the tidyverse we have chosen to be a bit stricter about what is considered a vector. The main question we ask ourselves to decide on the vectorness of a type is whether it makes sense to include that object as a column in a data frame.

The main difference is that S3 lists are considered vectors by base R but in the tidyverse that’s not the case by default:
fit <- lm(1:3 ~ 1)

typeof(fit)
#> [1] "list"
class(fit)
#> [1] "lm"

# S3 lists can be subset like a vector using base R:
fit[1:3]
#> $coefficients
#> (Intercept)
#> 2
#>
#> $residuals
#> 1 2 3
#> -1.000000e+00 -3.885781e-16 1.000000e+00
#>
#> $effects
#> (Intercept)
#> -3.4641016 0.3660254 1.3660254

# But not in vctrs
vctrs::vec_slice(fit, 1:3)
#> Error: Input must be a vector, not a `lm` object.

Defused function calls are another (more esoteric) example:
call <- quote(foo(bar = TRUE, baz = FALSE))
call
#> foo(bar = TRUE, baz = FALSE)

# They can be subset like a vector using base R:
call[1:2]
#> foo(bar = TRUE)
lapply(call, function(x) x)
#> [[1]]
#> foo
#>
#> $bar
#> [1] TRUE
#>
#> $baz
#> [1] FALSE

# But not with vctrs:
vctrs::vec_slice(call, 1:2)
#> Error: Input must be a vector, not a call.

I get a scalar type error but I think this is a bug

It’s possible the author of the class needs to do some work to declare their class a vector. Consider reaching out to the author. We have written a developer FAQ page to help them fix the issue.
Description

This guide illustrates how to implement `vec_ptype2()` and `vec_cast()` methods for existing classes. Related topics:

- For an overview of how these generics work and their roles in vctrs, see `?theory-faq-coercion`.
- For an example of implementing coercion methods for data frame subclasses, see `?howto-faq-coercion-data-frame`.
- For a tutorial about implementing vctrs classes from scratch, see vignette("s3-vector")

The natural number class:

We'll illustrate how to implement coercion methods with a simple class that represents natural numbers. In this scenario we have an existing class that already features a constructor and methods for `print()` and subset.

```r
#' @export
new_natural <- function(x) {
  if (is.numeric(x) || is.logical(x)) {
    stopifnot(is_whole(x))
    x <- as.integer(x)
  } else {
    stop("Can't construct natural from unknown type."")
  }
  structure(x, class = "my_natural")
}

is_whole <- function(x) {
  all(x %% 1 == 0 | is.na(x))
}

#' @export
print.my_natural <- function(x, ...) {
  cat("<natural>
  x <- unclass(x)
  NextMethod()
}

#' @export
`[.my_natural` <- function(x, i, ...) {
  new_natural(NextMethod())
}
```

```r
new_natural(1:3)
#> <natural>
#> [1] 1 2 3
new_natural(c(1, NA))
#> <natural>
#> [1] 1 NA
```

Roxygen workflow:

To implement methods for generics, first import the generics in your namespace and redocument:
Note that for each batches of methods that you add to your package, you need to export the methods and redocument immediately, even during development. Otherwise they won’t be in scope when you run unit tests e.g. with testthat.

Implementing double dispatch methods is very similar to implementing regular S3 methods. In these examples we are using roxygen2 tags to register the methods, but you can also register the methods manually in your NAMESPACE file or lazily with s3_register().

Implementing vec_ptype2():

The self-self method:
The first method to implement is the one that signals that your class is compatible with itself:

```r
@export
vec_ptype2.my_natural.my_natural <- function(x, y, ...) {
  x
}
```

```r
vec_ptype2(new_natural(1), new_natural(2:3))
#> <natural>
#> integer(0)
```

vec_ptype2() implements a fallback to try and be compatible with simple classes, so it may seem that you don’t need to implement the self-self coercion method. However, you must implement it explicitly because this is how vctrs knows that a class that is implementing vctrs methods (for instance this disable fallbacks to base::c()). Also, it makes your class a bit more efficient.

The parent and children methods:
Our natural number class is conceptually a parent of <logical> and a child of <integer>, but the class is not compatible with logical, integer, or double vectors yet:

```r
vec_ptype2(TRUE, new_natural(2:3))
#> Error: Can’t combine <logical> and <natural>.
```

```r
vec_ptype2(new_natural(1), 2:3)
#> Error: Can’t combine <my_natural> and <integer>.
```

We’ll specify the twin methods for each of these classes, returning the richer class in each case.

```r
@export
vec_ptype2.my_natural.logical <- function(x, y, ...) {
  # The order of the classes in the method name follows the order of
  # the arguments in the function signature, so `x` is the natural
  # number and `y` is the logical
  x
}
```

```r
@export
vec_ptype2.logical.my_natural <- function(x, y, ...) {
  # In this case `y` is the richer natural number
  y
}
```

Between a natural number and an integer, the latter is the richer class:

```r
@export
vec_ptype2.my_natural.integer <- function(x, y, ...) {
  y
}```
We no longer get common type errors for logical and integer:

```r
vec_ptype2(TRUE, new_natural(2:3))
#> <natural>
#> integer(0)
vec_ptype2(new_natural(1), 2:3)
#> integer(0)
```

We are not done yet. Pairwise coercion methods must be implemented for all the connected nodes in the coercion hierarchy, which include double vectors further up. The coercion methods for grand-parent types must be implemented separately:

```r
class(vec_ptype2) <- c("integer", "my_natural")
class(vec_ptype2$my_natural) <- "double"
class(vec_ptype2$double) <- "my_natural"
```

### Incompatible attributes:

Most of the time, inputs are incompatible because they have different classes for which no `vec_ptype2()` method is implemented. More rarely, inputs could be incompatible because of their attributes. In that case incompatibility is signalled by calling `stop_incompatible_type()`.

In the following example, we implement a self-self `ptype2` method for a hypothetical subclass of `<factor>` that has stricter combination semantics. The method throws when the levels of the two factors are not compatible:

```r
vec_ptype2$my_strict_factor$my_strict_factor <- function(x, y, ..., x_arg = "", y_arg = "") {
  if (!setequal(levels(x), levels(y))) {
    stop_incompatible_type(x, y, x_arg, y_arg)
  }
  x
}
```

Note how the methods need to take `x_arg` and `y_arg` parameters and pass them on to `stop_incompatible_type()`. These argument tags help create more informative error messages when the common type determination is for a column of a data frame. They are part of the generic signature but can usually be left out if not used.

### Implementing `vec_cast()`:

Corresponding `vec_cast()` methods must be implemented for all `vec_ptype2()` methods. The general pattern is to convert the argument `x` to the type of `to`. The methods should validate the values in `x` and make sure they conform to the values of `to`.

Please note that for historical reasons, the order of the classes in the method name is in reverse order of the arguments in the function signature. The first class represents `to`, whereas the second class represents `x`.

The self-self method is easy in this case, it just returns the target input:
The other types need to be validated. We perform input validation in the `new_natural()` constructor, so that’s a good fit for our `vec_cast()` implementations.

```r
@export
vec_cast.my_natural.logical <- function(x, to, ...) {
  # The order of the classes in the method name is in reverse order
  # of the arguments in the function signature, so `to` is the natural
  # number and `x` is the logical
  new_natural(x)
}
vec_cast.my_natural.integer <- function(x, to, ...) {
  new_natural(x)
}
vec_cast.my_natural.double <- function(x, to, ...) {
  new_natural(x)
}

With these methods, `vctrs` is now able to combine logical and natural vectors. It properly returns the richer type of the two, a natural vector:

```r
evec_c(TRUE, new_natural(1), FALSE)
#> <natural>
#> [1] 1 1 0
```

Because we haven’t implemented conversions from natural, it still doesn’t know how to combine natural with the richer integer and double types:

```r
evec_c(new_natural(1), 10L)
#> Error: Can't convert <my_natural> to <integer>.
evec_c(1.5, new_natural(1))
#> Error: Can't convert <my_natural> to <double>.
```

This is quick work which completes the implementation of coercion methods for `vctrs`:

```r
@export
vec_cast.logical.my_natural <- function(x, to, ...) {
  # In this case `to` is the logical and `x` is the natural number
  attributes(x) <- NULL
  as.logical(x)
}
@export
vec_cast.integer.my_natural <- function(x, to, ...) {
  attributes(x) <- NULL
  as.integer(x)
}
@export
vec_cast.double.my_natural <- function(x, to, ...) {
  attributes(x) <- NULL
  as.double(x)
}
```

And we now get the expected combinations.
vec_c(new_natural(1), 10L)
#> [1] 1 10

vec_c(1.5, new_natural(1))
#> [1] 1.5 1.0

FAQ - How to implement ptype2 and cast methods? (Data frames)

Description

This guide provides a practical recipe for implementing vec_pfunc1() and vec_pfunc2() methods for coercions of data frame subclasses. Related topics:

- For an overview of the coercion mechanism in vctrs, see ?theory-faq-coercion.
- For an example of implementing coercion methods for simple vectors, see ?howto-faq-coercion.

Coercion of data frames occurs when different data frame classes are combined in some way. The two main methods of combination are currently row-binding with vec_rbind() and col-binding with vec_cbind() (which are in turn used by a number of dplyr and tidyr functions). These functions take multiple data frame inputs and automatically coerce them to their common type.

vctrs is generally strict about the kind of automatic coercions that are performed when combining inputs. In the case of data frames we have decided to be a bit less strict for convenience. Instead of throwing an incompatible type error, we fall back to a base data frame or a tibble if we don’t know how to combine two data frame subclasses. It is still a good idea to specify the proper coercion behaviour for your data frame subclasses as soon as possible.

We will see two examples in this guide. The first example is about a data frame subclass that has no particular attributes to manage. In the second example, we implement coercion methods for a tibble subclass that includes potentially incompatible attributes.

Roxygen workflow:

To implement methods for generics, first import the generics in your namespace and redocument:

```r
#' @importFrom vctrs vec_pfunc1 vec_pfunc2
NULL
```

Note that for each batches of methods that you add to your package, you need to export the methods and redocument immediately, even during development. Otherwise they won’t be in scope when you run unit tests e.g. with testthat.

Implementing double dispatch methods is very similar to implementing regular S3 methods. In these examples we are using roxygen2 tags to register the methods, but you can also register the methods manually in your NAMESPACE file or lazily with s3_register().

Parent methods:

Most of the common type determination should be performed by the parent class. In vctrs, double dispatch is implemented in such a way that you need to call the methods for the parent class manually. For vec_pfunc2() this means you need to call df_pfunc2() (for data frame subclasses) or tbl_pfunc2() (for tibble subclasses). Similarly, df_pcast() and tbl_pcast() are the workhorses for vec_pcast() methods of subtypes of data.frame and tbl_df. These functions take the union of the columns in x and y, and ensure shared columns have the same type.
These functions are much less strict than `vec_ptype2()` and `vec_cast()` as they accept any subclass of data frame as input. They always return a `data.frame` or a `tbl_df`. You will probably want to write similar functions for your subclass to avoid repetition in your code. You may want to export them as well if you are expecting other people to derive from your class.

A **data.table** example:

This example is the actual implementation of vttrs coercion methods for data.table. This is a simple example because we don’t have to keep track of attributes for this class or manage incompatibilities. See the tibble section for a more complicated example.

We first create the `dt_ptype2()` and `dt_cast()` helpers. They wrap around the parent methods `df_ptype2()` and `df_cast()`, and transform the common type or converted input to a data table.

You may want to export these helpers if you expect other packages to derive from your data frame class.

These helpers should always return data tables. To this end we use the conversion generic `as.data.table()`. Depending on the tools available for the particular class at hand, a constructor might be appropriate as well.

```r
dt_ptype2 <- function(x, y, ...) {
  as.data.table(df_ptype2(x, y, ...))
}
dt_cast <- function(x, to, ...) {
  as.data.table(df_cast(x, to, ...))
}
```

We start with the self-self method:

```r
#' @export
vec_ptype2.data.table.data.table <- function(x, y, ...) {
  dt_ptype2(x, y, ...)
}
```

Between a data frame and a data table, we consider the richer type to be data table. This decision is not based on the value coverage of each data structures, but on the idea that data tables have richer behaviour. Since data tables are the richer type, we call `dt_type2()` from the `vec_ptype2()` method. It always returns a data table, no matter the order of arguments:

```r
#' @export
vec_ptype2.data.table.data.frame <- function(x, y, ...) {
  dt_ptype2(x, y, ...)
}
```

The `vec_cast()` methods follow the same pattern, but note how the method for coercing to data frame uses `df_cast()` rather than `dt_cast()`.

Also, please note that for historical reasons, the order of the classes in the method name is in reverse order of the arguments in the function signature. The first class represents `to`, whereas the second class represents `x`.

```r
#' @export
vec_cast.data.table.data.table <- function(x, to, ...) {
  dt_cast(x, to, ...)
}
```
vec_cast.data.table.data.frame <- function(x, to, ...) {
  # `x` is a data.frame to be converted to a data.table
  dt_cast(x, to, ...)
}

vec_cast.data.frame.data.table <- function(x, to, ...) {
  # `x` is a data.table to be converted to a data.frame
  df_cast(x, to, ...)
}

With these methods vctrs is now able to combine data tables with data frames:

```r
vec_cbind(data.frame(x = 1:3), data.table(y = "foo"))
#>    x  y
#> 1: 1 foo
#> 2: 2 foo
#> 3: 3 foo
```

**A tibble example:**
In this example we implement coercion methods for a tibble subclass that carries a colour as a scalar metadata:

```r
# User constructor
my_tibble <- function(colour = NULL, ...) {
  new_my_tibble(tibble::tibble(...), colour = colour)
}

# Developer constructor
new_my_tibble <- function(x, colour = NULL) {
  stopifnot(is.data.frame(x))
  tibble::new_tibble(
    x,
    colour = colour,
    class = "my_tibble",
    nrow = nrow(x)
  )
}

df_colour <- function(x) {
  if (inherits(x, "my_tibble")) {
    attr(x, "colour")
  } else {
    NULL
  }
}

# @export
print.my_tibble <- function(x, ...) {
  cat(sprintf("<%s: %s>
", class(x)[[1]], df_colour(x)))
  cli::cat_line(format(x)[[-1]])
}

This subclass is very simple. All it does is modify the header.
```r
red <- my_tibble("red", x = 1, y = 1:2)
red
```r
#> <my_tibble: red>
#> x  y
#> <dbl> <int>
#> 1 1 1
#> 2 1 2

red[2]
#> <my_tibble: red>
#> y
#> <int>
#> 1 1
#> 2 2

green <- my_tibble("green", z = TRUE)
green
#> <my_tibble: green>
#> z
#> <lgl>
#> 1 TRUE

Combinations do not work properly out of the box, instead vctrs falls back to a bare tibble:

vec_rbind(red, tibble::tibble(x = 10:12))
#> # A tibble: 5 x 2
#> x y
#> <dbl> <int>
#> 1 1 1
#> 2 1 2
#> 3 10 NA
#> 4 11 NA
#> 5 12 NA

Instead of falling back to a data frame, we would like to return a <my_tibble> when combined with a data frame or a tibble. Because this subclass has more metadata than normal data frames (it has a colour), it is a supertype of tibble and data frame, i.e., it is the richer type. This is similar to how a grouped tibble is a more general type than a tibble or a data frame. Conceptually, the latter are pinned to a single constant group.

The coercion methods for data frames operate in two steps:

• They check for compatible subclass attributes. In our case the tibble colour has to be the same, or be undefined.

• They call their parent methods, in this case tib_ptype2() and tib_cast() because we have a subclass of tibble. This eventually calls the data frame methods df_ptype2() and tib_ptype2() which match the columns and their types.

This process should usually be wrapped in two functions to avoid repetition. Consider exporting these if you expect your class to be derived by other subclasses.

We first implement a helper to determine if two data frames have compatible colours. We use the df_colour() accessor which returns NULL when the data frame colour is undefined.

```
Next we implement the coercion helpers. If the colours are not compatible, we call `stop_incompatible_cast()` or `stop_incompatible_type()`. These strict coercion semantics are justified because in this class colour is a *data* attribute. If it were a non essential *detail* attribute, like the timezone in a datetime, we would just standardise it to the value of the left-hand side.

In simpler cases (like the data.table example), these methods do not need to take the arguments suffixed in `arg`. Here we do need to take these arguments so we can pass them to the `stop_` functions when we detect an incompatibility. They also should be passed to the parent methods.

```r
# @export
my_tib_cast <- function(x, to, ..., x_arg = '', to_arg = '') {
  out <- tib_cast(x, to, ..., x_arg = x_arg, to_arg = to_arg)

  if (!has_compatible_colours(x, to)) {
    stop_incompatible_cast(
      x,
      to,
      x_arg = x_arg,
      to_arg = to_arg,
      details = "Can't combine colours."
    )
  }

  colour <- df_colour(x) || df_colour(to)
  new_my_tibble(out, colour = colour)
}

# @export
my_tib_ptype2 <- function(x, y, ..., x_arg = '', y_arg = '') {
  out <- tib_ptype2(x, y, ..., x_arg = x_arg, y_arg = y_arg)

  if (!has_compatible_colours(x, y)) {
    stop_incompatible_type(
      x,
      y,
      x_arg = x_arg,
      y_arg = y_arg,
      details = "Can't combine colours."
    )
  }

  colour <- df_colour(x) || df_colour(y)
  new_my_tibble(out, colour = colour)
}
```

Let's now implement the coercion methods, starting with the self-self methods.

```r
# @export
vec_ptype2.my_tibble.my_tibble <- function(x, y, ...) {
  my_tib_ptype2(x, y, ...)
}

# @export
vec_cast.my_tibble.my_tibble <- function(x, to, ...) {
  my_tib_cast(x, to, ...)
}
```

We can now combine compatible instances of our class!
vec_rbind(red, red)
#> <my_tibble: red>
#> x   y
#> <dbl> <int>
#> 1   1   1
#> 2   1   2
#> 3   1   1
#> 4   1   2

vec_rbind(green, green)
#> <my_tibble: green>
#> z
#> <lgl>
#> 1 TRUE
#> 2 TRUE

vec_rbind(green, red)
#> Error: Can't combine ´..1´ <my_tibble> and ´..2´ <my_tibble>.
#> Can't combine colours.

The methods for combining our class with tibbles follow the same pattern. For ptype2 we return our class in both cases because it is the richer type:

```r
#' @export
vec_ptype2.my_tibble.tbl_df <- function(x, y, ...) {
  my_tib_ptype2(x, y, ...)
}
```
```
#' @export
vec_ptype2.tbl_df.my_tibble <- function(x, y, ...) {
  my_tib_ptype2(x, y, ...)
}
```

For cast are careful about returning a tibble when casting to a tibble. Note the call to vctrs::tib_cast():

```r
#' @export
vec_cast.my_tibble.tbl_df <- function(x, to, ...) {
  my_tib_cast(x, to, ...)
}
```
```
#' @export
vec_cast.tbl_df.my_tibble <- function(x, to, ...) {
  tib_cast(x, to, ...)
}
```

From this point, we get correct combinations with tibbles:

```r
vec_rbind(red, tibble::tibble(x = 10:12))
#> <my_tibble: red>
#> x   y
#> <dbl> <int>
#> 1   1   1
#> 2   1   2
#> 3  10   NA
#> 4  11   NA
#> 5  12   NA
```
However we are not done yet. Because the coercion hierarchy is different from the class hierarchy, there is no inheritance of coercion methods. We’re not getting correct behaviour for data frames yet because we haven’t explicitly specified the methods for this class:

```r
vec_rbind(red, data.frame(x = 10:12))
#> # A tibble: 5 x 2
#>    x  y
#> <dbl> <int>
#> 1 1  1
#> 2 1  2
#> 3 10 NA
#> 4 11 NA
#> 5 12 NA
```

Let’s finish up the boiler plate:

```r
#' @export
vec_ptype2.my_tibble.data.frame <- function(x, y, ...) {
  my_tib_ptype2(x, y, ...)
}
#' @export
vec_ptype2.data.frame.my_tibble <- function(x, y, ...) {
  my_tib_ptype2(x, y, ...)
}

#' @export
vec_cast.my_tibble.data.frame <- function(x, to, ...) {
  my_tib_cast(x, to, ...)
}
#' @export
vec_cast.data.frame.my_tibble <- function(x, to, ...) {
  df_cast(x, to, ...)
}
```

This completes the implementation:

```r
vec_rbind(red, data.frame(x = 10:12))
#> <my_tibble: red>
#>    x  y
#> <dbl> <int>
#> 1 1  1
#> 2 1  2
#> 3 10 NA
#> 4 11 NA
#> 5 12 NA
```
Description

The tidyverse is a bit stricter than base R regarding what kind of objects are considered as vectors (see the user FAQ about this topic). Sometimes vctrs won’t treat your class as a vector when it should.

**Why isn’t my list class considered a vector?:**

By default, S3 lists are not considered to be vectors by vctrs:

```r
my_list <- structure(list(), class = "my_class")
```

```r
vctrs::vec_is(my_list)
#> [1] FALSE
```

To be treated as a vector, the class must either inherit from "list" explicitly:

```r
my_explicit_list <- structure(list(), class = c("my_class", "list"))
```

```r
evctrs::vec_is(my_explicit_list)
#> [1] TRUE
```

Or it should implement a `vec_proxy()` method that returns its input if explicit inheritance is not possible or troublesome:

```r
#' @export
vec_proxy.my_class <- function(x, ...) x
```

```r
evctrs::vec_is(my_list)
#> [1] FALSE
```

Note that explicit inheritance is the preferred way because this makes it possible for your class to dispatch on list methods of S3 generics:

```r
my_generic <- function(x) UseMethod("my_generic")
my_generic.list <- function(x) "dispatched!"
```

```r
my_generic(my_list)
#> Error in UseMethod("my_generic"): no applicable method for 'my_generic' applied to an object of class "my_class".
```

```r
my_generic(my_explicit_list)
#> [1] "dispatched!"
```

**Why isn’t my data frame class considered a vector?:**

The most likely explanation is that the data frame has not been properly constructed. However, if you get an “Input must be a vector” error with a data frame subclass, it probably means that the data frame has not been properly constructed. The main cause of these errors are data frames whose base class is not "data.frame":

```r
my_df <- data.frame(x = 1)
class(my_df) <- c("data.frame", "my_class")
```

```r
vctrs::vec_assert(my_df)
#> Error: 'my_df' must be a vector, not a 'data.frame/my_class' object.
```

This is problematic as many tidyverse functions won’t work properly:

```r
dplyr::slice(my_df, 1)
#> Error: Input must be a vector, not a 'data.frame/my_class' object.
```
It is generally not appropriate to declare your class to be a superclass of another class. We generally consider this undefined behaviour (UB). To fix these errors, you can simply change the construction of your data frame class so that "data.frame" is a base class, i.e. it should come last in the class vector:

```r
class(my_df) <- c("my_class", "data.frame")

vctrs::vec_assert(my_df)

dplyr::slice(my_df, 1)
#> x
#> 1 1
```

---

### Description

**Promotion monoid:**

Promotions (i.e. automatic coercions) should always transform inputs to their richer type to avoid losing values of precision. `vec_ptype2()` returns the *richer* type of two vectors, or throws an incompatible type error if none of the two vector types include the other. For example, the richer type of integer and double is the latter because double covers a larger range of values than integer. `vec_ptype2()` is a *monoid* over vectors, which in practical terms means that it is a well behaved operation for *reduction*. Reduction is an important operation for promotions because that is how the richer type of multiple elements is computed. As a monoid, `vec_ptype2()` needs an identity element, i.e. a value that doesn’t change the result of the reduction. `vctrs` has two identity values, `NULL` and `unspecified` vectors.

**The NULL identity:**

As an identity element that shouldn’t influence the determination of the common type of a set of vectors, `NULL` is promoted to any type:

```r
vec_ptype2(NULL, "")
#> character(0)
vec_ptype2(1L, NULL)
#> integer(0)
```

The common type of `NULL` and `NULL` is the identity `NULL`:

```r
vec_ptype2(NULL, NULL)
#> NULL
```

This way the result of `vec_ptype2(NULL,NULL)` does not influence subsequent promotions:

```r
vec_ptype2(
    vec_ptype2(NULL, NULL),
    ""
)
#> character(0)
```
Unspecified vectors:
In the vctrs coercion system, logical vectors of missing values are also automatically promoted to the type of any other vector, just like NULL. We call these vectors unspecified. The special coercion semantics of unspecified vectors serve two purposes:

1. It makes it possible to assign vectors of NA inside any type of vectors, even when they are not coercible with logical:

   ```r
   x <- letters[1:5]
   vec_assign(x, 1:2, c(NA, NA))
   #> [1] NA NA "c" "d" "e"
   ```

2. We can’t put NULL in a data frame, so we need an identity element that behaves more like a vector. Logical vectors of NA seem a natural fit for this.

   Unspecified vectors are thus promoted to any other type, just like NULL:

   ```r
   vec_ptype2(NA, "")
   #> character(0)
   vec_ptype2(1L, c(NA, NA))
   #> integer(0)
   ```

Finalising common types:
vctrs has an internal vector type of class vctrs_unspecified. Users normally don’t see such vectors in the wild, but they do come up when taking the common type of an unspecified vector with another identity value:

```r
vec_ptype2(NA, NA)
#> <unspecified> [0]
vec_ptype2(NA, NULL)
#> <unspecified> [0]
vec_ptype2(NULL, NA)
#> <unspecified> [0]
```

We can’t return NA here because vec_ptype2() normally returns empty vectors. We also can’t return NULL because unspecified vectors need to be recognised as logical vectors if they haven’t been promoted at the end of the reduction.

```r
vec_ptype_finalise(vec_ptype2(NULL, NA))
#> logical(0)
```

See the output of vec_ptype_common() which performs the reduction and finalises the type, ready to be used by the caller:

```r
vec_ptype_common(NULL, NULL)
#> NULL
vec_ptype_common(NA, NULL)
#> logical(0)
```

Note that partial types in vctrs make use of the same mechanism. They are finalised with vec_ptype_finalise().
list_of

list_of S3 class for homogenous lists

Description

A list_of object is a list where each element has the same type. Modifying the list with $, [, and [[ preserves the constraint by coercing all input items.

Usage

list_of(..., .ptype = NULL)

as_list_of(x, ...)

validate_list_of(x)

is_list_of(x)

## S3 method for class 'vctrs_list_of'
vec_ptype2(x, y, ..., x_arg = "", y_arg = ")

## S3 method for class 'vctrs_list_of'
vec_cast(x, to, ...)

Arguments

... Vectors to coerce.

.ptype If NULL, the default, the output type is determined by computing the common type across all elements of .... Alternatively, you can supply .ptype to give the output known type. If getOption("vctrs.no_guessing") is TRUE you must supply this value: this is a convenient way to make production code demand fixed types.

x For as_list_of(), a vector to be coerced to list_of.

ty, to Arguments to vec_ptype2() and vec_cast().

x_arg Argument names for x and y. These are used in error messages to inform the user about the locations of incompatible types (see stop_incompatible_type()).

y_arg Argument names for x and y. These are used in error messages to inform the user about the locations of incompatible types (see stop_incompatible_type()).

Details

Unlike regular lists, setting a list element to NULL using [[ does not remove it.

Examples

x <- list_of(1:3, 5:6, 10:15)
if (requireNamespace("tibble", quietly = TRUE)) {
  tibble::tibble(x = x)
}

vec_c(list_of(1, 2), list_of(FALSE, TRUE))
Description

A name specification describes how to combine an inner and outer names. This sort of name combination arises when concatenating vectors or flattening lists. There are two possible cases:

- Named vector:
  \[ \text{vec}_c(\text{outer} = \text{c}(\text{inner1} = 1, \text{inner2} = 2)) \]
- Unnamed vector:
  \[ \text{vec}_c(\text{outer} = 1:2) \]

In r-lib and tidyverse packages, these cases are errors by default, because there’s no behaviour that works well for every case. Instead, you can provide a name specification that describes how to combine the inner and outer names of inputs. Name specifications can refer to:

- \text{outer}: The external name recycled to the size of the input vector.
- \text{inner}: Either the names of the input vector, or a sequence of integer from 1 to the size of the vector if it is unnamed.

Arguments

\text{name_spec}, \text{.name_spec}

A name specification for combining inner and outer names. This is relevant for inputs passed with a name, when these inputs are themselves named, like \text{outer} = \text{c}(\text{inner} = 1), or when they have length greater than 1: \text{outer} = 1:2. By default, these cases trigger an error. You can resolve the error by providing a specification that describes how to combine the names or the indices of the inner vector with the name of the input. This specification can be:

- A function of two arguments. The outer name is passed as a string to the first argument, and the inner names or positions are passed as second argument.
- An anonymous function as a purrr-style formula.
- A glue specification of the form \text{"{outer}_\{inner\}"}. 
- An \text{rlang::zap()} object, in which case both outer and inner names are ignored and the result is unnamed.

See the name specification topic.

Examples

# By default, named inputs must be length 1:
\text{vec}_c(\text{name} = 1)  \quad \# \text{ok}
\text{try}(\text{vec}_c(\text{name} = 1:3))  \quad \# \text{bad}

# They also can’t have internal names, even if scalar:
\text{try}(\text{vec}_c(\text{name} = \text{c}(\text{internal} = 1)))  \quad \# \text{bad}

# Pass a name specification to work around this. A specification
# can be a glue string referring to ‘outer’ and ‘inner’:

new_data_frame

Assemble attributes for data frame construction

Description

new_data_frame() constructs a new data frame from an existing list. It is meant to be performant, and does not check the inputs for correctness in any way. It is only safe to use after a call to df_list(), which collects and validates the columns used to construct the data frame.

Usage

new_data_frame(x = list(), n = NULL, ..., class = NULL)

Arguments

x
A named list of equal-length vectors. The lengths are not checked; it is responsibility of the caller to make sure they are equal.

n
Number of rows. If NULL, will be computed from the length of the first element of x.

..., class
Additional arguments for creating subclasses. The "names" and "row.names" attributes override input in x and n, respectively:

• "names" is used if provided, overriding existing names in x
• "row.names" is used if provided, if n is provided it must be consistent.

See Also

df_list() for a way to safely construct a data frame’s underlying data structure from individual columns. This can be used to create a named list for further use by new_data_frame().

Examples

new_data_frame(list(x = 1:10, y = 10:1))
Description

vctrs provides a framework for working with vector classes in a generic way. However, it implements several compatibility fallbacks to base R methods. In this reference you will find how vctrs tries to be compatible with your vector class, and what base methods you need to implement for compatibility.

If you’re starting from scratch, we think you’ll find it easier to start using `new_vctr()` as documented in vignette("s3-vector"). This guide is aimed for developers with existing vector classes.

Aggregate operations with fallbacks:

All vctrs operations are based on four primitive generics described in the next section. However there are many higher level operations. The most important ones implement fallbacks to base generics for maximum compatibility with existing classes.

- `vec_slice()` falls back to the base `[ generic if no `vec_proxy()` method is implemented. This way foreign classes that do not implement `vec_restore()` can restore attributes based on the new subsetted contents.
- `vec_c()` and `vec_rbind()` now fall back to `base::c()` if the inputs have a common parent class with a `c()` method (only if they have no self-to-self `vec_ptype2()` method).

vctrs works hard to make your `c()` method success in various situations (with `NULL` and `NA` inputs, even as first input which would normally prevent dispatch to your method). The main downside compared to using vctrs primitives is that you can’t combine vectors of different classes since there is no extensible mechanism of coercion in `c()`, and it is less efficient in some cases.

The vctrs primitives:

Most functions in vctrs are aggregate operations: they call other vctrs functions which themselves call other vctrs functions. The dependencies of a vctrs functions are listed in the Dependencies section of its documentation page. Take a look at `vec_count()` for an example.

These dependencies form a tree whose leaves are the four vctrs primitives. Here is the diagram for `vec_count()`:

```
     vec_count()
    /        \
vec_proxy_equal()   vec_slice()  vec_order()
    /        \
vec_proxy()          vec_restore() vec_proxy_compare()
```

The coercion generics:

The coercion mechanism in vctrs is based on two generics:

- `vec_ptype2()`
• **vec_cast()**

  See the [theory overview](#).

  Two objects with the same class and the same attributes are always considered compatible by `ptype2` and `cast`. If the attributes or classes differ, they throw an incompatible type error. Coercion errors are the main source of incompatibility with vctrs. See the [howto guide](#) if you need to implement methods for these generics.

  **The proxy and restoration generics:**
  • **vec_proxy()**
  • **vec_restore()**

  These generics are essential for vctrs but mostly optional. `vec_proxy()` defaults to an identity function and you normally don’t need to implement it. The proxy a vector must be one of the atomic vector types, a list, or a data frame. By default, S3 lists that do not inherit from "list" do not have an identity proxy. In that case, you need to explicitly implement `vec_proxy()` or make your class inherit from list.

---

**FAQ - How does coercion work in vctrs?**

**Description**

This is an overview of the usage of `vec_ptype2()` and `vec_cast()` and their role in the vctrs coercion mechanism. Related topics:

• For an example of implementing coercion methods for simple vectors, see [howto-faq-coercion](#).
• For an example of implementing coercion methods for data frame subclasses, see [howto-faq-coercion-data-frame](#).
• For a tutorial about implementing vctrs classes from scratch, see vignette("s3-vector").

**Combination mechanism in vctrs:**

The coercion system in vctrs is designed to make combination of multiple inputs consistent and extensible. Combinations occur in many places, such as row-binding, joins, subset-assignment, or grouped summary functions that use the split-apply-combine strategy. For example:

```r
vec_c(TRUE, 1)
#> [1] 1 1

vec_c("a", 1)
#> Error: Can’t combine ‘..1’ <character> and ‘..2’ <double>.

vec_rbind(
  data.frame(x = TRUE),
  data.frame(x = 1, y = 2)
)
#>  x  y
#> 1 1 NA
#> 2 1 2

vec_rbind(
  data.frame(x = "a"),
  data.frame(x = 1, y = 2)
)
#> Error: Can’t combine ‘..1$x’ <character> and ‘..2$x’ <double>.
```
One major goal of vctrs is to provide a central place for implementing the coercion methods that make generic combinations possible. The two relevant generics are `vec_ptype2()` and `vec_cast()`. They both take two arguments and perform double dispatch, meaning that a method is selected based on the classes of both inputs.

The general mechanism for combining multiple inputs is:

1. Find the common type of a set of inputs by reducing (as in `base::Reduce()` or `purrr::reduce()`) the `vec_ptype2()` binary function over the set.
2. Convert all inputs to the common type with `vec_cast()`.
3. Initialise the output vector as an instance of this common type with `vec_init()`.
4. Fill the output vector with the elements of the inputs using `vec_assign()`.

The last two steps may require `vec_proxy()` and `vec_restore()` implementations, unless the attributes of your class are constant and do not depend on the contents of the vector. We focus here on the first two steps, which require `vec_ptype2()` and `vec_cast()` implementations.

`vec_ptype2()`:
Methods for `vec_ptype2()` are passed two prototypes, i.e. two inputs emptied of their elements. They implement two behaviours:

- If the types of their inputs are compatible, indicate which of them is the richer type by returning it. If the types are of equal resolution, return any of the two.
- Throw an error with `stop_incompatible_type()` when it can be determined from the attributes that the types of the inputs are not compatible.

**Type compatibility:**
A type is compatible with another type if the values it represents are a subset or a superset of the values of the other type. The notion of “value” is to be interpreted at a high level, in particular it is not the same as the memory representation. For example, factors are represented in memory with integers but their values are more related to character vectors than to round numbers:

```r
# Two factors are compatible
vec_ptype2(factor("a"), factor("b"))
#> Factor(0)
#> Levels: a b

# Factors are compatible with a character
vec_ptype2(factor("a"), "b")
#> character(0)

# But they are incompatible with integers
vec_ptype2(factor("a"), 1L)
#> Error: Can't combine <factor<127a2>> and <integer>.
```

**Richness of type:**
Richness of type is not a very precise notion. It can be about richer data (for instance a double vector covers more values than an integer vector), richer behaviour (a `data.table` has richer behaviour than a `data.frame`), or both. If you have trouble determining which one of the two types is richer, it probably means they shouldn’t be automatically coercible.

Let’s look again at what happens when we combine a factor and a character:

```r
vec_ptype2(factor("a"), "b")
#> character(0)
```

The `ptype2` method for `<character>` and `<factor<"a">>` returns `<character>` because the former is a richer type. The factor can only contain "a" strings, whereas the character can contain any strings. In this sense, factors are a subset of character.
Note that another valid behaviour would be to throw an incompatible type error. This is what a strict factor implementation would do. We have decided to be laxer in vctrs because it is easy to inadvertently create factors instead of character vectors, especially with older versions of R where `stringsAsFactors` is still true by default.

**Consistency and symmetry on permutation:**
Each `ptype2` method should strive to have exactly the same behaviour when the inputs are permuted. This is not always possible, for example factor levels are aggregated in order:

```r
vec_ptype2(factor(c("a", "c")), factor("b"))
#> factor(0)
#> Levels: a c b
```

```r
vec_ptype2(factor("b"), factor(c("a", "c")))
#> factor(0)
#> Levels: b a c
```

In any case, permuting the input should not return a fundamentally different type or introduce an incompatible type error.

**Coercion hierarchy:**
Coercible classes form a coercion (or subtyping) hierarchy. Here is a simplified diagram of the hierarchy for base types. In this diagram the directions of the arrows express which type is richer. They flow from the bottom (more constrained types) to the top (richer types).

As a class implementor, you have two options. The simplest is to create an entirely separate hierarchy. The date and date-time classes are an example of an S3-based hierarchy that is completely separate. Alternatively, you can integrate your class in an existing hierarchy, typically by adding parent nodes on top of the hierarchy (your class is richer), by adding children node at the root of the hierarchy (your class is more constrained), or by inserting a node in the tree.

These coercion hierarchies are *implicit*, in the sense that they are implied by the `vec_ptype2()` implementations. There is no structured way to create or modify a hierarchy, instead you need to implement the appropriate coercion methods for all the types in your hierarchy, and diligently return the richer type in each case. The `vec_ptype2()` implementations are not transitive nor inherited, so all pairwise methods between classes lying on a given path must be implemented manually. This is something we might make easier in the future.

`vec_cast()`:
The second generic, `vec_cast()`, is the one that looks at the data and actually performs the conversion. Because it has access to more information than `vec_ptype2()`, it may be stricter and...
cause an error in more cases. `vec_cast()` has three possible behaviours:

- Determine that the prototypes of the two inputs are not compatible. This must be decided in exactly the same way as for `vec_ptype2()`. Call `stop_incompatible_cast()` if you can determine from the attributes that the types are not compatible.
- Detect incompatible values. Usually this is because the target type is too restricted for the values supported by the input type. For example, a fractional number can’t be converted to an integer. The method should throw an error in that case.
- Return the input vector converted to the target type if all values are compatible. Whereas `vec_ptype2()` must return the same type when the inputs are permuted, `vec_cast()` is directional. It always returns the type of the right-hand side, or dies trying.

**Double dispatch:**
The dispatch mechanism for `vec_ptype2()` and `vec_cast()` looks like S3 but is actually a custom mechanism. Compared to S3, it has the following differences:

- It dispatches on the classes of the first two inputs.
- There is no inheritance of ptype2 and cast methods. This is because the S3 class hierarchy is not necessarily the same as the coercion hierarchy.
- `NextMethod()` does not work. Parent methods must be called explicitly if necessary.
- The default method is hard-coded.

**Data frames:**
The determination of the common type of data frames with `vec_ptype2()` happens in three steps:

1. Match the columns of the two input data frames. If some columns don’t exist, they are created and filled with adequately typed `NA` values.
2. Find the common type for each column by calling `vec_ptype2()` on each pair of matched columns.
3. Find the common data frame type. For example the common type of a grouped tibble and a tibble is a grouped tibble because the latter is the richer type. The common type of a data table and a data frame is a data table.

`vec_cast()` operates similarly. If a data frame is cast to a target type that has fewer columns, this is an error.

If you are implementing coercion methods for data frames, you will need to explicitly call the parent methods that perform the common type determination or the type conversion described above. These are exported as `df_ptype2()` and `df_cast()`.

**Data frame fallbacks:**
Being too strict with data frame combinations would cause too much pain because there are many data frame subclasses in the wild that don’t implement vctrs methods. We have decided to implement a special fallback behaviour for foreign data frames. Incompatible data frames fall back to a base data frame:

```
df1 <- data.frame(x = 1)
df2 <- structure(df1, class = c("foreign_df", "data.frame"))
```

```
vec_rbind(df1, df2)
#>     x
#> 1  1
#> 2  1
```

When a tibble is involved, we fall back to tibble:

```
df3 <- tibble::as_tibble(df1)
```
vec_rbind(df1, df3)

#> # A tibble: 2 x 1
#>     x
#>  1 <dbl>
#>  2  1

These fallbacks are not ideal but they make sense because all data frames share a common data structure. This is not generally the case for vectors. For example factors and characters have different representations, and it is not possible to find a fallback time mechanically. However this fallback has a big downside: implementing vctrs methods for your data frame subclass is a breaking behaviour change. The proper coercion behaviour for your data frame class should be specified as soon as possible to limit the consequences of changing the behaviour of your class in R scripts.

---

**vec_rep**  
Repeat a vector

**Description**

- `vec_rep()` repeats an entire vector a set number of times.
- `vec_rep_each()` repeats each element of a vector a set number of times.

**Usage**

```r
vec_rep(x, times)
vec_rep_each(x, times)
```

**Arguments**

- `x`  
  A vector.
- `times`  
  For `vec_rep()`, a single integer for the number of times to repeat the entire vector.
  
  For `vec_rep_each()`, an integer vector of the number of times to repeat each element of `x`. `times` will be recycled to the size of `x`.

**Details**

`vec_rep()` and `vec_rep_each()` work along the size of `x`, rather than its length. For data frames, this means that rows are repeated rather than columns.

**Value**

- For `vec_rep()`, a vector the same type as `x` with size `vec_size(x) * times`.
- For `vec_rep_each()`, a vector the same type as `x` with size `sum(vec_recycle(times, vec_size(x)))`.

**Dependencies**

- `vec_slice()`
Examples

# Repeat the entire vector
vec_rep(1:2, 3)

# Repeat within each vector
vec_rep_each(1:2, 3)
vec_rep_each(1:2, c(3, 4))

df <- data.frame(x = 1:2, y = 3:4)

# `rep()` repeats columns of data frames, and returns lists
rep(df, each = 2)

# `vec_rep()` and `vec_rep_each()` repeat rows, and return data frames
vec_rep(df, 2)
vec_rep_each(df, 2)

vec_assert

Assert an argument has known prototype and/or size

Description

• vec_is() is a predicate that checks if its input is a vector that conforms to a prototype and/or a size.

• vec_assert() throws an error when the input is not a vector or doesn’t conform.

Usage

vec_assert(x, ptype = NULL, size = NULL, arg = as_label(substitute(x)))

vec_is(x, ptype = NULL, size = NULL)

Arguments

x A vector argument to check.

ptype Prototype to compare against. If the prototype has a class, its vec_ptype() is compared to that of x with identical(). Otherwise, its typeof() is compared to that of x with ==.

size Size to compare against

arg Name of argument being checked. This is used in error messages. The label of the expression passed as x is taken as default.

Value

vec_is() returns TRUE or FALSE. vec_assert() either throws a typed error (see section on error types) or returns x, invisibly.
Scalars and vectors

Informally, a vector is a collection that makes sense to use as column in a data frame. An object is a vector if one of the following conditions hold:

- A `vec_proxy()` method is implemented for the class of the object.
- The base type of the object is atomic: "logical", "integer", "double", "complex", "character", "raw"
- The object is a `data.frame`.
- The base type is "list", and one of:
  - The object is a bare "list" without a "class" attribute.
  - The object explicitly inherits from "list". That is, the "class" attribute contains "list" and inherits(x,"list") is TRUE.

Otherwise an object is treated as scalar and cannot be used as a vector. In particular:

- NULL is not a vector.
- S3 lists like `lm` objects are treated as scalars by default.
- Objects of type `expression` are not treated as vectors.
- Support for S4 vectors is currently limited to objects that inherit from an atomic type.
- Subclasses of `data.frame` that `append` their class to the "class" attribute are not treated as vectors. If you inherit from an S3 class, always prepend your class to the "class" attribute for correct dispatch.

Error types

`vec_is()` never throws. `vec_assert()` throws the following errors:

- If the input is not a vector, an error of class "vctrs_error_scalar_type" is raised.
- If the prototype doesn’t match, an error of class "vctrs_error_assert_ptype" is raised.
- If the size doesn’t match, an error of class "vctrs_error_assert_size" is raised.

Both errors inherit from "vctrs_error_assert".

vec_as_names

Retrieve and repair names

Description

`vec_as_names()` takes a character vector of names and repairs it according to the `repair` argument. It is the r-lib and tidyverse equivalent of `base::make.names()`.

vctrs deals with a few levels of name repair:

- **minimal** names exist. The names attribute is not NULL. The name of an unnamed element is "" and never NA. For instance, `vec.as.names()` always returns minimal names and data frames created by the tibble package have names that are, at least, minimal.
- **unique** names are minimal, have no duplicates, and can be used where a variable name is expected. Empty names, ..., and .. followed by a sequence of digits are banned.
  - All columns can be accessed by name via `df[["name"]][df$name` and `with(df,"name")`.
- **universal** names are unique and syntactic (see Details for more).
  - Names work everywhere, without quoting: `df$name` and `with(df,name)` and `lm(name1 ~ name2, data = df)` and `dplyr::select(df,name)` all work.

universal implies unique, unique implies minimal. These levels are nested.
**vec_as_names**

**Usage**

```r
vec_as_names(
  names,
  ...,  
  repair = c("minimal", "unique", "universal", "check_unique"),
  repair_arg = "",
  quiet = FALSE
)
```

**Arguments**

- `names`: A character vector.
- `...`: These dots are for future extensions and must be empty.
- `repair`: Either a string or a function. If a string, it must be one of "check_unique", "minimal", "unique", or "universal". If a function, it is invoked with a vector of minimal names and must return minimal names, otherwise an error is thrown.
  - Minimal names are never NULL or NA. When an element doesn’t have a name, its minimal name is an empty string.
  - Unique names are unique. A suffix is appended to duplicate names to make them unique.
  - Universal names are unique and syntactic, meaning that you can safely use the names as variables without causing a syntax error.
  The "check_unique" option doesn’t perform any name repair. Instead, an error is raised if the names don’t suit the "unique" criteria.
- `repair_arg`: If specified and `repair = "check_unique"`, any errors will include a hint to set the `repair_arg`.
- `quiet`: By default, the user is informed of any renaming caused by repairing the names. This only concerns unique and universal repairing. Set `quiet` to TRUE to silence the messages.

**minimal names**

Minimal names exist. The names attribute is not NULL. The name of an unnamed element is "" and never NA.

Examples:

Original names of a vector with length 3: NULL

```
minimal names: "" "" ""
```

Original names: "x" NA

```
minimal names: "x" ""
```

**unique names**

Unique names are minimal, have no duplicates, and can be used (possibly with backticks) in contexts where a variable is expected. Empty names, ..., and .. followed by a sequence of digits are banned. If a data frame has unique names, you can index it by name, and also access the columns by name. In particular, df[["name"]], df$`name` and also with(df, `name`) always work.

There are many ways to make names unique. We append a suffix of the form ...j to any name that is "" or a duplicate, where j is the position. We also change ..# and ... to ...#.

Example:
vec_as_names

Original names: "" "x" "y" "x" ..2" ...
unique names: "...1" "x...2" "...3" "y" "x...5" "...6" "...7"

Pre-existing suffixes of the form ...j are always stripped, prior to making names unique, i.e. reconstructing the suffixes. If this interacts poorly with your names, you should take control of name repair.

universal names

universal names are unique and syntactic, meaning they:

- Are never empty (inherited from unique).
- Have no duplicates (inherited from unique).
- Are not .... Do not have the form ...i, where i is a number (inherited from unique).
- Consist of letters, numbers, and the dot . or underscore _ characters.
- Start with a letter or start with the dot . not followed by a number.
- Are not a reserved word, e.g., if or function or TRUE.

If a vector has universal names, variable names can be used "as is" in code. They work well with nonstandard evaluation, e.g., df$name works.

vctrs has a different method of making names syntactic than base::make.names(). In general, vctrs prepends one or more dots . until the name is syntactic.

Examples:

Original names: "" "x" NA "x"
universal names: "...1" "x...2" "...3" "x...4"

Original names: "(y)" "z" "2fa" "FALSE"
universal names: ".y." ".z" "..2fa" ".FALSE"

See Also

rlang::names2() returns the names of an object, after making them minimal.

The Names attribute section in the "tidyverse package development principles".

Examples

# By default, `vec_as_names()` returns minimal names:
vec_as_names(c(NA, NA, "foo"))

# You can make them unique:
vec_as_names(c(NA, NA, "foo"), repair = "unique")

# Universal repairing fixes any non-syntactic name:
vec_as_names(c("_foo", "+"), repair = "universal")
vec_bind

Combine many data frames into one data frame

Description

This pair of functions binds together data frames (and vectors), either row-wise or column-wise. Row-binding creates a data frame with common type across all arguments. Column-binding creates a data frame with common length across all arguments.

Usage

```r
vec_rbind(
  ..., .ptype = NULL,
  .names_to = rlang::zap(),
  .name_repair = c("unique", "universal", "check_unique"),
  .name_spec = NULL
)
```

```r
vec_cbind(
  ..., .ptype = NULL,
  .size = NULL,
  .name_repair = c("unique", "universal", "check_unique", "minimal")
)
```

Arguments

... Data frames or vectors.

When the inputs are named:

- `vec_rbind()` assigns names to row names unless `.names_to` is supplied. In that case the names are assigned in the column defined by `.names_to`.
- `vec_cbind()` creates packed data frame columns with named inputs.

NULL inputs are silently ignored. Empty (e.g. zero row) inputs will not appear in the output, but will affect the derived `.ptype`.

.ptype If NULL, the default, the output type is determined by computing the common type across all elements of ....

Alternatively, you can supply `.ptype` to give the output known type. If `getOption("vctrs.no_guessing")` is TRUE you must supply this value: this is a convenient way to make production code demand fixed types.

.names_to This controls what to do with input names supplied in ....

- By default, input names are zapped.
- If a string, specifies a column where the input names will be copied. These names are often useful to identify rows with their original input. If a column name is supplied and ... is not named, an integer column is used instead.
- If NULL, the input names are used as row names.
.name_repair One of "unique", "universal", or "check_unique". See `vec_as_names()` for the meaning of these options.

With `vec_rbind()`, the repair function is applied to all inputs separately. This is because `vec_rbind()` needs to align their columns before binding the rows, and thus needs all inputs to have unique names. On the other hand, `vec_cbind()` applies the repair function after all inputs have been concatenated together in a final data frame. Hence `vec_cbind()` allows the more permissive minimal names repair.

.name_spec A name specification (as documented in `vec_c()`) for combining the outer inputs names in ... and the inner row names of the inputs. This only has an effect when .names_to is set to NULL, which causes the input names to be assigned as row names.

.size If, NULL, the default, will determine the number of rows in `vec_cbind()` output by using the standard recycling rules. Alternatively, specify the desired number of rows, and any inputs of length 1 will be recycled appropriately.

Value

A data frame, or subclass of data frame.

If ... is a mix of different data frame subclasses, vec.ptype2() will be used to determine the output type. For `vec_rbind()`, this will determine the type of the container and the type of each column; for `vec_cbind()` it only determines the type of the output container. If there are no non-NULL inputs, the result will be `data.frame()`.

Invariants

All inputs are first converted to a data frame. The conversion for 1d vectors depends on the direction of binding:

- For `vec_rbind()`, each element of the vector becomes a column in a single row.
- For `vec_cbind()`, each element of the vector becomes a row in a single column.

Once the inputs have all become data frames, the following invariants are observed for row-binding:

- `vec_size(vec_rbind(x,y)) == vec_size(x) + vec_size(y)`
- `vec_ptype(vec_rbind(x,y)) = vec_ptype_common(x,y)`

Note that if an input is an empty vector, it is first converted to a 1-row data frame with 0 columns. Despite being empty, its effective size for the total number of rows is 1.

For column-binding, the following invariants apply:

- `vec_size(vec_cbind(x,y)) == vec_size_common(x,y)`
- `vec_ptype(vec_cbind(x,y)) == vec_cbind(vec_ptype(x),vec_ptype(x))`

Dependencies

vctrs dependencies:

- `vec_cast_common()`
- `vec_proxy()`
- `vec_init()`
- `vec_assign()`
vec_bind

- vec_restore()

**base dependencies of vec_rbind():**
- base::c()

If columns to combine inherit from a common class, vec_rbind() falls back to base::c() if there exists a c() method implemented for this class hierarchy.

**See Also**

vec_c() for combining 1d vectors.

**Examples**

# row binding -----------------------------------------

# common columns are coerced to common class
vec_rbind(
  data.frame(x = 1),
  data.frame(x = FALSE)
)

# unique columns are filled with NAs
vec_rbind(
  data.frame(x = 1),
  data.frame(y = "x")
)

# null inputs are ignored
vec_rbind(
  data.frame(x = 1),
  NULL,
  data.frame(x = 2)
)

# bare vectors are treated as rows
vec_rbind(
  c(x = 1, y = 2),
  c(y = 3)
)

# default names will be supplied if arguments are not named
vec_rbind(
  1:2,
  1:3,
  1:4
)

# column binding --------------------------------------

# each input is recycled to have common length
vec_cbind(
  data.frame(x = 1),
  data.frame(y = 1:3)
)

# bare vectors are treated as columns
vec_cbind(
  data.frame(x = 1),
  y = letters[1:3]
)

# if you supply a named data frame, it is packed in a single column
data <- vec_cbind(
  x = data.frame(a = 1, b = 2),
  y = 1
)
data

# Packed data frames are nested in a single column. This makes it
# possible to access it through a single name:
data$x

# since the base print method is suboptimal with packed data
# frames, it is recommended to use tibble to work with these:
if (rlang::is_installed("tibble")) {
  vec_cbind(x = tibble::tibble(a = 1, b = 2), y = 1)
}

# duplicate names are flagged
vec_cbind(x = 1, x = 2)

---

vec_c Combine many vectors into one vector

Description
Combine all arguments into a new vector of common type.

Usage
vec_c(
  ..., .ptype = NULL,
  .name_spec = NULL,
  .name_repair = c("minimal", "unique", "check_unique", "universal")
)

Arguments
... Vectors to coerce.
.ptype If NULL, the default, the output type is determined by computing the common
type across all elements of .... Alternatively, you can supply .ptype to give the output known type. If getOption("vctrs.no_guessing") is TRUE you must supply this value: this is a convenient way to make production
code demand fixed types.
vec_c

.name_spec  A name specification for combining inner and outer names. This is relevant for inputs passed with a name, when these inputs are themselves named, like outer = c(inner = 1), or when they have length greater than 1: outer = 1:2. By default, these cases trigger an error. You can resolve the error by providing a specification that describes how to combine the names or the indices of the inner vector with the name of the input. This specification can be:

- A function of two arguments. The outer name is passed as a string to the first argument, and the inner names or positions are passed as second argument.
- An anonymous function as a purrr-style formula.
- A glue specification of the form "{outer}_{inner}".
- An rlang::zap() object, in which case both outer and inner names are ignored and the result is unnamed.

See the name specification topic.

.name_repair  How to repair names, see repair options in vec_as_names().

Value

A vector with class given by .ptype, and length equal to the sum of the vec_size() of the contents of ....

The vector will have names if the individual components have names (inner names) or if the arguments are named (outer names). If both inner and outer names are present, an error is thrown unless a .name_spec is provided.

Invariants

- vec_size(vec_c(x,y)) == vec_size(x) + vec_size(y)
- vec_ptype(vec_c(x,y)) == vec_ptype_common(x,y).

 Dependencies

vctrs dependencies:
- vec_cast_common() with fallback
- vec_proxy()
- vec_restore()

base dependencies:
- base::c()

If inputs inherit from a common class hierarchy, vec_c() falls back to base::c() if there exists a c() method implemented for this class hierarchy.

See Also

vec_cbind()/vec_rbind() for combining data frames by rows or columns.
Examples

```
vec_c(FALSE, 1L, 1.5)

# Date/times -------------------------
c(Sys.Date(), Sys.time())
c(Sys.time(), Sys.Date())

vec_c(Sys.Date(), Sys.time())
vec_c(Sys.time(), Sys.Date())

# Factors ---------------------------
c(factor("a"), factor("b"))
vec_c(factor("a"), factor("b"))

# By default, named inputs must be length 1:
vec_c(name = 1)
try(vec_c(name = 1:3))

# Pass a name specification to work around this:
vec_c(name = 1:3, .name_spec = "{outer}_{inner}")

# See '?name_spec' for more examples of name specifications.
```
## S3 method for class 'character'
vec_cast(x, to, ...)

## S3 method for class 'list'
vec_cast(x, to, ...)

### Arguments

- **x**: Vectors to cast.
- **to, .to**: Type to cast to. If `NULL`, `x` will be returned as is.
- **...**: For `vec_cast_common()`, vectors to cast. For `vec_cast()`, `vec_cast_default()`, and `vec_restore()`, these dots are only for future extensions and should be empty.
- **x_arg, to_arg**: Argument names for `x` and `to`. These are used in error messages to inform the user about the locations of incompatible types (see `stop_incompatible_type()`).

### Value

A vector the same length as `x` with the same type as `to`, or an error if the cast is not possible. An error is generated if information is lost when casting between compatible types (i.e. when there is no 1-to-1 mapping for a specific value).

### Implementing coercion methods

- For an overview of how these generics work and their roles in vctrs, see `?theory-faq-coercion`.
- For an example of implementing coercion methods for simple vectors, see `?howto-faq-coercion`.
- For an example of implementing coercion methods for data frame subclasses, see `?howto-faq-coercion-data-frame`.
- For a tutorial about implementing vctrs classes from scratch, see vignette("s3-vector").

### Dependencies of `vec_cast_common()`

- **vctrs dependencies:**
  - `vec_ptype2()`
  - `vec_cast()`

- **base dependencies:**
  Some functions enable a base-class fallback for `vec_cast_common()`. In that case the inputs are deemed compatible when they have the same base type and inherit from the same base class.

### See Also

- Call `stop_incompatible_cast()` when you determine from the attributes that an input can’t be cast to the target type.

### Examples

```r
# x is a double, but no information is lost
vec_cast(1, integer())
```

```r
# When information is lost the cast fails
try(vec_cast(c(1, 1.5), integer()))
```
try(vec_cast(c(1, 2), logical()))

# You can suppress this error and get the partial results
allow_lossy_cast(vec_cast(c(1, 1.5), integer()))
allow_lossy_cast(vec_cast(c(1, 2), logical()))

# By default this suppress all lossy cast errors without
# distinction, but you can be specific about what cast is allowed
# by supplying prototypes
allow_lossy_cast(vec_cast(c(1, 1.5), integer()), to_ptype = integer())
try(allow_lossy_cast(vec_cast(c(1, 2), logical()), to_ptype = integer()))

# No sensible coercion is possible so an error is generated
try(vec_cast(1.5, factor("a")))

# Cast to common type
vec_cast_common(factor("a"), factor(c("a", "b")))

---

**vec_chop**

**Chopping**

**Description**

- `vec_chop()` provides an efficient method to repeatedly slice a vector. It captures the pattern of `map(indices, vec_slice, x = x)`. When no indices are supplied, it is generally equivalent to `as.list()`.
- `vec_unchop()` combines a list of vectors into a single vector, placing elements in the output according to the locations specified by `indices`. It is similar to `vec_c()`, but gives greater control over how the elements are combined. When no indices are supplied, it is identical to `vec_c()`.

If `indices` selects every value in `x` exactly once, in any order, then `vec_unchop()` is the inverse of `vec_chop()` and the following invariant holds:

`vec_unchop(vec_chop(x, indices), indices) == x`

**Usage**

```
vec_chop(x, indices = NULL)
vec_unchop(
  x,
  indices = NULL,
  ptype = NULL,
  name_spec = NULL,
  name_repair = c("minimal", "unique", "check_unique", "universal")
)
```

**Arguments**

- `x` A vector
vec_chop

indices
For vec_chop(), a list of positive integer vectors to slice x with, or NULL. If NULL, x is split into its individual elements, equivalent to using an indices of as.list(vec_seq_along(x)).

For vec_unchop(), a list of positive integer vectors specifying the locations to place elements of x in. Each element of x is recycled to the size of the corresponding index vector. The size of indices must match the size of x. If NULL, x is combined in the order it is provided in, which is equivalent to using vec_c().

ptype
If NULL, the default, the output type is determined by computing the common type across all elements of x. Alternatively, you can supply ptype to give the output a known type.

name_spec
A name specification for combining inner and outer names. This is relevant for inputs passed with a name, when these inputs are themselves named, like outer = c(inner = 1), or when they have length greater than 1: outer = 1:2.

By default, these cases trigger an error. You can resolve the error by providing a specification that describes how to combine the names or the indices of the inner vector with the name of the input. This specification can be:

• A function of two arguments. The outer name is passed as a string to the first argument, and the inner names or positions are passed as second argument.
• An anonymous function as a purrr-style formula.
• A glue specification of the form "{outer}_{inner}".
• An rlang::zap() object, in which case both outer and inner names are ignored and the result is unnamed.

See the name specification topic.

name_repair
How to repair names, see repair options in vec_as_names().

Value

• vec_chop(): A list of size vec_size(indices) or, if indices == NULL, vec_size(x).
• vec_unchop(): A vector of type vec_ptype_common(!!!x), or ptype, if specified. The size is computed as vec_size_common(!!!indices) unless the indices are NULL, in which case the size is vec_size_common(!!!x).

Dependencies of vec_chop()

• vec_slice()

Dependencies of vec_unchop()

• vec_c()

Examples

vec_chop(1:5)
vec_chop(1:5, list(1, 1:2))
vec_chop(mtcars, list(1:3, 4:6))

# If 'indices' selects every value in 'x' exactly once,
# in any order, then 'vec_unchop()' inverts 'vec_chop('
vec_chop(x, indices)
vec_compare

vec_unchop(vec_chop(x, indices), indices)

# When unchopping, size 1 elements of `x` are recycled
# to the size of the corresponding index
vec_unchop(list(1, 2:3), list(c(1, 3, 5), c(2, 4)))

# Names are retained, and outer names can be combined with inner
# names through the use of a `name_spec`
lst <- list(x = c(a = 1, b = 2), y = 1)
vec_unchop(lst, list(c(3, 2), c(1, 4)), name_spec = "(outer)_(inner)"

# An alternative implementation of `ave()` can be constructed using
# `vec_chop()` and `vec_unchop()` in combination with `vec_group_loc()`
ave2 <- function(.x, .by, .f, ...) {
  indices <- vec_group_loc(.by)$loc
  chopped <- vec_chop(.x, indices)
  out <- lapply(chopped, .f, ...)
  vec_unchop(out, indices)
}

breaks <- warpbreaks$breaks
wool <- warpbreaks$wool
ave2(breaks, wool, mean)

identical(
  ave2(breaks, wool, mean),
  ave(breaks, wool, FUN = mean)
)

---

vec_compare

**Compare two vectors**

**Description**

Compare two vectors

**Usage**

vec_compare(x, y, na_equal = FALSE, .ptype = NULL)

**Arguments**

- `x, y` Vectors with compatible types and lengths.
- `na_equal` Should NA values be considered equal?
- `.ptype` Override to optionally specify common type

**Value**

An integer vector with values -1 for \( x < y \), 0 if \( x = y \), and 1 if \( x > y \). If `na_equal` is `FALSE`, the result will be `NA` if either `x` or `y` is `NA`. 
vec_count

S3 dispatch

vec_compare() is not generic for performance; instead it uses vec_proxy_compare() to

Dependencies

• vec_cast_common() with fallback
• vec_recycle_common()
• vec_proxy_compare()

Examples

vec_compare(c(TRUE, FALSE, NA), FALSE)
vec_compare(c(TRUE, FALSE, NA), FALSE, na_equal = TRUE)

vec_compare(1:10, 5)
vec_compare(runif(10), 0.5)
vec_compare(letters[1:10], "d")

df <- data.frame(x = c(1, 1, 1, 2), y = c(0, 1, 2, 1))
vec_compare(df, data.frame(x = 1, y = 1))

vec_count

Count unique values in a vector

Description

Count the number of unique values in a vector. vec_count() has two important differences to
table(): it returns a data frame, and when given multiple inputs (as a data frame), it only counts
combinations that appear in the input.

Usage

vec_count(x, sort = c("count", "key", "location", "none"))

Arguments

x
A vector (including a data frame).

sort
One of "count", "key", "location", or "none".
• "count", the default, puts most frequent values at top
• "key", orders by the output key column (i.e. unique values of x)
• "location", orders by location where key first seen. This is useful if you
want to match the counts up to other unique/duplicated functions.
• "none", leaves unordered.

Value

A data frame with columns key (same type as x) and count (an integer vector).
Dependencies

- vec_proxy_equal()
- vec_slice()
- vec_order()

Examples

vec_count(mtcars$vs)
vec_count(iris$Species)

# If you count a data frame you'll get a data frame
# column in the output
str(vec_count(mtcars[c("vs", "am")]))

# Sorting ---------------------------------------

x <- letters[rpois(100, 6)]
# default is to sort by frequency
vec_count(x)

# by can sort by key
vec_count(x, sort = "key")

# or location of first value
vec_count(x, sort = "location")
head(x)

# or not at all
vec_count(x, sort = "none")

---

vec_duplicate  

Find duplicated values

Description

- vec_duplicate_any(): detects the presence of duplicated values, similar to anyDuplicated().
- vec_duplicate_detect(): returns a logical vector describing if each element of the vector is duplicated elsewhere. Unlike duplicated(), it reports all duplicated values, not just the second and subsequent repetitions.
- vec_duplicate_id(): returns an integer vector giving the location of the first occurrence of the value.

Usage

vec_duplicate_any(x)
vec_duplicate_detect(x)
vec_duplicate_id(x)
Arguments

\[ x \]
A vector (including a data frame).

Value

- `vec_duplicate_any()`: a logical vector of length 1.
- `vec_duplicate_detect()`: a logical vector the same length as `x`.
- `vec_duplicate_id()`: an integer vector the same length as `x`.

Missing values

In most cases, missing values are not considered to be equal, i.e. `NA == NA` is not `TRUE`. This behaviour would be unappealing here, so these functions consider all NAs to be equal. (Similarly, all NaN are also considered to be equal.)

Dependencies

- `vec_proxy_equal()`

See Also

`vec_unique()` for functions that work with the dual of duplicated values: unique values.

Examples

```r
vec_duplicate_any(1:10)
vec_duplicate_any(c(1, 1:10))

x <- c(10, 10, 20, 30, 30, 40)
vec_duplicate_detect(x)
# Note that `duplicated()` doesn't consider the first instance to be a duplicate
duplicated(x)

# Identify elements of a vector by the location of the first element that they're equal to:
vec_duplicate_id(x)
# Location of the unique values:
vec_unique_loc(x)
# Equivalent to `duplicated()`:
vec_duplicate_id(x) == seq_along(x)
```

---

**vec_equal**

Test if two vectors are equal

Description

`vec_equal_na()` tests a special case: equality with NA. It is similar to `is.na` but:

- Considers the missing element of a list to be `NULL`.
- Considered data frames and records to be missing if every component is missing. This preserves the invariant that `vec_equal_na(x)` is equal to `vec_equal(x, vec_init(x), na_equal = TRUE)`.
vec_equal

Usage

\[
\text{vec_equal}(x, y, \text{na_equal} = \text{FALSE}, \text{.ptype} = \text{NULL})
\]

\[
\text{vec_equal}\_\text{na}(x)
\]

Arguments

- **x**: Vectors with compatible types and lengths.
- **y**: Vectors with compatible types and lengths.
- **na_equal**: Should NA values be considered equal?
- **.ptype**: Override to optionally specify common type

Value

A logical vector the same size as. Will only contain NAs if na_equal is FALSE.

Dependencies

- `vec\_cast\_common()` with fallback
- `vec\_recycle\_common()
- `vec\_proxy\_equal()

Examples

\[
\text{vec_equal}(\text{c(TRUE, FALSE, NA), FALSE})
\]

\[
\text{vec_equal}(\text{c(TRUE, FALSE, NA), FALSE, na_equal = TRUE})
\]

\[
\text{vec_equal}\_\text{na}(\text{c(TRUE, FALSE, NA)})
\]

\[
\text{vec_equal}(5, 1:10)
\]

\[
\text{vec_equal}(`d`, \text{letters}[1:10])
\]

\[
\text{df} <- \text{data.frame}(x = \text{c(1, 1, 2, 1, NA)}, y = \text{c(1, 2, 1, NA, NA)})
\]

\[
\text{vec_equal}(\text{df}, \text{data.frame}(x = 1, y = 2))
\]

\[
\text{vec_equal}\_\text{na}(\text{df})
\]

vec_init

Initialize a vector

Description

Initialize a vector

Usage

vec_init(x, n = 1L)

Arguments

- **x**: Template of vector to initialize.
- **n**: Desired size of result.
vec_is_list

Dependencies

- vec_slice()

Examples

vec_init(1:10, 3)
vec_init(Sys.Date(), 5)
vec_init(mtcars, 2)

<table>
<thead>
<tr>
<th>vec_is_list</th>
<th>Is the object a list?</th>
</tr>
</thead>
</table>

Description

vec_is_list() tests if x is considered a list in the vctrs sense. It returns TRUE if:

- x is a bare list with no class.
- x is a list explicitly inheriting from "list".

Usage

vec_is_list(x)

Arguments

x

An object.

Details

Notably, data frames and S3 record style classes like POSIXlt are not considered lists.

Examples

vec_is_list(list())
vec_is_list(list_of(1))
vec_is_list(data.frame())
**vec_match**

Find matching observations across vectors

**Description**

vec_in() returns a logical vector based on whether needle is found in haystack. vec_match() returns an integer vector giving location of needle in haystack, or NA if it's not found.

**Usage**

```r
vec_match(
  needles, haystack,
  ..., na_equal = TRUE, needles_arg = "", haystack_arg = ""
)
```

```r
vec_in(
  needles, haystack,
  ..., na_equal = TRUE, needles_arg = "", haystack_arg = ""
)
```

**Arguments**

- `needles`, `haystack`
  Vector of needles to search for in vector haystack. haystack should usually be unique; if not vec_match() will only return the location of the first match. needles and haystack are coerced to the same type prior to comparison.

- `...`
  These dots are for future extensions and must be empty.

- `na_equal`
  If TRUE, missing values in needles can be matched to missing values in haystack. If FALSE, they propagate, missing values in needles are represented as NA in the return value.

- `needles_arg`, `haystack_arg`
  Argument tags for needles and haystack used in error messages.

**Details**

vec_in() is equivalent to `%in%`; vec_match() is equivalent to match().

**Value**

A vector the same length as needles. vec_in() returns a logical vector; vec_match() returns an integer vector.
Missing values

In most cases places in R, missing values are not considered to be equal, i.e. `NA == NA` is not `TRUE`. The exception is in matching functions like `match()` and `merge()`, where an NA will match another NA. By `vec_match()` and `vec_in()` will match NAs; but you can control this behaviour with the `na_equal` argument.

Dependencies

- `vec_cast_common()` with fallback
- `vec_proxy_equal()`

Examples

```r
hadley <- strsplit("hadley", "")[[1]]
vec_match(hadley, letters)

vowels <- c("a", "e", "i", "o", "u")
vec_match(hadley, vowels)
vec_in(hadley, vowels)

# Only the first index of duplicates is returned
vec_match(c("a", "b"), c("a", "b", "a", "b"))
```

vec_names

Get or set the names of a vector

Description

These functions work like `rlang::names2()`, `names()` and `names<-()`, except that they return or modify the rowwise names of the vector. These are:

- The usual `names()` for atomic vectors and lists
- The row names for data frames and matrices
- The names of the first dimension for arrays Rowwise names are size consistent: the length of the names always equals `vec_size()`.

`vec_names2()` returns the repaired names from a vector, even if it is unnamed. See `vec_as_names()` for details on name repair.

`vec_names()` is a bare-bones version that returns NULL if the vector is unnamed.

`vec_set_names()` sets the names or removes them.

Usage

```r
vec_names2(
  x,
  ...,
  repair = c("minimal", "unique", "universal", "check_unique"),
  quiet = FALSE
)

vec_names(x)

vec_set_names(x, names)
```
## vec_order

### Description

Order and sort vectors

### Arguments

- **x**: A vector with names
- **...**: These dots are for future extensions and must be empty.
- **repair**: Either a string or a function. If a string, it must be one of "check_unique", "minimal", "unique", or "universal". If a function, it is invoked with a vector of minimal names and must return minimal names, otherwise an error is thrown.
  - Minimal names are never NULL or NA. When an element doesn't have a name, its minimal name is an empty string.
  - Unique names are unique. A suffix is appended to duplicate names to make them unique.
  - Universal names are unique and syntactic, meaning that you can safely use the names as variables without causing a syntax error.
  The "check_unique" option doesn't perform any name repair. Instead, an error is raised if the names don't suit the "unique" criteria.
- **quiet**: By default, the user is informed of any renaming caused by repairing the names. This only concerns unique and universal repairing. Set quiet to TRUE to silence the messages.
- **names**: A character vector, or NULL.

### Value

vec_names2() returns the names of `x`, repaired. vec_names() returns the names of `x` or NULL if unnamed. vec_set_names() returns `x` with names updated.

### Examples

```r
vec_names2(1:3)
vec_names2(1:3, repair = "unique")
vec_names2(c(a = 1, b = 2))

vec_set_names(1:3, letters[1:3])
vec_set_names(data.frame(a = 1:3), letters[1:3])
```

Consistently returns the rowwise names of data frames and arrays:
```r
vec_names(data.frame(a = 1, b = 2))
names(data.frame(a = 1, b = 2))
vec_names(mtcars)
names(mtcars)
vec_names(Titanic)
names(Titanic)
```

```r
vec_set_names(1:3, letters[1:3])
vec_set_names(data.frame(a = 1:3), letters[1:3])
```
vec_ptype

Usage

vec_order(x, direction = c("asc", "desc"), na_value = c("largest", "smallest"))
vec_sort(x, direction = c("asc", "desc"), na_value = c("largest", "smallest"))

Arguments

x
A vector
direction
Direction to sort in. Defaults to ascending.
na_value
Should NAs be treated as the largest or smallest values?

Value

- `vec_order()` an integer vector the same size as x.
- `vec_sort()` a vector with the same size and type as x.

Dependencies of `vec_order()`

- `vec_proxy_order()`

Dependencies of `vec_sort()`

- `vec_proxy_order()`
- `vec_order()`
- `vec_slice()`

Examples

x <- round(c(runif(9), NA), 3)
vec_order(x)
vec_sort(x)
vec_sort(x, "desc")

# Can also handle data frames
df <- data.frame(g = sample(2, 10, replace = TRUE), x = x)
vec_order(df)
vec_sort(df)
vec_sort(df, "desc")

vec_ptype

Find the prototype of a set of vectors

Description

`vec_ptype()` returns the unfinalised prototype of a single vector. `vec_ptype_common()` finds the common type of multiple vectors. `vec_ptype_show()` nicely prints the common type of any number of inputs, and is designed for interactive exploration.
Usage

vec_ptype(x, ..., x_arg = "")
vec_ptype_common(..., .ptype = NULL)
vec_ptype_show(...)

Arguments

x  A vector
... For vec_ptype(), these dots are for future extensions and must be empty.
For vec_ptype_common() and vec_ptype_show(), vector inputs.

x_arg  Argument name for x. This is used in error messages to inform the user about
the locations of incompatible types.

.ptype  If NULL, the default, the output type is determined by computing the common

type across all elements of ... Alternatively, you can supply .ptype to give the output known type. If getOption("vctrs.no_guessing")
is TRUE you must supply this value: this is a convenient way to make production
code demand fixed types.

Value

vec_ptype() and vec_ptype_common() return a prototype (a size-0 vector)

vec_ptype()

vec_ptype() returns size 0 vectors potentially containing attributes but no data. Generally, this is
just vec_slice(x,0L), but some inputs require special handling.

• While you can’t slice NULL, the prototype of NULL is itself. This is because we treat NULL as
an identity value in the vec_ptype2() monoid.

• The prototype of logical vectors that only contain missing values is the special unspecified

type, which can be coerced to any other 1d type. This allows bare NAs to represent missing
values for any 1d vector type.

See internal-faq-ptype2-identity for more information about identity values.

Because it may contain unspecified vectors, the prototype returned by vec_ptype() is said to be
unfinalised. Call vec_ptype_finalise() to finalise it. Commonly you will need the finalised
prototype as returned by vec_slice(x,0L).

vec_ptype_common()

vec_ptype_common() first finds the prototype of each input, then successively calls vec_ptype2() to
find a common type. It returns a finalised prototype.

Dependencies of vec_ptype()

• vec_slice() for returning an empty slice

Dependencies of vec_ptype_common()

• vec_ptype2()
• vec_ptype_finalise()
vec_ptype2.logical

Find the common type for a pair of vectors

Description

vec_ptype2() defines the coercion hierarchy for a set of related vector types. Along with vec_cast(),
this generic forms the foundation of type coercions in vctrs.

vec_ptype2() is relevant when you are implementing vctrs methods for your class, but it should not
usually be called directly. If you need to find the common type of a set of inputs, call vec_ptype_common()
instead. This function supports multiple inputs and finalises the common type.

Usage

## S3 method for class 'logical'
vec_ptype2(x, y, ..., x_arg = "", y_arg = "")

## S3 method for class 'integer'
vec_ptype2(x, y, ..., x_arg = "", y_arg = "")
## S3 method for class 'double'
vec_ptype2(x, y, ..., x_arg = "", y_arg = "")

## S3 method for class 'complex'
vec_ptype2(x, y, ..., x_arg = "", y_arg = "")

## S3 method for class 'character'
vec_ptype2(x, y, ..., x_arg = "", y_arg = "")

## S3 method for class 'raw'
vec_ptype2(x, y, ..., x_arg = "", y_arg = "")

## S3 method for class 'list'
vec_ptype2(x, y, ..., x_arg = "", y_arg = "")

vec_ptype2(x, y, ..., x_arg = "", y_arg = "")

Arguments

- **x, y**: Vector types.
- **...**: These dots are for future extensions and must be empty.
- **x_arg, y_arg**: Argument names for x and y. These are used in error messages to inform the user about the locations of incompatible types (see `stop_incompatible_type()`).

Implementing coercion methods

- For an overview of how these generics work and their roles in vctrs, see `?theory-faq-coercion`.
- For an example of implementing coercion methods for simple vectors, see `?howto-faq-coercion`.
- For an example of implementing coercion methods for data frame subclasses, see `?howto-faq-coercion-data-frame`.
- For a tutorial about implementing vctrs classes from scratch, see vignette("s3-vector")

Dependencies

- `vec_ptype()` is applied to x and y

See Also

- `stop_incompatible_type()` when you determine from the attributes that an input can’t be cast to the target type.

---

vec_recycle | Vector recycling

Description

vec_recycle(x, size) recycles a single vector to given size. vec_recycle_common(...) recycles multiple vectors to their common size. All functions obey the vctrs recycling rules, described below, and will throw an error if recycling is not possible. See vec_size() for the precise definition of size.
vec_recycle

Usage

vec_recycle(x, size, ..., x_arg = "")

vec_recycle_common(..., .size = NULL)

Arguments

x
A vector to recycle.

size
Desired output size.

... • For vec_recycle_common(), vectors to recycle.
   - For vec_recycle(), these dots should be empty.

x_arg
Argument name for x. These are used in error messages to inform the user about which argument has an incompatible size.

.size
Desired output size. If omitted, will use the common size from vec_size_common().

Recycling rules

The common size of two vectors defines the recycling rules, and can be summarise with the following table:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>m</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>m</td>
<td>n</td>
</tr>
<tr>
<td>m</td>
<td>m</td>
<td>m</td>
<td>X</td>
</tr>
<tr>
<td>n</td>
<td>n</td>
<td>X</td>
<td>n</td>
</tr>
</tbody>
</table>

(Note NULLs are handled specially; they are treated like empty arguments and hence don’t affect the size)

This is a stricter set of rules than base R, which will usually return output of length \( \max(nx, ny) \), warning if the length of the longer vector is not an integer multiple of the length of the shorter.

We say that two vectors have **compatible size** if they can be recycled to be the same length.
Dependencies

- vec_slice()

Examples

# Inputs with 1 observation are recycled
vec_recycle_common(1:5, 5)
vec_recycle_common(integer(), 5)
## Not run:
vec_recycle_common(1:5, 1:2)
## End(Not run)

# Data frames and matrices are recycled along their rows
vec_recycle_common(data.frame(x = 1), 1:5)
vec_recycle_common(array(1:2, c(1, 2)), 1:5)
vec_recycle_common(array(1:3, c(1, 3, 1)), 1:5)

---

vec_seq_along Useful sequences

Description

vec_seq_along() is equivalent to seq_along() but uses size, not length. vec_init_along() creates a vector of missing values with size matching an existing object.

Usage

vec_seq_along(x)
vec_init_along(x, y = x)

Arguments

x, y  Vectors

Value

- vec_seq_along() an integer vector with the same size as x.
- vec_init_along() a vector with the same type as x and the same size as y.

Examples

vec_seq_along(mtcars)
vec_init_along(head(mtcars))
vec_size

Description

vec_size(x) returns the size of a vector. vec_is_empty() returns TRUE if the size is zero, FALSE otherwise.

The size is distinct from the length() of a vector because it generalises to the "number of observations" for 2d structures, i.e. it's the number of rows in a matrix or a data frame. This definition has the important property that every column of a data frame (even data frame and matrix columns) have the same size. vec_size_common(...) returns the common size of multiple vectors.

list_sizes() returns an integer vector containing the size of each element of a list. It is nearly equivalent to, but faster than, map_int(x, vec_size), with the exception that list_sizes() will error on non-list inputs, as defined by vec_is_list(). list_sizes() is to vec_size() as lengths() is to length().

Usage

vec_size(x)

vec_size_common(..., .size = NULL, .absent = 0L)

list_sizes(x)

vec_is_empty(x)

Arguments

x, ...  Vector inputs or NULL.

.size  If NULL, the default, the output size is determined by recycling the lengths of all elements of .... Alternatively, you can supply .size to force a known size; in this case, x and ... are ignored.

.absent  The size used when no input is provided, or when all input is NULL. If left as NULL when no input is supplied, an error is thrown.

Details

There is no vctrs helper that retrieves the number of columns: as this is a property of the type. vec_size() is equivalent to NROW() but has a name that is easier to pronounce, and throws an error when passed non-vector inputs.

Value

An integer (or double for long vectors).

vec_size_common() returns .absent if all inputs are NULL or absent, 0L by default.

Invariants

- vec_size(dataframe) == vec_size(dataframe[[i]])
- vec_size(matrix) == vec_size(matrix[,i,drop = FALSE])
- vec_size(vec_c(x,y)) == vec_size(x) + vec_size(y)
The size of NULL

The size of NULL is hard-coded to 0L in vec_size(). vec_size_common() returns .absent when all inputs are NULL (if only some inputs are NULL, they are simply ignored).
A default size of 0 makes sense because sizes are most often queried in order to compute a total size while assembling a collection of vectors. Since we treat NULL as an absent input by principle, we return the identity of sizes under addition to reflect that an absent input doesn’t take up any size.
Note that other defaults might make sense under different circumstances. For instance, a default size of 1 makes sense for finding the common size because 1 is the identity of the recycling rules.

Dependencies

• vec_proxy()

See Also

vec_slice() for a variation of [ compatible with vec_size(), and vec_recycle() to recycle vectors to common length.

Examples

vec_size(1:100)
vec_size(mtcars)
vec_size(array(dim = c(3, 5, 10)))

vec_size_common(1:10, 1:10)
vec_size_common(1:10, 1)
vec_size_common(integer(), 1)
list_sizes(list("a", 1:5, letters))

vec_split Split a vector into groups

Description

This is a generalisation of split() that can split by any type of vector, not just factors. Instead of returning the keys in the character names, the are returned in a separate parallel vector.

Usage

vec_split(x, by)

Arguments

x Vector to divide into groups.
by Vector whose unique values defines the groups.

Value

A data frame with two columns and size equal to vec_size(vec_unique(by)). The key column has the same type as by, and the val column is a list containing elements of type vec_ptype(x).
Note for complex types, the default data.frame print method will be suboptimal, and you will want to coerce into a tibble to better understand the output.
**vec_unique**

**Find and count unique values**

**Dependencies**

- `vec_group_loc()`
- `vec_chop()`

**Examples**

```r
vec_split(mtcars$cyl, mtcars$vs)
vec_split(mtcars$cyl, mtcars[c("vs", "am")])

if (require("tibble")) {
  as_tibble(vec_split(mtcars$cyl, mtcars[c("vs", "am")]))
  as_tibble(vec_split(mtcars, mtcars[c("vs", "am")]))
}
```

**Description**

- `vec_unique()`: the unique values. Equivalent to `unique()`.
- `vec_unique_loc()`: the locations of the unique values.
- `vec_unique_count()`: the number of unique values.

**Usage**

```r
vec_unique(x)
vec_unique_loc(x)
vec_unique_count(x)
```

**Arguments**

- `x`: A vector (including a data frame).

**Value**

- `vec_unique()`: a vector the same type as `x` containing only unique values.
- `vec_unique_loc()`: an integer vector, giving locations of unique values.
- `vec_unique_count()`: an integer vector of length 1, giving the number of unique values.

**Dependencies**

- `vec_proxy_equal()`

**Missing values**

In most cases, missing values are not considered to be equal, i.e. `NA == NA` is not `TRUE`. This behaviour would be unappealing here, so these functions consider all NAs to be equal. (Similarly, all NaN are also considered to be equal.)
See Also

vec_duplicate for functions that work with the dual of unique values: duplicated values.

Examples

```r
x <- rpois(100, 8)
vec_unique(x)
vec_unique_loc(x)
vec_unique_count(x)

# 'vec_unique()' returns values in the order that encounters them
# use sort = "location" to match to the result of 'vec_count()'
head(vec_unique(x))
head(vec_count(x, sort = "location"))

# Normally missing values are not considered to be equal
NA == NA

# But they are for the purposes of considering uniqueness
vec_unique(c(NA, NA, NA, NA, 1, 2, 1))
```

%0% Default value for empty vectors

Description

Use this inline operator when you need to provide a default value for empty (as defined by vec_is_empty()) vectors.

Usage

```r
x %0% y
```

Arguments

- `x`: A vector
- `y`: Value to use if `x` is empty. To preserve type-stability, should be the same type as `x`.

Examples

```r
1:10 %0% 5
integer() %0% 5
```
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