

# Package ‘alabaster.base’

September 10, 2025

**Title** Save Bioconductor Objects to File

**Version** 1.8.1

**Date** 2025-06-04

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**Description** Save Bioconductor data structures into file artifacts, and load them back into memory. This is a more robust and portable alternative to serialization of such objects into RDS files. Each artifact is associated with metadata for further interpretation; downstream applications can enrich this metadata with context-specific properties.

**Imports** alabaster.schemas, methods, utils, S4Vectors, rhdf5 (>= 2.47.6), jsonlite, jsonvalidate, Rcpp

**Suggests** BiocStyle, rmarkdown, knitr, testthat, digest, Matrix, alabaster.matrix

**LinkingTo** Rcpp, assorthead (>= 1.1.2), Rhdf5lib

**VignetteBuilder** knitr

**SystemRequirements** C++17, GNU make

**RoxygenNote** 7.3.2

**Encoding** UTF-8

**biocViews** DataRepresentation, DataImport

**URL** <https://github.com/ArtifactDB/alabaster.base>

**BugReports** <https://github.com/ArtifactDB/alabaster.base/issues>

**git\_url** <https://git.bioconductor.org/packages/alabaster.base>

**git\_branch** RELEASE\_3\_21

**git\_last\_commit** 7f04096

**git\_last\_commit\_date** 2025-06-04

**Repository** Bioconductor 3.21

**Date/Publication** 2025-09-10

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|                |                                   |
|----------------|-----------------------------------|
| absolutizePath | <i>Make an absolute file path</i> |
|----------------|-----------------------------------|

---

**Description**

Create an absolute file path from a relative file path. All processing is purely lexical; the path itself does not have to exist on the filesystem.

**Usage**

```
absolutizePath(path)
```

**Arguments**

|      |                                                      |
|------|------------------------------------------------------|
| path | String containing an absolute or relative file path. |
|------|------------------------------------------------------|

**Value**

An absolute file path corresponding to path. This is cleaned to remove `..`, `.` and `~` components.

**Author(s)**

Aaron Lun

**Examples**

```
absolutizePath("alpha")
absolutizePath("../alpha")
absolutizePath("../..alpha/./bravo")
absolutizePath("/alpha/bravo")
```

---

|             |                                 |
|-------------|---------------------------------|
| acquireFile | <i>Acquire file or metadata</i> |
|-------------|---------------------------------|

---

**Description**

*WARNING: these functions are deprecated. Applications are expected to handle acquisition of files before loaders are called.* Acquire a file or metadata for loading. As one might expect, these are typically used inside a `load*` function.

## Usage

```
acquireFile(project, path)

acquireMetadata(project, path)

## S4 method for signature 'character'
acquireFile(project, path)

## S4 method for signature 'character'
acquireMetadata(project, path)
```

## Arguments

|         |                                                                                                                                                                                |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| project | Any value specifying the project of interest. The default methods expect a string containing a path to a staging directory, but other objects can be used to control dispatch. |
| path    | String containing a relative path to a resource inside the staging directory.                                                                                                  |

## Details

By default, files and metadata are loaded from the same staging directory that is written to by [stageObject](#). alabaster applications can define custom methods to obtain the files and metadata from a different location, e.g., remote databases. This is achieved by dispatching on a different class of project.

Each custom acquisition method should take two arguments. The first argument is an R object representing some concept of a “project”. In the default case, this is a string containing a path to the staging directory representing the project. However, it can be anything, e.g., a number containing a database identifier, a list of identifiers and versions, and so on - as long as the custom acquisition method is capable of understanding it, the `load*` functions don’t care.

The second argument is a string containing the relative path to the resource inside that project. This should be the path to a specific file inside the project, not the subdirectory containing the file. More concretely, it should be equivalent to the path in the *output* of [stageObject](#), not the path to the subdirectory used as the input to the same function.

The return value for each custom acquisition function should be the same as their local counterparts. That is, any custom file acquisition function should return a file path, and any custom metadata acquisition function should return a named list of metadata.

## Value

`acquireFile` methods return a local path to the file corresponding to the requested resource.

`acquireMetadata` methods return a named list of metadata for the requested resource.

## Author(s)

Aaron Lun

## Examples

```
# Staging an example DataFrame:
library(S4Vectors)
df <- DataFrame(A=1:10, B=LETTERS[1:10])
tmp <- tempfile()
dir.create(tmp)
info <- stageObject(df, tmp, path="coldata")
writeMetadata(info, tmp)

# Retrieving the metadata:
meta <- acquireMetadata(tmp, "coldata/simple.csv.gz")
str(meta)

# Retrieving the file:
acquireFile(tmp, "coldata/simple.csv.gz")
```

---

|               |                                   |
|---------------|-----------------------------------|
| altReadObject | <i>Alter the reading function</i> |
|---------------|-----------------------------------|

---

## Description

Allow alabaster applications to specify an alternative reading function in [altReadObject](#).

## Usage

```
altReadObject(path, ...)

altReadObjectFunction(fun)
```

## Arguments

|           |                                                                                   |
|-----------|-----------------------------------------------------------------------------------|
| path, ... | Further arguments to pass to <a href="#">readObject</a> or its equivalent.        |
| fun       | Function that can serve as a drop-in replacement for <a href="#">readObject</a> . |

## Details

By default, `altReadObject` is just a wrapper around [readObject](#). However, if `altReadObjectFunction` is called, `altReadObject` calls the replacement fun instead. This allows alabaster applications to inject wholesale or class-specific customizations into the reading process, e.g., to add more meta-data whenever an instance of a particular class is encountered. Developers of alabaster extensions should use `altReadObject` (instead of `readObject`) to read child objects when writing their own reading functions, to ensure that application-specific customizations are respected for the children.

To motivate the use of `altReadObject`, consider the following scenario.

1. We have created a reading function `readX` function to read an instance of class `X` in an alabaster extension. This function may be called by [readObject](#) if instances of `X` are children of other objects.

2. An alabaster application Y requires the addition of some custom metadata during the reading process for X. It defines an alternative reading function `readObject2` that, upon encountering a schema for X, redirects to a application-specific reader `readX2`. An example implementation for `readX2` would involve calling `readX` and decorating the result with the extra metadata.
3. When operating in the context of application Y, the `readObject2` generic is used to set `altReadObjectFunction`. Any calls to `altReadObject` in Y's context will subsequently call `readObject2`.
4. So, when writing a reading function in an alabaster extension for a class that might contain instances of X as children, we use `altReadObject` instead of directly using `readObject`. This ensures that, if a child instance of X is encountered *and* we are operating in the context of application Y, we correctly call `readObject2` and then ultimately `readX2`.

The application-specific fun is free to do anything it wants as long as it understands the representation. It is usually most convenient to leverage the existing functionality in `readObject`, but if the application-specific saver in `altSaveObject` does something unusual, then fun is responsible for the correct interpretation of any custom representation.

### Value

For `altReadObject`, any R object similar to those returned by `readObject`.

For `altReadObjectFunction`, the alternative function (if any) is returned if fun is missing. If fun is provided, it is used to define the alternative, and the previous alternative is returned.

### Author(s)

Aaron Lun

### Examples

```
old <- altReadObjectFunction()

# Setting it to something.
altReadObjectFunction(function(...) {
  print("YAY")
  readObject(...)
})

# Staging an example DataFrame:
library(S4Vectors)
df <- DataFrame(A=1:10, B=LETTERS[1:10])
tmp <- tempfile()
saveObject(df, tmp)

# And now reading it - this should print our message.
altReadObject(tmp)

# Restoring the old reader:
altReadObjectFunction(old)
```

---

|               |                                 |
|---------------|---------------------------------|
| altSaveObject | <i>Alter the saving generic</i> |
|---------------|---------------------------------|

---

## Description

Allow alabaster applications to divert to a different saving generic instead of [saveObject](#).

## Usage

```
altSaveObject(x, path, ...)
```

```
altSaveObjectFunction(generic)
```

## Arguments

|              |                                                                                           |
|--------------|-------------------------------------------------------------------------------------------|
| x, path, ... | Further arguments to pass to <a href="#">saveObject</a> or an equivalent generic.         |
| generic      | Generic function that can serve as a drop-in replacement for <a href="#">saveObject</a> . |

## Details

By default, `altSaveObject` is just a wrapper around [saveObject](#). However, if `altSaveObjectFunction` is called, `altSaveObject` calls the replacement generic instead. This allows alabaster applications to inject wholesale or class-specific customizations into the saving process, e.g., to save more metadata whenever an instance of a particular class is encountered. Developers of alabaster extensions should use `altSaveObject` to save child objects when implementing `saveObject` methods, to ensure that application-specific customizations are respected for the children.

To motivate the use of `altSaveObject`, consider the following scenario.

1. We have created a staging method for class X, defined for the [saveObject](#) generic.
2. An alabaster application Y requires the addition of some custom metadata during the staging process for X. It defines an alternative staging generic `saveObject2` that, upon encountering an instance of X, redirects to an application-specific method (i.e., `saveObject2, X-method`). For example, the `saveObject2` method for X could call X's `saveObject` method and add the necessary metadata to the result.
3. When operating in the context of application Y, the `saveObject2` generic is used to set `altSaveObjectFunction`. Any calls to `altSaveObject` in Y's context will subsequently call `saveObject2`.
4. So, when writing a `saveObject` method for any objects that might contain an instance of X as a child, we call [altSaveObject](#) on that X object instead of directly using [saveObject](#). This ensures that, if a child instance of X is encountered *and* we are operating in the context of application Y, we correctly call `saveObject2` and then ultimately the application-specific method.

The application-specific generic is free to do anything it wants as long as the custom representation is understood by the application-specific reader in [altReadObject](#). However, it is usually most convenient to re-use the existing representations created by [saveObject](#). This means that any

customizations should not interfere with the validity of those representations, as defined by the **takane** specifications and enforced by `validateObject`. We recommend that any customizations should manifest as new files starting with an underscore, as this will not interfere by any **takane** file specification.

## Value

For `altSaveObject`, files are created at the specified location, see `saveObject` for details.

For `altSaveObjectFunction`, the alternative generic (if any) is returned if `generic` is missing. If `generic` is provided, it is used to define the alternative, and the previous alternative is returned.

## Author(s)

Aaron Lun

## Examples

```
old <- altSaveObjectFunction()

# Creating a new generic for demonstration purposes:
setGeneric("superSaveObject", function(x, path, ...)
  standardGeneric("superSaveObject"))

setMethod("superSaveObject", "ANY", function(x, path, ...) {
  print("Falling back to the base method!")
  saveObject(x, path, ...)
})

altSaveObjectFunction(superSaveObject)

# Staging an example DataFrame. This should print our message.
library(S4Vectors)
df <- DataFrame(A=1:10, B=LETTERS[1:10])
tmp <- tempfile()
altSaveObject(df, tmp)

# Restoring the old loader:
altSaveObjectFunction(old)
```

---

anyMissing

*Find missing values*


---

## Description

Find missing (NA) values. This is smart enough to distinguish them from NaN values in numeric `x`. For all other types, it just calls `is.na` or `anyNA`.

**Usage**

```
anyMissing(x)
```

```
is.missing(x)
```

**Arguments**

x                      Vector or array of atomic values.

**Value**

For anyMissing, a logical scalar indicating whether any NA values were present in x.

For is.missing, a logical vector or array of shape equal to x, indicating whether each value is NA.

**Author(s)**

Aaron Lun

**Examples**

```
anyNA(c(NaN))
anyNA(c(NA))
anyMissing(c(NaN))
anyMissing(c(NA))

is.na(c(NA, NaN))
is.missing(c(NA, NaN))
```

---

```
chooseMissingPlaceholderForHdf5
```

*Choose a missing value placeholder*

---

**Description**

In the **alabaster**\* framework, we mark missing entries inside HDF5 datasets with placeholder values. This function chooses a value for the placeholder that does not overlap with anything else in a vector.

**Usage**

```
chooseMissingPlaceholderForHdf5(x, .version = 3)
```

**Arguments**

x                      An atomic vector to be saved to HDF5.

.version              Internal use only.

## Details

For floating-point datasets, the placeholder will not be NA if there are mixtures of NAs and NaNs. We do not rely on the NaN payload to distinguish between these two values.

Placeholder values are typically saved as scalar attributes on the HDF5 dataset that they are used in. The usual name of this attribute is "missing-value-placeholder", as encoding by `missingPlaceholderName`.

## Value

A placeholder value for missing values in `x`, guaranteed to not be equal to any non-missing value in `x`.

## Examples

```
chooseMissingPlaceholderForHdf5(c(TRUE, NA, FALSE))
chooseMissingPlaceholderForHdf5(c(1L, NA, 2L))
chooseMissingPlaceholderForHdf5(c("aaron", NA, "barry"))
chooseMissingPlaceholderForHdf5(c("aaron", NA, "barry", "NA"))
chooseMissingPlaceholderForHdf5(c(1.5, NA, 2.6))
chooseMissingPlaceholderForHdf5(c(1.5, NaN, NA, 2.6))
```

---

|                |                                    |
|----------------|------------------------------------|
| cloneDirectory | <i>Clone an existing directory</i> |
|----------------|------------------------------------|

---

## Description

Clone an existing directory to a new location. This is typically performed inside `saveObject` after detecting duplicated objects, see `?createDedupSession` for details.

## Usage

```
cloneDirectory(src, dest, action = c("link", "copy", "symlink", "relink"))
```

## Arguments

|                     |                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>src</code>    | String containing the path to the source directory, typically generated by a prior <code>saveObject</code> call.                                                                                                                                                                                                                                                                                                                |
| <code>dest</code>   | String containing the path to the destination directory, typically the path in a subsequent <code>saveObject</code> call.                                                                                                                                                                                                                                                                                                       |
| <code>action</code> | String specifying the action to use when cloning files from <code>src</code> to <code>dest</code> . <ul style="list-style-type: none"> <li>"copy": copy the files from <code>src</code> to <code>dest</code>.</li> <li>"link": create a hard link from the files in <code>src</code> to their new locations in <code>dest</code>. If this fails, we silently fall back to a copy. This mode is the default approach.</li> </ul> |

- "symlink": create a symbolic link from the files in `src` to their new locations in `dest`. Each symbolic link refers to an absolute path in the original directory, which is useful when the contents of `dest` might be moved (but the original directory will not).
- "relink": create a symbolic link from the files in `src` to their new locations in `dest`. Each symbolic link refers to a relative path to its corresponding file in the original directory, which is useful when both `src` and `dest` are moved together, e.g., as they are part of the same parent object like a `SummarizedExperiment`.

## Value

A new directory is created at `dest` with the contents of `src`, either copied or linked. `NULL` is invisibly returned.

## Author(s)

Aaron Lun

## Examples

```
tmp <- tempfile()
dir.create(tmp)

src <- file.path(tmp, "A")
dir.create(src)
write(file=file.path(src, "foobar"), LETTERS)

dest <- file.path(tmp, "B")
cloneDirectory(src, dest)
list.files(dest, recursive=TRUE)
```

---

|                    |                                        |
|--------------------|----------------------------------------|
| createDedupSession | <i>Deduplicate objects when saving</i> |
|--------------------|----------------------------------------|

---

## Description

Utilities for deduplicating objects inside `saveObject` to save time and/or storage space.

## Usage

```
createDedupSession()

checkObjectInDedupSession(x, session)

addObjectToDedupSession(x, session, path)
```

**Arguments**

|         |                                                                                                                                                                                                                                                    |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x       | Some object, typically S4.                                                                                                                                                                                                                         |
| session | Session object created by <a href="#">createDedupSession</a> .                                                                                                                                                                                     |
| path    | String containing the absolute path to the directory in which x is to be saved. This will be used for deduplication if another object is identified as a duplicate of x. If a relative path is provided, it will be converted to an absolute path. |

**Details**

These utilities allow extension developers to support deduplication of objects in a top-level call to [saveObject](#). For a given saveObject method, we can:

1. Accept a session object in an optional `<PREFIX>.dedup.session=` argument. We may also accept a `<PREFIX>.dedup.action=` argument to specify how any deduplication should be performed. Some `<PREFIX>` prefix should be chosen to avoid conflicts between multiple deduplication sessions.
2. If a session argument is provided, we call `checkObjectInDedupSession(x, session)` to see if the x is a duplicate of an existing object in the session. If a path is returned, we call [cloneDirectory](#) and return.
3. Otherwise, we save this object to disk, possibly passing the session argument as `<PREFIX>.dedup.session=` in further calls to `saveObject` for child objects. We call `addObjectToDedupSession` to add the current object to the session.

A user can enable deduplication by passing the output of `createDedupSession` to `<PREFIX>.dedup.session=` in the top-level call to `saveObject`. This is most typically performed when saving `SummarizedExperiment` objects with multiple assays, where one assay consists of delayed operations on another assay.

**Value**

`createDedupSession` will return a deduplication session that can be modified in-place.

If x is a duplicate of an object in session, `checkObjectInDedupSession` will return a string containing the absolute path to a directory representing that object. Otherwise, it will return `NULL`.

`addObjectToDedupSession` will add x to session with the supplied path. It returns `NULL` invisibly.

**Author(s)**

Aaron Lun

**Examples**

```
test <- function(x, path, test.dedup.session=NULL, test.dedup.action="link") {
  if (!is.null(test.dedup.session)) {
    original <- checkObjectInDedupSession(x, test.dedup.session)
    if (!is.null(original)) {
      cloneDirectory(original, path, test.dedup.action)
      return(invisible(NULL))
    }
  }
}
```

```

    }
    dir.create(path)
    saveRDS(x, file.path(path, "whee.rds")) # replace this with actual saving code.
    if (!is.null(test.dedup.session)) {
      addObjectToDedupSession(x, test.dedup.session, path)
    }
  }
}

library(S4Vectors)
y <- DataFrame(A=1:10, B=1:10)
tmp <- tempfile()
dir.create(tmp)

# Saving the first instance of the object, which is now stored in the session.
session <- createDedupSession()
checkObjectInDedupSession(y, session) # no duplicates yet.
test(y, file.path(tmp, "first"), test.dedup.session=session)

# Saving it again will trigger the deduplication.
checkObjectInDedupSession(y, session)
test(y, file.path(tmp, "duplicate"), test.dedup.session=session)

list.files(tmp, recursive=TRUE)

```

---

|                   |                                  |
|-------------------|----------------------------------|
| createRedirection | <i>Create a redirection file</i> |
|-------------------|----------------------------------|

---

## Description

**WARNING:** *this function is deprecated. Redirection is no longer supported in the latest **alabaster** framework.* Create a redirection to another path in the same staging directory. This is useful for creating short-hand aliases for resources that have inconveniently long paths.

## Usage

```
createRedirection(dir, src, dest)
```

## Arguments

|      |                                                                                                                                         |
|------|-----------------------------------------------------------------------------------------------------------------------------------------|
| dir  | String containing the path to the staging directory.                                                                                    |
| src  | String containing the source path relative to dir.                                                                                      |
| dest | String containing the destination path relative to dir. This may be any path that can also be used in <a href="#">acquireMetadata</a> . |

## Details

src should not correspond to an existing file inside dir. This avoids ambiguity when attempting to load src via [acquireMetadata](#). Otherwise, it would be unclear as to whether the user wants the file at src or the redirection target dest.

src may correspond to existing directories. This is because directories cannot be used in [acquireMetadata](#), so no such ambiguity exists.

## Value

A list of metadata that can be processed by [writeMetadata](#).

## Author(s)

Aaron Lun

## Examples

```
# Staging an example DataFrame:
library(S4Vectors)
df <- DataFrame(A=1:10, B=LETTERS[1:10])
tmp <- tempfile()
dir.create(tmp)
info <- stageObject(df, tmp, path="coldata")
writeMetadata(info, tmp)

# Creating a redirection:
redirect <- createRedirection(tmp, "foobar", "coldata/simple.csv.gz")
writeMetadata(redirect, tmp)

# We can then use this redirect to pull out metadata:
info2 <- acquireMetadata(tmp, "foobar")
str(info2)
```

---

|                    |                                                      |
|--------------------|------------------------------------------------------|
| getSaveEnvironment | <i>Track the environment used for saving objects</i> |
|--------------------|------------------------------------------------------|

---

## Description

Utilities to write, load and access the R environment used by [saveObject](#) for any given object.

## Usage

```
getSaveEnvironment()

formatSaveEnvironment()

useSaveEnvironment(use)
```

```
registerSaveEnvironment(info = NULL)

loadSaveEnvironment(path)
```

### Arguments

|      |                                                                                                                                                            |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| use  | Logical scalar specifying whether to use a save environment during reading/saving of objects.                                                              |
| info | Named list containing information about the environment used to save each object. If NULL, this is created by calling <code>formatSaveEnvironment</code> . |
| path | String containing the path to a directory representing an object, same as that used by <code>saveObject</code> and <code>readObject</code> .               |

### Details

When saving an object, `saveObject` will automatically record some details about the current R environment. This facilitates trouble-shooting and provides some opportunities for corrective measures if any bugs are found in older `saveObject` methods. Information about the save environment is stored in an `_environment.json` file inside the directory containing the object. Subdirectories for child objects may also have separate `_environment.json` files (e.g., if they were created in a different environment), otherwise it is assumed that they inherit the save environment from the parent object.

Application or extension developers are expected to call `getSaveEnvironment` from inside a loading function used by `readObject` or `altReadObject`. This will return the save environment that was used for the “current” object, i.e., the object that was previously saved at `path`. By accessing the historical save environment, developers can check if buggy versions of the corresponding `saveObject` or `altSaveObject` methods were used. Appropriate corrective measures can then be applied to recover the correct object, warn users, etc. `getSaveEnvironment` can also be called inside `saveObject` or `altSaveObject` methods, in which case the current object is the one being saved.

In most cases, `registerSaveEnvironment` does not need to be explicitly called by end-users or developers. It is automatically executed by the top-level calls to the `saveObject` or `altSaveObject` generics. Methods can simply call `getSaveEnvironment` to access the save environment information. Similarly, `loadSaveEnvironment` does not usually need to be explicitly called by end-users or developers, as it is automatically executed by each `readObject` or `altReadObject` call. Individual reader functions can simply call `getSaveEnvironment` to access the save environment information.

Tracking of the save environment can be disabled by setting `useSaveEnvironment(FALSE)`.

### Value

`getSaveEnvironment` returns a named list describing the environment used to save the “current” object (see Details). The list should have a `type` field specifying the type of environment, e.g., “R”. For objects created by `saveObject`, this will typically have the same format as the list returned by `formatSaveEnvironment`. Alternatively, NULL is returned if `useSaveEnvironment` is set to FALSE or no environment information was recorded for the current object.

`formatSaveEnvironment` returns a named list containing the current R environment, derived from the `sessionInfo`. This records the R version, the platform in which R is running, and the versions of all packages as a named list.

If `use` is not supplied, `useSaveEnvironment` returns a logical scalar indicating whether to use the save environment information. If `use` is supplied, it is used to define the save environment usage policy, and the previous setting of this value is invisibly returned.

`registerSaveEnvironment` registers the current environment information in memory so that it can be returned by `getSaveEnvironment`. It returns a list containing a restore function that should be called `on.exit` to (i) restore the previous environment information; and a write function that accepts a path to a directory in which to create an `_environment.json` file with the environment information. Both functions are no-ops if `useSaveEnvironment` is set to `FALSE` or if a save environment has already been registered.

`loadSaveEnvironment` loads the environment information from a `_environment.json` file in path. It also registers the environment information in memory so that it is returned when `getSaveEnvironment` is called. It returns a function that should be called `on.exit` to restore the previous environment information. This function is a no-op if `useSaveEnvironment` is set to `FALSE`, or if the environment information is not parsable (in which case a warning will be emitted).

### Author(s)

Aaron Lun

### Examples

```
str(formatSaveEnvironment())

prev <- useSaveEnvironment(TRUE)
tmp <- tempfile()
dir.create(tmp)

wfun <- registerSaveEnvironment(tmp)
getSaveEnvironment()
wfun$restore()

useSaveEnvironment(prev)
```

### Description

Basically just better versions of those in **rhdf5**, dedicated to **alabaster.base** and its dependents. Intended for **alabaster.\*** developers only.

---

|             |                                    |
|-------------|------------------------------------|
| listObjects | <i>List objects in a directory</i> |
|-------------|------------------------------------|

---

### Description

List all objects in a directory, along with their types.

### Usage

```
listObjects(dir, include.children = FALSE)
```

### Arguments

|                  |                                                                                                                                       |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| dir              | String containing a path to a directory containing objects saved by <a href="#">saveObject</a> , possibly in separate subdirectories. |
| include.children | Logical scalar indicating whether to include child objects.                                                                           |

### Value

A [DFrame](#) where each row corresponds to an object. It contains the following columns:

- path, the relative path to the object's subdirectory inside dir.
- type, the type of the object based on its OBJECT file (see [?readObjectFile](#)).
- child, whether the object is a child of another object.

If include.children=FALSE, metadata is only returned for non-child objects.

### Author(s)

Aaron Lun

### Examples

```
tmp <- tempfile()
dir.create(tmp)

library(S4Vectors)
df <- DataFrame(A=1:10, B=LETTERS[1:10])
saveObject(df, file.path(tmp, "whee"))

ll <- list(A=1, B=LETTERS, C=DataFrame(X=1:5))
saveObject(ll, file.path(tmp, "stuff"))

listObjects(tmp)
listObjects(tmp, include.children=TRUE)
```

---

|               |                                                  |
|---------------|--------------------------------------------------|
| loadDirectory | <i>Load all non-child objects in a directory</i> |
|---------------|--------------------------------------------------|

---

## Description

*WARNING: this function is deprecated, use [listObjects](#) and loop over entries with [readObject](#) instead.* As the title suggests, this function loads all non-child objects in a staging directory. All loading is performed using [altLoadObject](#) to respect any application-specific overrides. Children are used to assemble their parent objects and are not reported here.

## Usage

```
loadDirectory(dir, redirect.action = c("from", "to", "both"))
```

## Arguments

|                 |                                                                                                                                                                                                                                                                                                                                                                                     |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| dir             | String containing a path to a staging directory.                                                                                                                                                                                                                                                                                                                                    |
| redirect.action | String specifying how redirects should be handled: <ul style="list-style-type: none"> <li>• "to" will report an object at the redirection destination, not the redirection source.</li> <li>• "from" will report an object at the redirection source(s), not the destination.</li> <li>• "both" will report an object at both the redirection source(s) and destination.</li> </ul> |

## Value

A named list is returned containing all (non-child) R objects in `dir`.

## Author(s)

Aaron Lun

## Examples

```
tmp <- tempfile()
dir.create(tmp)

library(S4Vectors)
df <- DataFrame(A=1:10, B=LETTERS[1:10])
meta <- stageObject(df, tmp, path="whee")
writeMetadata(meta, tmp)

ll <- list(A=1, B=LETTERS, C=DataFrame(X=1:5))
meta <- stageObject(ll, tmp, path="stuff")
writeMetadata(meta, tmp)

redirect <- createRedirection(tmp, "whoop", "whee/simple.csv.gz")
```

```
writeMetadata(redirect, tmp)

all.meta <- loadDirectory(tmp)
str(all.meta)
```

---

moveObject

---

Move a non-child object in the staging directory

---

## Description

*WARNING: this function is deprecated, as directories of non-child objects can just be moved with regular methods (e.g., [file.rename](#)) in the latest version of **alabaster**.* Pretty much as it says in the title. This only works with non-child objects as children are referenced by their parents and cannot be safely moved in this manner.

## Usage

```
moveObject(dir, from, to, rename.redirections = TRUE)
```

## Arguments

|                     |                                                                                                                                                             |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| dir                 | String containing the path to the staging directory.                                                                                                        |
| from                | String containing the path to a non-child object inside dir, as used in <a href="#">acquireMetadata</a> . This can also be a redirection to such an object. |
| to                  | String containing the new path inside dir.                                                                                                                  |
| rename.redirections | Logical scalar specifying whether redirections pointing to from should be re-named as to.                                                                   |

## Details

This function will look around path for JSON files containing redirections to from, and update them to point to to. More specifically, if path is a subdirectory, it will search in the same directory containing path; otherwise, it will search in the directory containing dirname(path). Redirections in other locations will not be removed automatically - these will be caught by [checkValidDirectory](#) and should be manually updated.

If rename.redirections=TRUE, this function will additionally move the redirection files so that they are named as to. In the unusual case where from is the target of multiple redirection files, the renaming process will clobber all of them such that only one of them will be present after the move.

## Value

The object represented by path is moved, along with any redirections to it. A NULL is invisibly returned.

### Safety of moving operations

In general, **alabaster.\*** representations are safe to move as only the parent object's `resource.path` metadata properties will contain links to the children's paths. These links are updated with the new to path after running `moveObject` on the parent from.

However, alabaster applications may define custom data structures where the paths are present elsewhere, e.g., in the data file itself or in other metadata properties. If so, applications are responsible for updating those paths to reflect the naming to to.

### Author(s)

Aaron Lun

### Examples

```
tmp <- tempfile()
dir.create(tmp)

library(S4Vectors)
df <- DataFrame(A=1:10, B=LETTERS[1:10])
meta <- stageObject(df, tmp, path="whee")
writeMetadata(meta, tmp)

ll <- list(A=1, B=LETTERS, C=DataFrame(X=1:5))
meta <- stageObject(ll, tmp, path="stuff")
writeMetadata(meta, tmp)

redirect <- createRedirection(tmp, "whoop", "whee/simple.csv.gz")
writeMetadata(redirect, tmp)

list.files(tmp, recursive=TRUE)
moveObject(tmp, "whoop", "YAY")
list.files(tmp, recursive=TRUE)
```

---

quickLoadObject

*Convenience helpers for handling local directories*

---

### Description

*WARNING: these functions are deprecated as the saving/reading functions are already simple enough in the newer versions of the **alabaster** framework. Read and write objects from a local staging directory. These are just convenience wrappers around functions like [loadObject](#), [stageObject](#) and [writeMetadata](#).*

### Usage

```
quickLoadObject(dir, path, ...)
```

```
quickStageObject(x, dir, path, ...)
```

**Arguments**

|      |                                                                                                                                                            |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| dir  | String containing a path to the directory.                                                                                                                 |
| path | String containing a relative path to the object of interest inside dir.                                                                                    |
| ...  | Further arguments to pass to <code>loadObject</code> (for <code>quickLoadObject</code> ) or <code>stageObject</code> (for <code>quickStageObject</code> ). |
| x    | Object to be saved.                                                                                                                                        |

**Value**

For `quickLoadObject`, the object at path.

For `quickStageObject`, the object is saved to path inside dir. All necessary directories are created if they are not already present. A NULL is returned invisibly.

**Author(s)**

Aaron Lun

**Examples**

```
local <- tempfile()

# Creating a slightly complicated object:
library(S4Vectors)
df <- DataFrame(A=1:10, B=LETTERS[1:10])
df$C <- DataFrame(D=letters[1:10], E=runif(10))

# Saving it:
quickStageObject(df, local, "FOOBAR")

# Reading it back:
quickLoadObject(local, "FOOBAR")
```

---

`quickReadCsv`*Quickly read and write a CSV file*

---

**Description**

Quickly read and write a CSV file, usually as a part of staging or loading a larger object. This assumes that all files follow the **comservatory** specification.

**Usage**

```

quickReadCsv(
  path,
  expected.columns,
  expected.nrows,
  compression,
  row.names,
  parallel = TRUE
)

quickWriteCsv(
  df,
  path,
  ...,
  row.names = FALSE,
  compression = "gzip",
  validate = TRUE
)

```

**Arguments**

|                               |                                                                                                                                                                                                                      |
|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>path</code>             | String containing a path to a CSV to read/write.                                                                                                                                                                     |
| <code>expected.columns</code> | Named character vector specifying the type of each column in the CSV (excluding the first column containing row names, if <code>row.names=TRUE</code> ).                                                             |
| <code>expected.nrows</code>   | Integer scalar specifying the expected number of rows in the CSV.                                                                                                                                                    |
| <code>compression</code>      | String specifying the compression that was/will be used. This should be either "none", "gzip".                                                                                                                       |
| <code>row.names</code>        | For <code>.quickReadCsv</code> , a logical scalar indicating whether the CSV contains row names.<br>For <code>.quickWriteCsv</code> , a logical scalar indicating whether to save the row names of <code>df</code> . |
| <code>parallel</code>         | Whether reading and parsing should be performed concurrently.                                                                                                                                                        |
| <code>df</code>               | A <a href="#">DFrame</a> or data.frame object, containing only atomic columns.                                                                                                                                       |
| <code>...</code>              | Further arguments to pass to <a href="#">write.csv</a> .                                                                                                                                                             |
| <code>validate</code>         | Whether to double-check that the generated CSV complies with the conservative specification.                                                                                                                         |

**Value**

For `.quickReadCsv`, a [DFrame](#) containing the contents of `path`.

For `.quickWriteCsv`, `df` is written to `path` and a NULL is invisibly returned.

**Author(s)**

Aaron Lun

**Examples**

```
library(S4Vectors)
df <- DataFrame(A=1, B="Aaron")

temp <- tempfile()
.quickWriteCsv(df, path=temp, row.names=FALSE, compression="gzip")

.quickReadCsv(temp, c(A="numeric", B="character"), 1, "gzip", FALSE)
```

---

|                  |                                        |
|------------------|----------------------------------------|
| readAtomicVector | <i>Read an atomic vector from disk</i> |
|------------------|----------------------------------------|

---

**Description**

Read a vector consisting of atomic elements from its on-disk representation. This is usually not directly called by users, but is instead called by dispatch in [readObject](#).

**Usage**

```
readAtomicVector(path, metadata, ...)
```

**Arguments**

|          |                                                                                                |
|----------|------------------------------------------------------------------------------------------------|
| path     | Path to a directory created with any of the vector methods for <a href="#">saveObject</a> .    |
| metadata | Named list containing metadata for the object, see <a href="#">readObjectFile</a> for details. |
| ...      | Further arguments, ignored.                                                                    |

**Value**

The vector described by info.

**Author(s)**

Aaron Lun

**See Also**

["saveObject, integer-method"](#), for one of the staging methods.

**Examples**

```
tmp <- tempfile()
saveObject(setNames(runif(26), letters), tmp)
readObject(tmp)
```

---

|                |                                |
|----------------|--------------------------------|
| readBaseFactor | <i>Read a factor from disk</i> |
|----------------|--------------------------------|

---

### Description

Read a base R [factor](#) from its on-disk representation. This is usually not directly called by users, but is instead called by dispatch in [readObject](#).

### Usage

```
readBaseFactor(path, metadata, ...)
```

### Arguments

|          |                                                                                                                 |
|----------|-----------------------------------------------------------------------------------------------------------------|
| path     | String containing a path to a directory, itself created with the <a href="#">saveObject</a> method for factors. |
| metadata | Named list containing metadata for the object, see <a href="#">readObjectFile</a> for details.                  |
| ...      | Further arguments, ignored.                                                                                     |

### Value

The vector described by info.

### Author(s)

Aaron Lun

### See Also

"[saveObject, factor-method](#)", for the staging method.

### Examples

```
tmp <- tempfile()
saveObject(factor(letters[1:10], letters), tmp)
readObject(tmp)
```

---

|              |                                   |
|--------------|-----------------------------------|
| readBaseList | <i>Read a base list from disk</i> |
|--------------|-----------------------------------|

---

## Description

Read a [list](#) from its on-disk representation. This is usually not directly called by users, but is instead called by dispatch in [readObject](#).

## Usage

```
readBaseList(path, metadata, simple_list.parallel = TRUE, ...)
```

## Arguments

|                      |                                                                                                                          |
|----------------------|--------------------------------------------------------------------------------------------------------------------------|
| path                 | String containing a path to a directory, itself created with the list method for <a href="#">stageObject</a> .           |
| metadata             | Named list containing metadata for the object, see <a href="#">readObjectFile</a> for details.                           |
| simple_list.parallel | Whether to perform reading and parsing in parallel for greater speed. Only relevant for lists stored in the JSON format. |
| ...                  | Further arguments to be passed to <a href="#">altReadObject</a> for complex child objects.                               |

## Details

The **uzuki2** specification (see <https://github.com/ArtifactDB/uzuki2>) allows length-1 vectors to be stored as-is or as a scalar. If the file stores a length-1 vector as-is, `readBaseList` will read the list element as a length-1 vector with the [AsIs](#) class. If the file stores a length-1 vector as a scalar, `readBaseList` will read the list element as a length-1 vector without this class. This allows downstream users to distinguish between the storage modes in the rare cases that it is necessary.

## Value

The list represented by path.

## Author(s)

Aaron Lun

## See Also

["stageObject, list-method"](#), for the staging method.

Examples

```
library(S4Vectors)
ll <- list(A=1, B=LETTERS, C=DataFrame(X=letters))

tmp <- tempfile()
saveObject(ll, tmp)
readObject(tmp)
```

---

|               |                                   |
|---------------|-----------------------------------|
| readDataFrame | <i>Read a DataFrame from disk</i> |
|---------------|-----------------------------------|

---

Description

Read a [DFrame](#) from its on-disk representation. This is usually not directly called by users, but is instead called by dispatch in [readObject](#).

Usage

```
readDataFrame(path, metadata, ...)
```

Arguments

- path               String containing a path to the directory, itself created with [saveObject](#) method for [DFrames](#).
- metadata           Named list containing metadata for the object, see [readObjectFile](#) for details.
- ...                Further arguments, passed to [altLoadObject](#) for complex nested columns.

Value

The [DFrame](#) represented by path.

Author(s)

Aaron Lun

See Also

"[saveObject,DataFrame-method](#)", for the staging method.

Examples

```
library(S4Vectors)
df <- DataFrame(A=1:10, B=LETTERS[1:10])

tmp <- tempfile()
saveObject(df, tmp)
readObject(tmp)
```

---

|                     |                                          |
|---------------------|------------------------------------------|
| readDataFrameFactor | <i>Read a DataFrame factor from disk</i> |
|---------------------|------------------------------------------|

---

## Description

Read a [DataFrameFactor](#) from its on-disk representation. This is usually not directly called by users, but is instead called by dispatch in [readObject](#).

## Usage

```
readDataFrameFactor(path, metadata, ...)
```

## Arguments

|          |                                                                                                                                           |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------|
| path     | String containing a path to a directory, itself created with the <a href="#">saveObject</a> method for <a href="#">DataFrameFactors</a> . |
| metadata | Named list containing metadata for the object, see <a href="#">readObjectFile</a> for details.                                            |
| ...      | Further arguments to pass to internal <a href="#">altSaveObject</a> calls.                                                                |

## Value

A [DataFrameFactor](#) represented by path.

## Author(s)

Aaron Lun

## See Also

"[saveObject, DataFrameFactor-method](#)", for the staging method.

## Examples

```
library(S4Vectors)
df <- DataFrame(X=LETTERS[1:5], Y=1:5)
out <- DataFrameFactor(df[sample(5, 100, replace=TRUE),,drop=FALSE])

tmp <- tempfile()
saveObject(out, tmp)
readObject(tmp)
```

---

|              |                              |
|--------------|------------------------------|
| readMetadata | <i>Read R-level metadata</i> |
|--------------|------------------------------|

---

### Description

Read [metadata](#) and [mcols](#) for a [Annotated](#) or [Vector](#) object, respectively. This is typically used inside loading functions for concrete subclasses.

### Usage

```
readMetadata(x, metadata.path, mcols.path, ...)
```

### Arguments

|                            |                                                                                                                                                                                                   |
|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>             | An <a href="#">Vector</a> or <a href="#">Annotated</a> object.                                                                                                                                    |
| <code>metadata.path</code> | String containing a path to a directory, itself containing an on-disk representation of a base R list to be used as the <a href="#">metadata</a> . Alternatively NULL to skip loading.            |
| <code>mcols.path</code>    | String containing a path to a directory, itself containing an on-disk representation of a <a href="#">DataFrame</a> to be used as the <a href="#">mcols</a> . Alternatively NULL to skip loading. |
| <code>...</code>           | Further arguments to be passed to <a href="#">altReadObject</a> .                                                                                                                                 |

### Value

`x` is returned, possibly with `mcols` and `metadata` added to it.

### Author(s)

Aaron Lun

### See Also

[saveMetadata](#), which does the staging.

---

|            |                                 |
|------------|---------------------------------|
| readObject | <i>Read an object from disk</i> |
|------------|---------------------------------|

---

### Description

Read an object from its on-disk representation. This is done by dispatching to an appropriate loading function based on the type in the OBJECT file.

**Usage**

```
readObject(path, metadata = NULL, ...)

readObjectFunctionRegistry()

registerReadObjectFunction(type, fun, existing = c("old", "new", "error"))
```

**Arguments**

|          |                                                                                                                                                                                                                        |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| path     | String containing a path to a directory, itself created with a <a href="#">saveObject</a> method.                                                                                                                      |
| metadata | Named list containing metadata for the object - most importantly, the type field that controls dispatch to the correct loading function. If NULL, this is automatically read by <a href="#">readObjectFile</a> (path). |
| ...      | Further arguments to pass to individual methods.                                                                                                                                                                       |
| type     | String specifying the name of type of the object.                                                                                                                                                                      |
| fun      | A loading function that accepts path, metadata and ... (in that order), and returns the associated object. This may also be NULL to delete an existing entry in the registry.                                          |
| existing | Logical scalar indicating the action to take if a function has already been registered for type - keep the old or new function, or throw an error.                                                                     |

**Value**

For `readObject`, an object created from the on-disk representation in path.

For `readObjectFunctionRegistry`, a named list of functions used to load each object type.

For `registerReadObjectFunction`, the function is added to the registry.

**Comments for extension developers**

`readObject` uses an internal registry of functions to decide how an object should be loaded into memory. Developers of alabaster extensions can add extra functions to this registry, usually in the `.onLoad` function of their packages. Alternatively, extension developers can request the addition of their packages to default registry.

If a loading function makes use of additional arguments in ..., those arguments should be prefixed by the name of the object type for each method, e.g., `simple_list.parallel`. This avoids problems with conflicts in the interpretation of identically named arguments between different functions. Unlike the ... arguments in [saveObject](#), we prefix by the object type instead of the output class, as the former is used for dispatch here.

When writing loading functions for complex classes, extension developers may need to load child objects to compose the output object. In such cases, developers should use [altReadObject](#) on the child subdirectories, rather than calling `readObject` directly. This ensures that any application-level overrides of the loading functions are respected. It is also expected that arguments in ... are forwarded to internal [altReadObject](#) calls.

Developers can manually control `readObject` dispatch by supplying a metadata list where `metadata$type` is set to the desired object type. This pattern is commonly used inside the loading function for a

subclass - an instance of the base class is first constructed by an internal `readObject` call with the modified `metadata$type`, after which the subclass-specific slots are added. (In practice, base construction should be done using `altReadObject` so as to respect application-specific overrides.)

### Comments for application developers

Application developers can override `readObject` by specifying a custom function in `altReadObject`. This can be used to point to a different registry of reading functions, to perform pre- or post-reading actions, etc. If customization is type-specific, the custom `altReadObject` function can read the type from the OBJECT file to determine the most appropriate course of action; the OBJECT metadata can then be passed to the `metadata` argument of any internal `readObject` calls to avoid a redundant read from the same file.

### Author(s)

Aaron Lun

### Examples

```
library(S4Vectors)
df <- DataFrame(A=1:10, B=LETTERS[1:10])

tmp <- tempfile()
saveObject(df, tmp)
readObject(tmp)
```

---

`readObjectFile`

*Utilities to read and save the object file*

---

### Description

The OBJECT file inside each directory provides some high-level metadata of the object represented by that directory. It is guaranteed to have a `type` property that specifies the object type; individual objects may add their own information to this file. These methods are intended for developers to easily read and load information in the OBJECT file.

### Usage

```
readObjectFile(path)

saveObjectFile(path, type, extra = list())
```

### Arguments

|                    |                                                                                                                                                                                                           |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>path</code>  | Path to the directory representing an object.                                                                                                                                                             |
| <code>type</code>  | String specifying the type of the object.                                                                                                                                                                 |
| <code>extra</code> | Named list containing extra metadata to be written to the OBJECT file in <code>path</code> . Names should be unique, and any element named <code>"type"</code> will be overwritten by <code>type</code> . |

**Value**

readObjectFile returns a named list of metadata for path.  
saveObjectFile saves metadata to the OBJECT file inside path

**Author(s)**

Aaron Lun

**Examples**

```
tmp <- tempfile()
dir.create(tmp)
saveObjectFile(tmp, "foo", list(bar=list(version="1.0")))
readObjectFile(tmp)
```

---

|              |                                                             |
|--------------|-------------------------------------------------------------|
| removeObject | <i>Remove a non-child object from the staging directory</i> |
|--------------|-------------------------------------------------------------|

---

**Description**

*WARNING: this function is deprecated, as directories of non-child objects can just be deleted with regular methods (e.g., [file.rename](#)) in the latest version of **alabaster**.* Pretty much as it says in the title. This only works with non-child objects as children are referenced by their parents and cannot be safely removed in this manner.

**Usage**

```
removeObject(dir, path)
```

**Arguments**

|      |                                                                                                                                                                           |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| dir  | String containing the path to the staging directory.                                                                                                                      |
| path | String containing the path to a non-child object inside <code>dir</code> , as used in <a href="#">acquireMetadata</a> . This can also be a redirection to such an object. |

**Details**

This function will search around path for JSON files containing redirections to path, and remove them. More specifically, if path is a subdirectory, it will search in the same directory containing path; otherwise, it will search in the directory containing `dirname(path)`. Redirections in other locations will not be removed automatically - these will be caught by [checkValidDirectory](#) and should be manually removed.

**Value**

The object represented by path is removed, along with any redirections to it. A NULL is invisibly returned.

**Author(s)**

Aaron Lun

**Examples**

```
tmp <- tempfile()
dir.create(tmp)

library(S4Vectors)
df <- DataFrame(A=1:10, B=LETTERS[1:10])
meta <- stageObject(df, tmp, path="whee")
writeMetadata(meta, tmp)

ll <- list(A=1, B=LETTERS, C=DataFrame(X=1:5))
meta <- stageObject(ll, tmp, path="stuff")
writeMetadata(meta, tmp)

redirect <- createRedirection(tmp, "whoop", "whee/simple.csv.gz")
writeMetadata(redirect, tmp)

list.files(tmp, recursive=TRUE)
removeObject(tmp, "whoop")
list.files(tmp, recursive=TRUE)
```

---

Rfc3339

*Representing Internet date/times*


---

**Description**

The Rfc3339 class is a character vector that stores Internet Date/time timestamps, formatted as described in RFC3339. It provides a faithful representation of any RFC3339-compliant string in an R session.

**Usage**

```
as.Rfc3339(x)

## S3 method for class 'character'
as.Rfc3339(x)

## Default S3 method:
as.Rfc3339(x)

## S3 method for class 'POSIXt'
as.Rfc3339(x)

## S3 method for class 'Rfc3339'
```

```

as.character(x, ...)

is.Rfc3339(x)

## S3 method for class 'Rfc3339'
as.POSIXct(x, tz = "", ...)

## S3 method for class 'Rfc3339'
as.POSIXlt(x, tz = "", ...)

## S3 method for class 'Rfc3339'
x[i]

## S3 method for class 'Rfc3339'
x[[i]]

## S3 replacement method for class 'Rfc3339'
x[i] <- value

## S3 replacement method for class 'Rfc3339'
x[[i]] <- value

## S3 method for class 'Rfc3339'
c(..., recursive = TRUE)

## S4 method for signature 'Rfc3339'
saveObject(x, path, ...)

```

## Arguments

|                                 |                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>                  | For <code>as.Rfc3339</code> methods, object to be coerced to an <code>Rfc3339</code> instance.<br>For the subset and combining methods, an <code>Rfc3339</code> instance.<br>For <code>as.character</code> , <code>as.POSIXlt</code> and <code>as.POSIXct</code> methods, an <code>Rfc3339</code> instance.<br>For <code>is.Rfc3339</code> , any object to be tested for <code>Rfc3339</code> -ness. |
| <code>tz, recursive, ...</code> | Further arguments to be passed to individual methods.                                                                                                                                                                                                                                                                                                                                                |
| <code>i</code>                  | Indices specifying elements to extract or replace.                                                                                                                                                                                                                                                                                                                                                   |
| <code>value</code>              | Replacement values, either as another <code>Rfc3339</code> instance, a character vector or something that can be coerced into one.                                                                                                                                                                                                                                                                   |
| <code>path</code>               | String containing the path to a directory in which to save <code>x</code> .                                                                                                                                                                                                                                                                                                                          |

## Details

This class is motivated by the difficulty in using the various [POSIXt](#) classes to faithfully represent any RFC3339-compliant string. In particular:

- The POSIXt classes do not automatically capture the string's timezone offset, instead converting all times to the local timezone. This is problematic as it discards information about the original timezone. Technically, the [POSIXt](#) class is capable of holding this information in the `gmtoff` field but it is not clear how to set this.
- There is no way to distinguish between the timezones Z and +00:00. These are functionally the same but will introduce differences in the checksums of saved files and thus interfere with deduplication mechanisms in storage backends.
- Coercion of POSIXt classes to strings may print more or fewer digits in the fractional seconds than what was present in the original string. Functionally, this is probably unimportant but will still introduce differences in the checksums.

By comparison, the `Rfc3339` class preserves all information in the original string, avoiding unexpected modifications from a roundtrip through [readObject](#) and [saveObject](#). This is especially relevant for strings that were created from other languages, e.g., Node.js Date's ISO string conversion uses Z by default.

That said, users should not expect too much from this class. It is only used to provide a faithful representation of RFC3339 strings, and does not support any time-related arithmetic. Users are advised to convert to [POSIXct](#) or similar if such operations are required.

## Value

For `as.Rfc3339`, the subset and combining methods, an `Rfc3339` instance is returned.

For the other `as.*` methods, an instance of the corresponding type generated from an `Rfc3339` instance.

## Author(s)

Aaron Lun

## Examples

```
out <- as.Rfc3339(Sys.time() + 1:10)
out

out[2:5]
out[2] <- "2"
c(out, out)

as.character(out)
as.POSIXct(out)
```

---

saveAtomicVector

*Save atomic vectors to disk*

---

## Description

Save vectors containing atomic elements (or values that can be cast as such, e.g., dates and times) to an on-disk representation.

## Usage

```
## S4 method for signature 'integer'
saveObject(x, path, character.vls = FALSE, ...)

## S4 method for signature 'character'
saveObject(x, path, character.vls = FALSE, ...)

## S4 method for signature 'logical'
saveObject(x, path, character.vls = FALSE, ...)

## S4 method for signature 'double'
saveObject(x, path, character.vls = FALSE, ...)

## S4 method for signature 'numeric'
saveObject(x, path, character.vls = FALSE, ...)

## S4 method for signature 'Date'
saveObject(x, path, character.vls = FALSE, ...)

## S4 method for signature 'POSIXlt'
saveObject(x, path, character.vls = FALSE, ...)

## S4 method for signature 'POSIXct'
saveObject(x, path, character.vls = FALSE, ...)

## S4 method for signature 'numeric_version'
saveObject(x, path, ...)
```

## Arguments

|               |                                                                                                                                                                                                                              |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x             | Any of the atomic vector types, or <a href="#">Date</a> objects, or time objects, e.g., <a href="#">POSIXct</a> .                                                                                                            |
| path          | String containing the path to a directory in which to save x.                                                                                                                                                                |
| character.vls | Logical scalar indicating whether to save character vectors in the custom variable length string (VLS) array format. If NULL, this is determined based on a comparison of the expected storage against a fixed length array. |
| ...           | Further arguments that are ignored.                                                                                                                                                                                          |

## Value

x is saved inside path. NULL is invisibly returned.

## Author(s)

Aaron Lun

## See Also

[readAtomicVector](#), to read the files back into the session.

**Examples**

```
tmp <- tempfile()
dir.create(tmp)
saveObject(LETTERS, file.path(tmp, "foo"))
saveObject(setNames(runif(26), letters), file.path(tmp, "bar"))
list.files(tmp, recursive=TRUE)
```

---

|                |                              |
|----------------|------------------------------|
| saveBaseFactor | <i>Save a factor to disk</i> |
|----------------|------------------------------|

---

**Description**

Pretty much as it says, let's save a base R [factor](#) to an on-disk representation.

**Usage**

```
## S4 method for signature 'factor'
saveObject(x, path, ...)
```

**Arguments**

|      |                                                               |
|------|---------------------------------------------------------------|
| x    | A factor.                                                     |
| path | String containing the path to a directory in which to save x. |
| ...  | Further arguments that are ignored.                           |

**Value**

x is saved inside path. NULL is invisibly returned.

**Author(s)**

Aaron Lun

**See Also**

[readBaseFactor](#), to read the files back into the session.

**Examples**

```
tmp <- tempfile()
saveObject(factor(1:10, 1:30), tmp)
list.files(tmp, recursive=TRUE)
```

---

|              |                                 |
|--------------|---------------------------------|
| saveBaseList | <i>Save a base list to disk</i> |
|--------------|---------------------------------|

---

### Description

Save a [list](#) or [List](#) to a JSON or HDF5 file, with extra files created for any of the more complex list elements (e.g., DataFrames, arrays). This uses the [uzuki2](#) specification to ensure that appropriate types are declared.

### Usage

```
## S4 method for signature 'list'
saveObject(
  x,
  path,
  list.format = saveBaseListFormat(),
  list.character.vls = NULL,
  ...
)

## S4 method for signature 'List'
saveObject(x, path, list.format = saveBaseListFormat(), ...)

saveBaseListFormat(list.format)
```

### Arguments

|                                 |                                                                                                                                                                                                                                                                                           |
|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>                  | An ordinary R list, named or unnamed. Alternatively, a <a href="#">List</a> to be coerced into a list.                                                                                                                                                                                    |
| <code>path</code>               | String containing the path to a directory in which to save <code>x</code> .                                                                                                                                                                                                               |
| <code>list.format</code>        | String specifying the format in which to save the list.                                                                                                                                                                                                                                   |
| <code>list.character.vls</code> | Logical scalar indicating whether to save character vectors in the custom variable length string (VLS) array format. If <code>NULL</code> , this is determined based on a comparison of the expected storage against a fixed length array. Only used if <code>list.format="hdf5"</code> . |
| <code>...</code>                | Further arguments, passed to <a href="#">altSaveObject</a> for complex child objects.                                                                                                                                                                                                     |

### Value

For the `saveObject` method, `x` is saved inside `dir`. `NULL` is invisibly returned.

For `saveBaseListFormat`; if `list.format` is missing, a string containing the current format is returned. If `list.format` is supplied, it is used to define the current format, and the *previous* format is returned.

### File formats

If `list.format="json.gz"` (default), the list is saved to a Gzip-compressed JSON file (the default). This is an easily parsed format with low storage overhead.

If `list.format="hdf5"`, `x` is saved into a HDF5 file instead. This format is most useful for random access and for preserving the precision of numerical data.

### Storing scalars

The **uzuki2** specification (see <https://github.com/ArtifactDB/uzuki2>) allows length-1 vectors to be stored as-is or as a scalar. If a list element is of length 1, `saveBaseList` will store it as a scalar on-disk, effectively “unboxing” it for languages with a concept of scalars. Users can override this behavior by adding the **AsIs** class to the affected list element, which will force storage as a length-1 vector. This reflects the decisions made by `readBaseList` and mimics the behavior of packages like **jsonlite**.

### Author(s)

Aaron Lun

### See Also

<https://github.com/ArtifactDB/uzuki2> for the specification.

`readBaseList`, to read the list back into the R session.

### Examples

```
library(S4Vectors)
ll <- list(A=1, B=LETTERS, C=DataFrame(X=1:5))

tmp <- tempfile()
saveObject(ll, tmp)
list.files(tmp, recursive=TRUE)
```

---

saveFormats

*Choose the format for certain objects*

---

### Description

Alter the format used to save DataFrames in its `stageObject` methods.

### Usage

```
saveDataFrameFormat(format)
```

**Arguments**

format                      String containing the format to use. The "csv", "csv.gz" (default) or "hdf5". Alternatively NULL, to use the default format.

**Details**

`stageObject` methods will treat a `format=NULL` in the same manner as the default format. The distinction exists to allow downstream applications to set their own defaults while still responding to user specification. For example, an application can detect if the existing format is NULL, and if so, apply another default via `.saveDataFrameFormat`. On the other hand, if the format is not NULL, this is presumably specified by the user explicitly and should be respected by the application.

**Value**

If format is missing, a string containing the current format is returned, or NULL to use the default format.

If format is supplied, it is used to define the current format, and the *previous* format is returned.

**Author(s)**

Aaron Lun

**Examples**

```
(old <- .saveDataFrameFormat())

.saveDataFrameFormat("hdf5")
.saveDataFrameFormat()

# Setting it back.
.saveDataFrameFormat(old)
```

---

|              |                                      |
|--------------|--------------------------------------|
| saveMetadata | <i>Save R-level metadata to disk</i> |
|--------------|--------------------------------------|

---

**Description**

Save `metadata` and `mcols` for `Annotated` or `Vector` objects, respectively, to disk. These are typically used inside `saveObject` methods for concrete subclasses.

**Usage**

```
saveMetadata(x, metadata.path, mcols.path, ...)
```

**Arguments**

|                            |                                                                                                          |
|----------------------------|----------------------------------------------------------------------------------------------------------|
| <code>x</code>             | A <a href="#">Vector</a> or <a href="#">Annotated</a> object.                                            |
| <code>metadata.path</code> | String containing the path in which to save the metadata. If NULL, no <a href="#">metadata</a> is saved. |
| <code>mcols.path</code>    | String containing the path in which to save the mcols. If NULL, no <a href="#">mcols</a> is saved.       |
| <code>...</code>           | Further arguments to be passed to <a href="#">altSaveObject</a> .                                        |

**Details**

If `mcols(x)` has no columns, nothing is saved by `saveMcols`. Similarly, if `metadata(x)` is an empty list, nothing is saved by `saveMetadata`. This avoids creating unnecessary files with no meaningful content.

If `mcols(x)` has non-NULL row names, these are removed prior to staging. These names are usually redundant with the names associated with elements of `x` itself.

**Value**

The metadata for `x` is saved to `metadata.path`, and similarly for the `mcols`.

**Author(s)**

Aaron Lun

**See Also**

[readMetadata](#), which restores metadata to the object.

---

saveObject

*Save objects to disk*

---

**Description**

Generic to save assorted R objects into appropriate on-disk representations. More methods may be defined by other packages to extend the **alabaster.base** framework to new classes.

**Usage**

```
saveObject(x, path, ...)
```

**Arguments**

|                   |                                                                             |
|-------------------|-----------------------------------------------------------------------------|
| <code>x</code>    | A Bioconductor object of the specified class.                               |
| <code>path</code> | String containing the path to a directory in which to save <code>x</code> . |
| <code>...</code>  | Additional named arguments to pass to specific methods.                     |

**Value**

dir is created and populated with files containing the contents of x. NULL should be invisibly returned.

**Comments for extension developers**

Methods for the saveObject generic should create a directory at path in which the contents of x are to be saved. The files may consist of any format, though language-agnostic formats like HDF5, CSV, JSON are preferred. For more complex objects, multiple files and subdirectories may be created within path. The only strict requirements are:

- There must be an OBJECT file inside path, containing a JSON object with a "type" string property that specifies the class of the object, e.g., "data\_frame", "summarized\_experiment". This will be used by loading functions to determine how to load the files into memory.
- The names of files and subdirectories should not start with \_ or .. These are reserved for applications, e.g., to build manifests or to store additional metadata.

Callers can pass optional parameters to specific saveObject methods via .... Any options recognized by a method should be prefixed by the name of the class used in the method's signature, e.g., any options for [saveObject,DataFrame-method](#) should start with DataFrame.. This scoping avoids conflicts between otherwise identically-named options of different methods.

When developing saveObject methods of complex objects, a simple approach is to decompose x into its "child" components. Each component can then be saved into a subdirectory of path, leveraging the existing saveObject methods for the component classes. In such cases, extension developers should actually call [altSaveObject](#) on each child component, rather than calling [saveObject](#) directly. This ensures that any application-level overrides of the loading functions are respected. It is expected that each method will forward ... (possibly after modification) to any internal [altSaveObject](#) calls.

**Comments for application developers**

Application developers can override saveObject by specifying a custom function in [altSaveObject](#). This can be used to point to a different function to handle the saving process for each class. The custom function can be as simple as a wrapper around saveObject with some additional actions (e.g., to save more metadata), or may be as complex as a full-fledged generic with its own methods for class-specific customizations.

**Author(s)**

Aaron Lun

**Examples**

```
library(S4Vectors)
X <- DataFrame(X=LETTERS, Y=sample(3, 26, replace=TRUE))

tmp <- tempfile()
saveObject(X, tmp)
list.files(tmp, recursive=TRUE)
```

---

 saveObject,DataFrame-method

*Save a DataFrame to disk*


---

## Description

Stage a DataFrame by saving it to a HDF5 file.

## Usage

```
## S4 method for signature 'DataFrame'
saveObject(x, path, DataFrame.character.vls = NULL, ...)

## S4 method for signature 'data.frame'
saveObject(x, path, DataFrame.character.vls = NULL, ...)
```

## Arguments

|                                      |                                                                                                                                                                                                                                            |
|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>                       | A <a href="#">DataFrame</a> or <code>data.frame</code> .                                                                                                                                                                                   |
| <code>path</code>                    | String containing the path to a directory in which to save <code>x</code> .                                                                                                                                                                |
| <code>DataFrame.character.vls</code> | Logical scalar indicating whether to save character vectors in the custom variable length string (VLS) array format. If <code>NULL</code> , this is determined based on a comparison of the expected storage against a fixed length array. |
| <code>...</code>                     | Additional named arguments to pass to specific methods.                                                                                                                                                                                    |

## Details

This method creates a `basic_columns.h5` file that contains columns for atomic vectors, factors, dates and date-times. Dates and date-times are converted to character vectors and saved as such inside the file. Factors are saved as a HDF5 group with both the codes and the levels as separate datasets.

Any non-atomic columns are saved to a `other_columns` subdirectory inside `path` via [saveObject](#), named after its zero-based positional index within `x`.

If [metadata](#) or [mcols](#) are present, they are saved to the `other_annotations` and `column_annotations` subdirectories, respectively, via [saveObject](#).

In the on-disk representation, no distinction is made between [DataFrame](#) and `data.frame` instances of `x`. Calling `readDataFrame` will always produce a [DFrame](#) regardless of the class of `x`.

## Value

A named list containing the metadata for `x`. `x` itself is written to a HDF5 file inside `path`. Additional files may also be created inside `path` and referenced from the metadata.

## Author(s)

Aaron Lun

**Examples**

```
library(S4Vectors)
df <- DataFrame(A=1:10, B=LETTERS[1:10])

tmp <- tempfile()
saveObject(df, tmp)
list.files(tmp, recursive=TRUE)
```

---

 saveObject,DataFrameFactor-method

*Stage a DataFrameFactor object*


---

**Description**

Stage a [DataFrameFactor](#) object, a generalization of the base factor where each level is a row of a [DataFrame](#).

**Usage**

```
## S4 method for signature 'DataFrameFactor'
saveObject(x, path, ...)
```

**Arguments**

|      |                                                                             |
|------|-----------------------------------------------------------------------------|
| x    | A <a href="#">DataFrameFactor</a> object.                                   |
| path | String containing the path to a directory in which to save x.               |
| ...  | Further arguments, to pass to internal <a href="#">altSaveObject</a> calls. |

**Value**

x is saved to an on-disk representation inside path.

**Author(s)**

Aaron Lun

**Examples**

```
library(S4Vectors)
df <- DataFrame(X=LETTERS[1:5], Y=1:5)
out <- DataFrameFactor(df[sample(5, 100, replace=TRUE),,drop=FALSE])

tmp <- tempfile()
saveObject(out, tmp)
list.files(tmp, recursive=TRUE)
```

---

`transformVectorForHdf5`*Transform a vector to save in a HDF5 file*

---

## Description

This handles type casting and missing placeholder value selection/substitution. It is primarily intended for developers of **alabaster.\*** extensions.

## Usage

```
transformVectorForHdf5(x, .version = 3)
```

## Arguments

|                       |                                       |
|-----------------------|---------------------------------------|
| <code>x</code>        | An atomic vector to be saved to HDF5. |
| <code>.version</code> | Internal use only.                    |

## Value

A list containing:

- `transformed`, the transformed vector. This may be the same as `x` if no NA values were detected. Note that logical vectors are cast to integers.
- `placeholder`, the placeholder value used to represent NA values. This is NULL if no NA values were detected in `x`, otherwise it is the same as the output of [chooseMissingPlaceholderForHdf5](#).

## Author(s)

Aaron Lun

## Examples

```
transformVectorForHdf5(c(TRUE, NA, FALSE))
transformVectorForHdf5(c(1L, NA, 2L))
transformVectorForHdf5(c(1L, NaN, 2L))
transformVectorForHdf5(c("FOO", NA, "BAR"))
transformVectorForHdf5(c("FOO", NA, "NA"))
```

---

|                   |                                        |
|-------------------|----------------------------------------|
| validateDirectory | <i>Validate a directory of objects</i> |
|-------------------|----------------------------------------|

---

## Description

Check whether each object in a directory is valid by calling [validateObject](#) on each non-child object.

## Usage

```
validateDirectory(dir, legacy = NULL, ...)
```

## Arguments

|        |                                                                                                                                                                                                                    |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| dir    | String containing the path to a directory with subdirectories populated by <a href="#">saveObject</a> .                                                                                                            |
| legacy | Logical scalar indicating whether to validate a directory with legacy objects (created by the old <code>stageObject</code> ). If <code>NULL</code> , this is auto-detected from the contents of <code>dir</code> . |
| ...    | Further arguments to use when <code>legacy=TRUE</code> , for back-compatibility only.                                                                                                                              |

## Details

We assume that the process of validating an object will call [validateObject](#) on any child objects. This allows us to skip explicit calls to [validateObject](#) on each component of a complex object.

## Value

Character vector of the paths inside `dir` that were validated, invisibly. If any validation failed, an error is raised.

## Author(s)

Aaron Lun

## Examples

```
# Mocking up an object:
library(S4Vectors)
ncols <- 123
df <- DataFrame(
  X = rep(LETTERS[1:3], length.out=ncols),
  Y = runif(ncols)
)
df$Z <- DataFrame(AA = sample(ncols))

# Mocking up the directory:
tmp <- tempfile()
dir.create(tmp, recursive=TRUE)
```

```

saveObject(df, file.path(tmp, "foo"))

# Checking that it's valid:
validateDirectory(tmp)

# Adding an invalid object:
dir.create(file.path(tmp, "bar"))
write(file=file.path(tmp, "bar", "OBJECT"), '[ "WHEEE" ]')
try(validateDirectory(tmp))

```

---

|                |                                                    |
|----------------|----------------------------------------------------|
| validateObject | <i>Validate an object's on-disk representation</i> |
|----------------|----------------------------------------------------|

---

## Description

Validate an object's on-disk representation against the **takane** specifications. This is done by dispatching to an appropriate validation function based on the type in the OBJECT file.

## Usage

```

validateObject(path, metadata = NULL)

registerValidateObjectFunction(type, fun, existing = c("old", "new", "error"))

registerValidateObjectHeightFunction(
  type,
  fun,
  existing = c("old", "new", "error")
)

registerValidateObjectDimensionsFunction(
  type,
  fun,
  existing = c("old", "new", "error")
)

registerValidateObjectSatisfiesInterface(
  type,
  interface,
  action = c("add", "remove")
)

registerValidateObjectDerivedFrom(type, parent, action = c("add", "remove"))

```

**Arguments**

|           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| path      | String containing a path to a directory, itself created with a <a href="#">saveObject</a> method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| metadata  | List containing metadata for the object. If this is not supplied, it is automatically read from the OBJECT file inside path.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| type      | String specifying the name of type of the object.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| fun       | <p>For registerValidateObjectFunction, a function that accepts path and metadata, and raises an error if the object at path is invalid. It can be assumed that metadata is a list created by reading OBJECT.</p> <p>For registerValidateObjectHeightFunction, a function that accepts path and metadata, and returns an integer specifying the “height” of the object. This is usually the length for vector-like or 1-dimensional objects, and the extent of the first dimension for higher-dimensional objects.</p> <p>For registerValidateObjectDimensionsFunction, a function that accepts path and metadata, and returns an integer vector specifying the dimensions of the object.</p> <p>This may also be NULL to delete an existing registry from any of the functions mentioned above.</p> |
| existing  | Logical scalar indicating the action to take if a function has already been registered for type - keep the old or new function, or throw an error.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| interface | String specifying the name of the interface that is represented by type.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| action    | String specifying whether to add or remove type from the list of types that implements interface or is derived from parent.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| parent    | String specifying the parent object from which type is derived.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

**Value**

For validateObject, NULL is returned invisibly upon success, otherwise an error is raised.

For the registerValidObject\*Function functions, the supplied fun is added to the corresponding registry for type. If fun = NULL, any existing entry for type is removed; a logical scalar is returned indicating whether removal was performed.

For the registerValidateObjectSatisfiesInterface and registerValidateObjectDerivedFrom functions, type is added to or removed from relevant list of types. A logical scalar is returned indicating whether the type was added or removed - this may be FALSE if type was already present or absent, respectively.

**Author(s)**

Aaron Lun

**See Also**

<https://github.com/ArtifactDB/takane>, for detailed specifications of the on-disk representation for various Bioconductor objects.

Examples

```
library(S4Vectors)
df <- DataFrame(A=1:10, B=LETTERS[1:10])

tmp <- tempfile()
saveObject(df, tmp)
validateObject(tmp)
```

---

|     |                      |
|-----|----------------------|
| vls | VLS saving utilities |
|-----|----------------------|

---

Description

Utilities for saving our custom variable length string array format in HDF5. Intended for **alabaster**.\* developers only.

---

|               |                     |
|---------------|---------------------|
| writeMetadata | Saving the metadata |
|---------------|---------------------|

---

Description

*WARNING: this function is deprecated as newer versions of **alabaster** do not need to write meta-data.* Helper function to write metadata from a named list to a JSON file. This is commonly used inside [stageObject](#) methods to create the metadata file for a child object.

Usage

```
writeMetadata(meta, dir, ignore.null = TRUE)
```

Arguments

- meta            A named list containing metadata. This should contain at least the "\$schema" and "path" elements.
- dir            String containing a path to the staging directory.
- ignore.null   Logical scalar indicating whether NULL values should be ignored during coercion to JSON.

## Details

Any NULL values in meta are pruned out prior to writing when `ignore.null=TRUE`. This is done recursively so any NULL values in sub-lists of meta are also ignored.

Any scalars are automatically unboxed so array values should be explicitly specified as such with `I()`.

Any starting `"/` in `meta$path` will be automatically removed. This allows staging methods to save in the current directory by setting `path=" "`, without the need to pollute the paths with a `"/` prefix.

The JSON-formatted metadata is validated against the schema in `meta[["$schema"]]` using **json-validate**. The location of the schema is taken from the package attribute in that string, if one exists; otherwise, it is assumed to be in the **alabaster.schemas** package. (All schemas are assumed to live in the `inst/schemas` subdirectory of their indicated packages.)

We also use the schema to determine whether meta refers to an actual artifact or is a metadata-only document. If it refers to an actual file, we compute its MD5 sum and store it in the metadata for saving. We also save its associated metadata into a JSON file at a location obtained by appending `".json"` to `meta$path`.

For artifacts, the MD5 sum calculation will be skipped if the meta already contains a `md5sum` field. This can be useful on some occasions, e.g., to improve efficiency when the MD5 sum was already computed during staging, or if the artifact does not actually exist in its full form on the file system.

## Value

A JSON file containing the metadata is created at `path`. A list of resource metadata is returned, e.g., for inclusion as the `"resource"` property in parent schemas.

## Author(s)

Aaron Lun

## Examples

```
library(S4Vectors)
df <- DataFrame(A=1:10, B=LETTERS[1:10])

tmp <- tempfile()
dir.create(tmp)
info <- stageObject(df, tmp, path="coldata")
writeMetadata(info, tmp)
cat(readLines(file.path(tmp, "coldata/simple.csv.gz.json")), sep="\n")
```

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