Package ‘chihaya’

November 13, 2025

Title Save Delayed Operations to a HDF5 File

Description Saves the delayed operations of a DelayedArray to a HDF5 file.
This enables efficient recovery of the DelayedArray's contents in other languages and analysis frameworks.

Version 1.11.0

Date 2024-09-16

License GPL-3

Depends DelayedArray

Imports methods, Matrix, rhdf5, Rcpp, HDF5Array

Suggests BiocGenerics, S4Vectors, BiocSingular, ResidualMatrix, BiocStyle, testthat, rmarkdown, knitr

LinkingTo Rcpp, Rhdf5lib

VignetteBuilder knitr

BugReports https://github.com/ArtifactDB/chihaya-R/issues

URL https://github.com/ArtifactDB/chihaya-R

SystemRequirements C++17, GNU make

Encoding UTF-8

RoxygenNote 7.3.2

biocViews DataImport, DataRepresentation

git_url https://git.bioconductor.org/packages/chihaya

git_branch devel

git_last_commit d520e49

git_last_commit_date 2025-10-29

Repository Bioconductor 3.23

Date/Publication 2025-11-13

Author Aaron Lun [cre, aut]

Maintainer Aaron Lun <infinite.monkeys.with.keyboards@gmail.com>

Contents

allowExternalSeeds . . . 2
chihaya-utils . . . 3
knownOperations . . . 5
loadDelayed . . . 6
saveDelayed . . . 7
saveDelayedObject . . . 8
saveDelayedObject,ANY-method . . . 9
saveDelayedObject,array-method . . . 10
saveDelayedObject,ConstantArraySeed-method . . . 11
saveDelayedObject,DelayedAbind-method . . . 12
saveDelayedObject,DelayedAperm-method . . . 13
saveDelayedObject,DelayedNaryIsoOp-method . . . 14
saveDelayedObject,DelayedSetDimnames-method . . . 15
saveDelayedObject,DelayedSubassign-method . . . 16
saveDelayedObject,DelayedSubset-method . . . 17
saveDelayedObject,DelayedUnaryIsoOpStack-method . . . 18
saveDelayedObject,DelayedUnaryIsoOpWithArgs-method . . . 19
saveDelayedObject,HDF5ArraySeed-method . . . 20
validate . . . 21

Index **22**

`allowExternalSeeds` *Allow saving of external seeds*

Description

Should external array seeds be saved in `saveDelayed`? If `FALSE`, an error is raised upon encountering external references such as HDF5ArraySeeds. This prevents the creation of delayed objects that cannot be used on different filesystems.

Usage

```
allowExternalSeeds(allow)
```

Arguments

`allow`	Logical scalar indicating whether to allow downloads of external seeds.

Value

If `allow` is not supplied, the current value of this flag is returned.

If `allow` is supplied, it is used to define the value of this flag, and the *previous* value of the flag is returned.

Author(s)

Aaron Lun

Examples

```
allowExternalSeeds()

a <- allowExternalSeeds(FALSE)
allowExternalSeeds()

# Setting it back
allowExternalSeeds(a)
```

---

chihaya-utils *Developer utilities for custom extensions*

Description

Convenience utilities for extending the **chihaya** format with "custom" seeds or operations. These should only be used by package developers.

Usage

```
.saveList(file, name, x, parent = NULL, vectors.only = FALSE)

.loadList(file, name, parent = NULL, vectors.only = FALSE)

.labelOperationGroup(file, name, op)

.labelArrayGroup(file, name, arr)

.saveDataset(
  file,
  name,
  x,
  parent = NULL,
  scalar = FALSE,
  optimize.type = FALSE,
  h5type = NULL,
  chunks = NULL
)

.pickArrayType(x)
```

Arguments

`file`	String containing a path to a file.
`name`	String containing the name of the object inside the file. This should be a full path from the root of the file, unless `parent` is provided, in which case it may be the name of the child.
`x`	The object to save. • For `.pickArrayType`, this should be an array-like object. • For `.saveList`, this should be a list. • For `.saveDataset`, this should be a integer, logical, character or double vector or array.
`parent`	String containing the name of the parent containing the child `name`.
`vectors.only`	Logical scalar indicating whether elements of `x` should be saved and loaded as 1-d arrays rather than seeds.
`op`	String containing the name of the delayed operation to use to label the group.
`arr`	String containing the name of the delayed array to use to label the group.
`scalar`	Logical scalar indicating whether length-1 `x` should be saved to file as a scalar.
`optimize.type`	Logical scalar indicating whether to optimize the HDF5 storage type for non-scalar, non-string `x`.
`h5type`	String specifying the HDF5 storage type to use for non-scalar, non-string `x`, see `h5const("H5T")` for possible choices. This is ignored if `optimize.type=TRUE`.
`chunks`	Integer vector of length equal to the number of dimensions of non-scalar `x`, specifying the chunk dimensions to use. If `NULL`, this is set to the length of `x` (if `x` is a vector) or chosen by **HDF5Array** (if `x` is an array).

Value

`.saveList` and `.saveScalar` will write `x` to file, returning `NULL` invisibly.

`.labelArrayGroup` and `.labelOperationGroup` will apply the label to the specified group, returning `NULL` invisibly.

`.loadList` will return a list containing the contents of `name`. This is guaranteed to contain only vectors (or fail) if `vectors.only=TRUE`.

`.pickArrayType` will return a string containing the **chihaya** type for an array-like `x`.

Author(s)

Aaron Lun

knownOperations *Get or set loaders for operations/arrays*

Description

Get or set loading functions for operations or arrays that were saved into the HDF5 file. This enables third-party packages to modify the **chihaya** framework for their own purposes.

Usage

```
knownOperations(operations)

knownArrays(arrays)
```

Arguments

operations	Named list of loading functions for operations. Each function should accept the same arguments as loadDelayed and return a matrix-like object. Names should match the delayed_operation string used to save the operation to file.
arrays	Named list of loading functions for arrays. Each function should accept the same arguments as loadDelayed and return a matrix-like object. Names should match the delayed_array string used to save the array to file.

Details

This function can be used to modify the loading procedure for existing operations/arrays or to add new loaders for new arrays.

Custom arrays should use a "custom " prefix in the name to ensure that they do not clash with future additions to the **chihaya** specification. If an instance of a custom array contains an **r_package** scalar string dataset inside its HDF5 group, the string is assumed to hold the name of the package that implements its loading handler; if this package is installed, it will be automatically loaded and used by loadDelayed.

Custom operations can be added, but they are not currently supported via validate, so it is assumed that such operations will be created outside of saveDelayed.

Value

If operations is missing, customLoadOperations will return a list of the current custom operations that have been registered with **chihaya**. If operations is provided, it is used to define the set of custom operations, and the *previous* set of operations is returned. The same approach is used for arrays in customLoadArrays.

Author(s)

Aaron Lun

Examples

```
library(HDF5Array)
X <- rsparsematrix(100, 20, 0.1)
Y <- DelayedArray(X)
Z <- log2(Y + 1)

temp <- tempfile(fileext=".h5")
saveDelayed(Z, temp)

# Overriding an existing operation:
ops <- knownOperations()
old_unary <- ops[["unary math"]]
ops[["unary math"]] <- function(file, path) {
    cat("WHEE!\n")
    old_unary(file, path)
}
old <- knownOperations(ops)

# Prints our little message:
loadDelayed(temp)

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

`loadDelayed` *Load a DelayedMatrix*

Description

Load a DelayedMatrix object from a location within a HDF5 file.

Usage

```
loadDelayed(file, path = "delayed")
```

Arguments

`file`	String containing a path to a HDF5 file.
`path`	String containing a path inside a HDF5 file containing the DelayedMatrix.

Value

A DelayedMatrix containing the contents at `path`.

Author(s)

Aaron Lun

See Also

knownOperations and knownArrays, to modify the loading procedure.

Examples

```
library(HDF5Array)
X <- rsparsematrix(100, 20, 0.1)
Y <- DelayedArray(X)
Z <- log2(Y + 1)

temp <- tempfile(fileext=".h5")
saveDelayed(Z, temp)
loadDelayed(temp)
```

---

saveDelayed *Save a DelayedMatrix*

Description

Save a DelayedMatrix object to a location within a HDF5 file.

Usage

```
saveDelayed(x, file, path = "delayed")
```

Arguments

x	A DelayedArray object.
file	String containing a path to a HDF5 file. This will be created if it does not yet exist.
path	String containing a path inside a HDF5 file. This should not already exist, though any parent groups should already be constructed.

Details

See the various saveDelayedObject methods for how each suite of delayed operations is handled. Also see https://artifactdb.github.io/chihaya/ for more details on the data layout inside the HDF5 file.

Value

The contents of x are written to file and a NULL is invisibly returned.

Author(s)

Aaron Lun

Examples

```
library(HDF5Array)
X <- rsparsematrix(100, 20, 0.1)
Y <- DelayedArray(X)
Z <- log2(Y + 1)

temp <- tempfile(fileext=".h5")
saveDelayed(Z, temp)
rhdf5::h5ls(temp)
```

`saveDelayedObject` *Save a delayed object*

Description

Saves a delayed object recursively.

Usage

```
saveDelayedObject(x, file, name)

## S4 method for signature 'DelayedArray'
saveDelayedObject(x, file, name)
```

Arguments

`x`	An R object containing a delayed operation or seed class.
`file`	String containing the path to a HDF5 file.
`name`	String containing the name of the group to save into.

Details

The `saveDelayedObject` generic is intended for developers to create methods for new operations. End-users should use the `saveDelayed` function instead.

The DelayedArray method will simply extract the seed and use it to call `saveDelayedObject` again.

Value

A `NULL` is returned invisibly. A group is created at `name` inside `file` and the delayed operation is saved within.

Author(s)

Aaron Lun

Examples

```
library(HDF5Array)
X <- rsparsematrix(100, 20, 0.1)
Y <- DelayedArray(X)[1:10,1:5]

temp <- tempfile(fileext=".h5")
rhdf5::h5createFile(temp)
saveDelayedObject(Y, temp, "FOO")
rhdf5::h5ls(temp)
```

`saveDelayedObject,ANY-method`

Saving other seed classes

Description

Optional methods to save other classes, depending on the availability of the packages in the current R installation.

Usage

```
## S4 method for signature 'ANY'
saveDelayedObject(x, file, name)
```

Arguments

`x`	An R object of a supported class, see Details.
`file`	String containing the path to a HDF5 file.
`name`	String containing the name of the group to save into.

Details

The ANY method will dispatch to classes that are implemented in other packages:

- If `x` is a LowRankMatrixSeed from the **BiocSingular** package, it is handled as a delayed matrix product.
- If `x` is a ResidualMatrixSeed from the **ResidualMatrix** package, it is converted into the corresponding series of delayed operations. However, the top-level group will contain a `"r_type_hint"` dataset to indicate that it was originally a ResidualMatrix object. This provides R clients with the opportunity to reload it as a ResidualMatrix, which may be more efficient than the naive DelayedArray representation.
- Otherwise, if `x` comes from package **Y**, we will try to load **chihaya.Y**. This is assumed to define an appropriate `saveDelayedObject` method for `x`.

Value

A `NULL`, invisibly. A group is created at `name` containing the contents of `x`.

Author(s)

Aaron Lun

Examples

```
# Saving a matrix product.
library(BiocSingular)
left <- matrix(rnorm(100000), ncol=20)
right <- matrix(rnorm(50000), ncol=20)
thing <- LowRankMatrix(left, right)
temp <- tempfile()
saveDelayed(thing, temp)
rhdf5::h5ls(temp)
loadDelayed(temp)
```

---

saveDelayedObject,array-method

Saving simple seed classes

Description

Methods to save simple seed classes - namely, ordinary matrices or sparse **Matrix** objects - into the delayed operation file. See "Dense arrays" and "Sparse matrices" at https://artifactdb.github.io/chihaya/ for more details.

Usage

```
## S4 method for signature 'array'
saveDelayedObject(x, file, name)

## S4 method for signature 'CsparseMatrix'
saveDelayedObject(x, file, name)
```

Arguments

x	An R object of the indicated class.
file	String containing the path to a HDF5 file.
name	String containing the name of the group to save into.

Details

For string arrays, missing values are handled by the "missing-value-placeholder" attribute on the data dataset. All NA values in the array are replaced by the placeholder value in the attribute when they are saved inside the HDF5 file. If this attribute is not present, it can be assumed that all strings are non-missing.

Value

A NULL, invisibly. A group is created at name containing the contents of x.

Author(s)

Aaron Lun

Examples

```
# Saving an ordinary matrix.
X <- matrix(rpois(100, 2), 5, 20)
Y <- DelayedArray(X)
temp <- tempfile(fileext=".h5")
saveDelayed(Y, temp)
rhdf5::h5ls(temp)
loadDelayed(temp)

# Saving a sparse matrix.
X <- rsparsematrix(100, 20, 0.1)
Y <- DelayedArray(X)
temp <- tempfile(fileext=".h5")
saveDelayed(Y, temp)
rhdf5::h5ls(temp)
loadDelayed(temp)
```

---

saveDelayedObject,ConstantArraySeed-method

Saving a ConstantArraySeed

Description

Save a ConstantArraySeed object. See the "Constant array" section at https://artifactdb.github.io/chihaya/ for more details.

Usage

```
## S4 method for signature 'ConstantArraySeed'
saveDelayedObject(x, file, name)
```

Arguments

x	A ConstantArraySeed object.
file	String containing the path to a HDF5 file.
name	String containing the name of the group to save into.

Value

A NULL, invisibly. A group is created at name containing the contents of the ConstantArraySeed.

Author(s)

Aaron Lun

Examples

```
X <- ConstantArray(value=NA_real_, dim=c(11, 25))
temp <- tempfile(fileext=".h5")
saveDelayed(X, temp)
rhdf5::h5ls(temp)
loadDelayed(temp)
```

---

saveDelayedObject,DelayedAbind-method

Saving a DelayedAbind

Description

Save a DelayedAbind object. See the "Combining" operation at https://artifactdb.github.io/chihaya/ for more details.

Usage

```
## S4 method for signature 'DelayedAbind'
saveDelayedObject(x, file, name)
```

Arguments

x	A DelayedAbind object.
file	String containing the path to a HDF5 file.
name	String containing the name of the group to save into.

Value

A NULL, invisibly. A group is created at name containing the contents of the DelayedAbind.

Author(s)

Aaron Lun

Examples

```
X <- DelayedArray(matrix(runif(100), ncol=20))
Y <- cbind(X, X)
temp <- tempfile(fileext=".h5")
saveDelayed(Y, temp)
rhdf5::h5ls(temp)
loadDelayed(temp)
```

saveDelayedObject,DelayedAperm-method
Saving a DelayedAperm

Description

Save a DelayedAperm object. See the "Transposition" operation at https://artifactdb.github.io/chihaya/ for more details.

Usage

```
## S4 method for signature 'DelayedAperm'
saveDelayedObject(x, file, name)
```

Arguments

x	A DelayedAperm object.
file	String containing the path to a HDF5 file.
name	String containing the name of the group to save into.

Value

A NULL, invisibly. A group is created at name containing the contents of the DelayedAperm.

Author(s)

Aaron Lun

Examples

```
X <- DelayedArray(matrix(runif(100), ncol=20))
Y <- t(X)
temp <- tempfile(fileext=".h5")
saveDelayed(Y, temp)
rhdf5::h5ls(temp)
loadDelayed(temp)
```

`saveDelayedObject,DelayedNaryIsoOp-method`
Saving a DelayedNaryIsoOp

Description

Save a DelayedNaryIsoOp object into a HDF5 file. See the "Binary ..." operations at https://artifactdb.github.io/chihaya/ for more details.

Usage

```
## S4 method for signature 'DelayedNaryIsoOp'
saveDelayedObject(x, file, name)
```

Arguments

`x`	A DelayedNaryIsoOp object.
`file`	String containing the path to a HDF5 file.
`name`	String containing the name of the group to save into.

Value

A `NULL`, invisibly. A group is created at `name` containing the contents of the DelayedNaryIsoOp.

Author(s)

Aaron Lun

Examples

```
X <- DelayedArray(matrix(runif(100), ncol=5))
Y <- DelayedArray(matrix(runif(100), ncol=5))
Z <- X * Y
temp <- tempfile(fileext=".h5")
saveDelayed(Z, temp)
rhdf5::h5ls(temp)
loadDelayed(temp)
```

saveDelayedObject,DelayedSetDimnames-method
Saving a DelayedSetDimnames

Description

Save a DelayedSetDimnames object. See the "Dimnames assignment" operation at https://artifactdb.github.io/chihaya/ for more details.

Usage

```
## S4 method for signature 'DelayedSetDimnames'
saveDelayedObject(x, file, name)
```

Arguments

x	A DelayedSetDimnames object.
file	String containing the path to a HDF5 file.
name	String containing the name of the group to save into.

Value

A NULL, invisibly. A group is created at name containing the contents of the DelayedSetDimnames.

Author(s)

Aaron Lun

Examples

```
X <- DelayedArray(matrix(runif(100), ncol=20))
colnames(X) <- LETTERS[1:20]
temp <- tempfile(fileext=".h5")
saveDelayed(X, temp)
rhdf5::h5ls(temp)
loadDelayed(temp)
```

`saveDelayedObject,DelayedSubassign-method` *Saving a DelayedSubassign*

Description

Save a DelayedSubassign object into a HDF5 file. See the "Subset assignment" operation at https://artifactdb.github.io/chihaya/ for more details.

Usage

```
## S4 method for signature 'DelayedSubassign'
saveDelayedObject(x, file, name)
```

Arguments

x	A DelayedSubassign object.
file	String containing the path to a HDF5 file.
name	String containing the name of the group to save into.

Value

A NULL, invisibly. A group is created at name containing the contents of the DelayedSubassign.

Author(s)

Aaron Lun

Examples

```
X <- DelayedArray(matrix(runif(100), ncol=20))
X[1:2,3:5] <- matrix(-runif(6), ncol=3)
temp <- tempfile(fileext=".h5")
saveDelayed(X, temp)
rhdf5::h5ls(temp)
loadDelayed(temp)
```

saveDelayedObject,DelayedSubset-method
Saving a DelayedSubset

Description

Save a DelayedSubset object into a HDF5 file. See the "Subsetting" operation at https://artifactdb.github.io/chihaya/ for more details.

Usage

```
## S4 method for signature 'DelayedSubset'
saveDelayedObject(x, file, name)
```

Arguments

x	A DelayedSubset object.
file	String containing the path to a HDF5 file.
name	String containing the name of the group to save into.

Value

A NULL, invisibly. A group is created at name containing the contents of the DelayedSubset.

Author(s)

Aaron Lun

Examples

```
X <- DelayedArray(matrix(runif(100), ncol=20))
Y <- X[1:2,3:5]
temp <- tempfile(fileext=".h5")
saveDelayed(Y, temp)
rhdf5::h5ls(temp)
loadDelayed(temp)
```

`saveDelayedObject,DelayedUnaryIsoOpStack-method`
Saving a DelayedUnaryIsoOpStack

Description

Save a DelayedUnaryIsoOpStack object into a HDF5 file. See the "Unary ..." operations at https://artifactdb.github.io/chihaya/ for more details.

Usage

```
## S4 method for signature 'DelayedUnaryIsoOpStack'
saveDelayedObject(x, file, name)
```

Arguments

x	A DelayedUnaryIsoOpStack object.
file	String containing the path to a HDF5 file.
name	String containing the name of the group to save into.

Value

A NULL, invisibly. A group is created at name containing the contents of the DelayedUnaryIsoOpStack.

Author(s)

Aaron Lun

Examples

```
X <- DelayedArray(matrix(runif(100), ncol=20))
Y <- log2(X + 10)
temp <- tempfile(fileext=".h5")
saveDelayed(Y, temp)
rhdf5::h5ls(temp)
loadDelayed(temp)
```

saveDelayedObject,DelayedUnaryIsoOpWithArgs-method
Saving a DelayedUnaryIsoOpWithArgs

Description

Save a DelayedUnaryIsoOpWithArgs object into a HDF5 file. See the "Unary ..." operation at https://artifactdb.github.io/chihaya/ for more details.

Usage

```
## S4 method for signature 'DelayedUnaryIsoOpWithArgs'
saveDelayedObject(x, file, name)
```

Arguments

x	A DelayedUnaryIsoOpWithArgs object.
file	String containing the path to a HDF5 file.
name	String containing the name of the group to save into.

Value

A NULL, invisibly. A group is created at name containing the contents of the DelayedUnaryIsoOpWithArgs.

Author(s)

Aaron Lun

Examples

```
X <- DelayedArray(matrix(runif(100), ncol=5))
Y <- (1:20 + X) / runif(5)
temp <- tempfile(fileext=".h5")
saveDelayed(Y, temp)
rhdf5::h5ls(temp)
loadDelayed(temp)
```

saveDelayedObject,HDF5ArraySeed-method
Save HDF5-based seeds

Description

Save HDF5ArraySeed or H5SparseMatrix objects or their subclasses. See "External HDF5 arrays" at https://artifactdb.github.io/chihaya/ for more details.

Usage

```
## S4 method for signature 'HDF5ArraySeed'
saveDelayedObject(x, file, name)

## S4 method for signature 'H5SparseMatrixSeed'
saveDelayedObject(x, file, name)
```

Arguments

x	A HDF5ArraySeed or H5SparseMatrix object or subclass thereof.
file	String containing the path to a HDF5 file.
name	String containing the name of the group to save into.

Value

A NULL, invisibly. A group is created at name containing the contents of the HDF5-based seed.

Author(s)

Aaron Lun

Examples

```
library(HDF5Array)
X <- writeHDF5Array(matrix(runif(100), ncol=20))
Y <- X + 1
temp <- tempfile(fileext=".h5")
saveDelayed(Y, temp)
rhdf5::h5ls(temp)
loadDelayed(temp)
```

validate *Validate an artifact*

Description

Validate the delayed objects inside a HDF5 file. This is automatically run at the end of every saveDelayed call to check the integrity of the saved files. See https://artifactdb.github.io/chihaya/ for more details.

Usage

```
validate(path, name)
```

Arguments

path	String containing the path to the HDF5 file.
name	String containing the name of the delayed object inside the file.

Value

NULL if there are no problems, otherwise an error is raised.

Author(s)

Aaron Lun

See Also

See https://artifactdb.github.io/chihaya/ for the specification.

Examples

```
X <- DelayedArray(matrix(runif(100), ncol=20))
Y <- X[1:2,3:5]
temp <- tempfile(fileext=".h5")
saveDelayed(Y, temp)
validate(temp, "delayed")
```

Index

.labelArrayGroup *(*chihaya-utils*)*, 3
.labelOperationGroup *(*chihaya-utils*)*, 3
.loadList *(*chihaya-utils*)*, 3
.pickArrayType *(*chihaya-utils*)*, 3
.saveDataset *(*chihaya-utils*)*, 3
.saveList *(*chihaya-utils*)*, 3

allowExternalSeeds, 2

chihaya-utils, 3
ConstantArraySeed, *11*

DelayedAbind, *12*
DelayedAperm, *13*
DelayedArray, *7, 8*
DelayedMatrix, *6, 7*
DelayedNaryIsoOp, *14*
DelayedSetDimnames, *15*
DelayedSubassign, *16*
DelayedSubset, *17*
DelayedUnaryIsoOpStack, *18*
DelayedUnaryIsoOpWithArgs, *19*

h5const, *4*
H5SparseMatrix, *20*
HDF5ArraySeed, *2*, *20*

knownArrays, *7*
knownArrays *(*knownOperations*)*, 5
knownOperations, 5, *7*

loadDelayed, *5*, 6

saveDelayed, *2*, *5*, 7, *8*, *21*
saveDelayedObject, *7, 8*, 8
saveDelayedObject,ANY-method, 9
saveDelayedObject,array-method, 10
saveDelayedObject,ConstantArraySeed-method, 11
saveDelayedObject,CsparseMatrix-method *(*saveDelayedObject,array-method*)*, 10
saveDelayedObject,DelayedAbind-method, 12
saveDelayedObject,DelayedAperm-method, 13
saveDelayedObject,DelayedArray-method *(*saveDelayedObject*)*, 8
saveDelayedObject,DelayedNaryIsoOp-method, 14
saveDelayedObject,DelayedSetDimnames-method, 15
saveDelayedObject,DelayedSubassign-method, 16
saveDelayedObject,DelayedSubset-method, 17
saveDelayedObject,DelayedUnaryIsoOpStack-method, 18
saveDelayedObject,DelayedUnaryIsoOpWithArgs-method, 19
saveDelayedObject,H5SparseMatrixSeed-method *(*saveDelayedObject,HDF5ArraySeed-method*)*, 20
saveDelayedObject,HDF5ArraySeed-method, 20

validate, *5*, 21