Building Interoperability in Existing Software Ecosystems with S3 Classes

Hugo Gruson, Lead Software Architect @ data.org

Why do we care about interoperability?

Piping system on a chemical tanker, by Hervé Cozanet, CC BY-SA

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Piping system on a chemical tanker, by Hervé Cozanet, CC BY-SA

Lots of data wrangling is required to:

- Make successive pieces fit well with one another
- Swap one piece for another equivalent one

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Piping system on a chemical tanker, by Hervé Cozanet, CC BY-SA

Precious time wasted reformatting inputs and outputs.

Very costly in times of emergency.

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Precious time wasted reformatting inputs and outputs.

Very costly in times of emergency.

Efforts invested now in interoperability will pay important dividends later down the line.

An international multi-stakeholder project to

harmonise the ecosystem of epidemiology tools in R

- ☑️ Make existing tools interoperable
- ☑️ Support existing tools to adopt global standards
- ☑️ Develop a sustainable community

Universidad de los Andes Colombia

Pontificia Universidad JAVERIANA Colombia

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

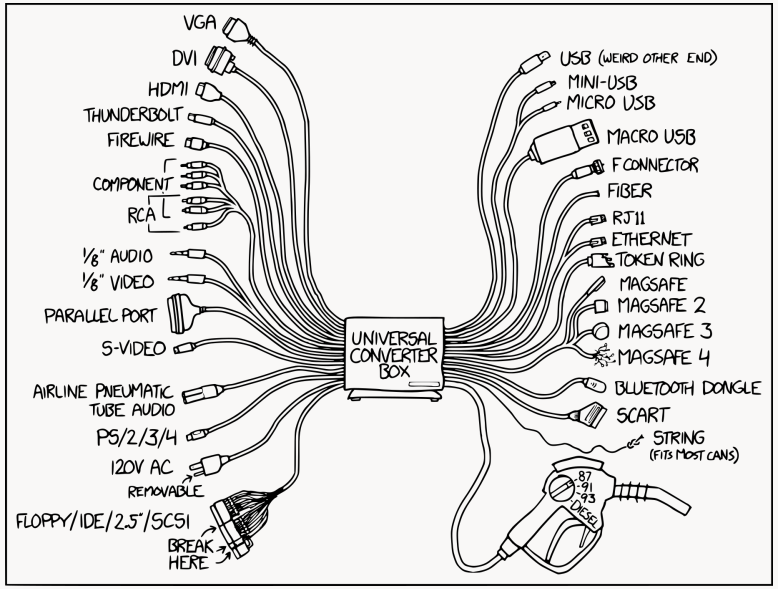
MRC Unit The Gambia

But we also care about preserving the ecosystem!

More about this in my “CRAN Task View Analysis” poster tomorrow

Conversion functions do not scale

XKCD 1406: *Universal Converter Box*, by Randall Munroe, CC BY-NC



Related article: https://voltrondata.com/codex/open-standards

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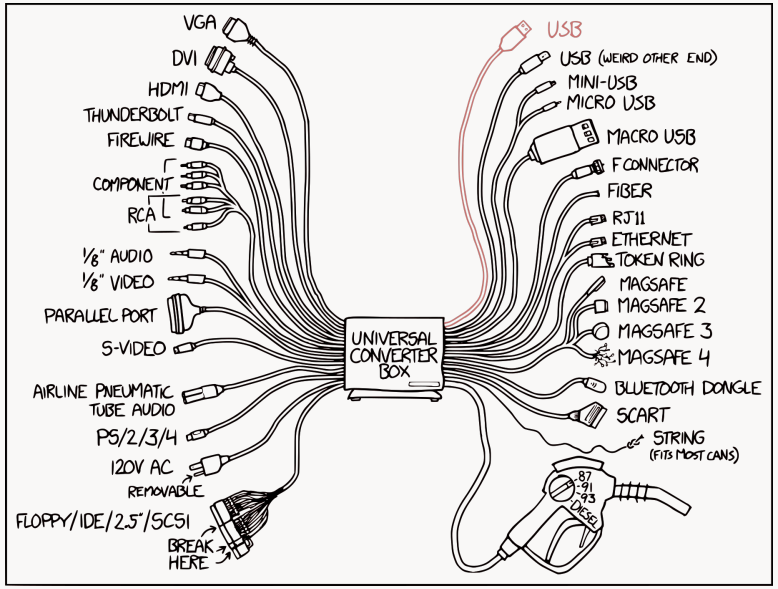

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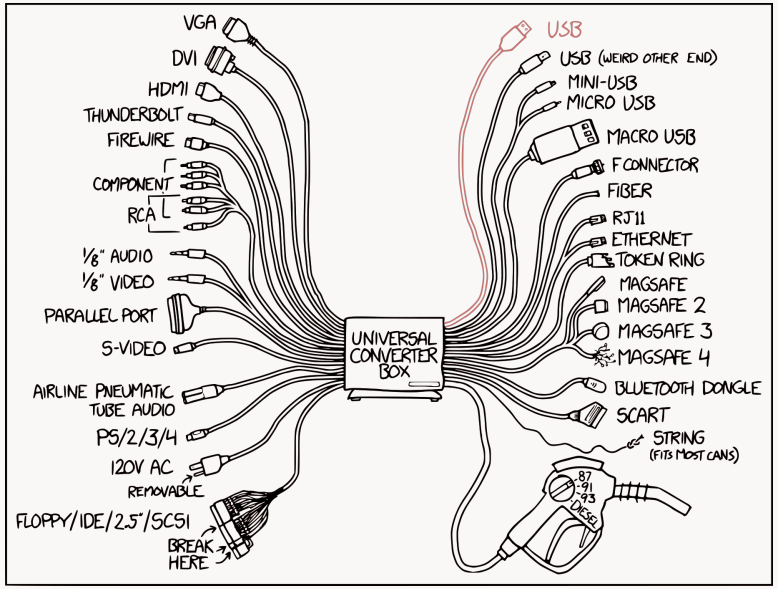
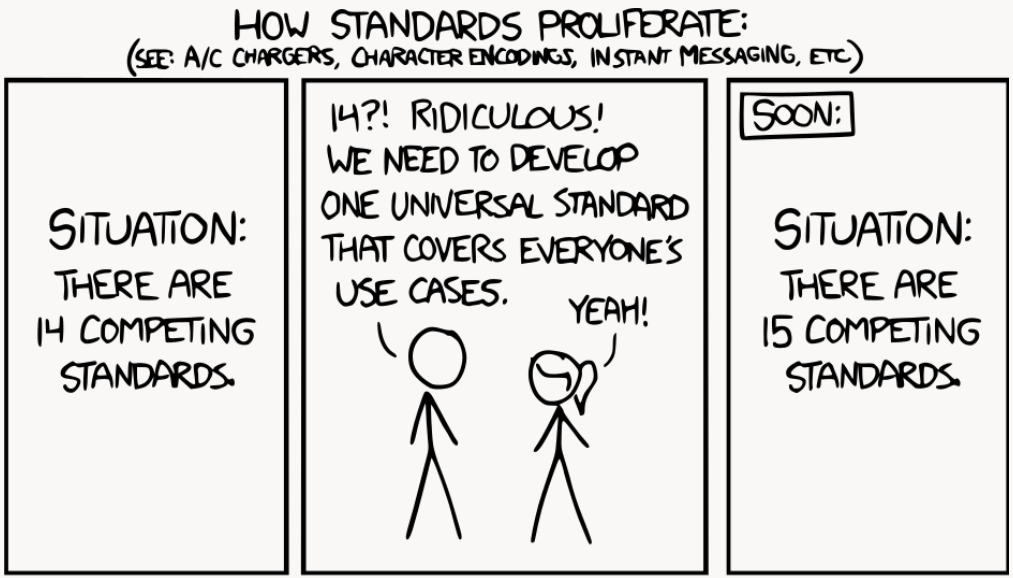


Standards are the only viable solution

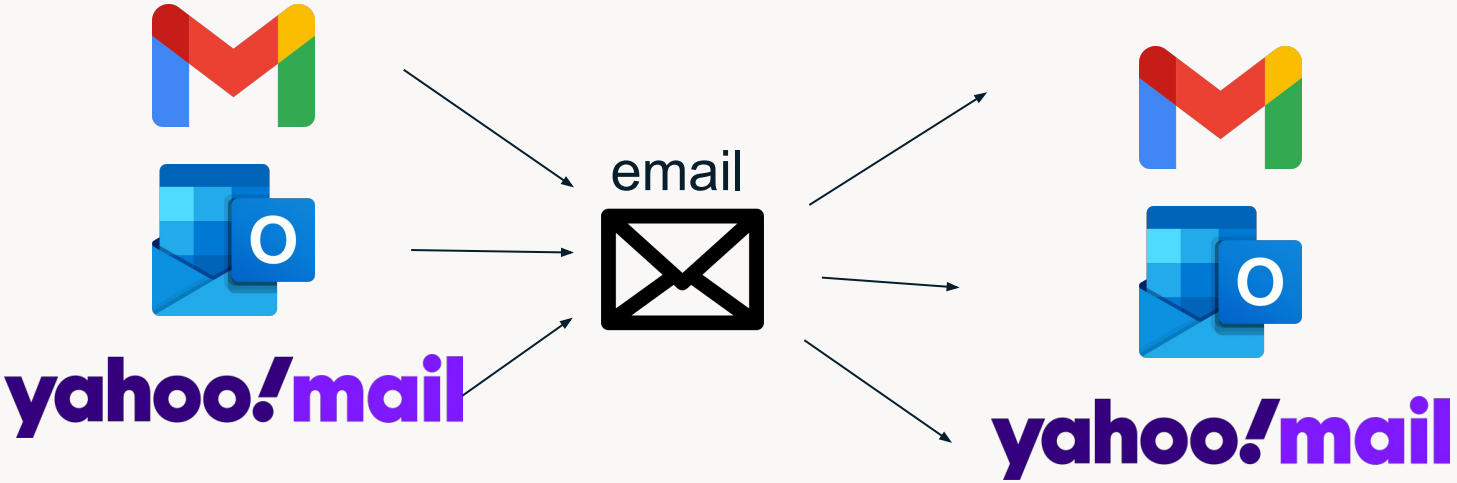
Related article: https://voltrondata.com/codex/open-standards

Standards are hard…



XKCD 927: *Standards*, by Randall Munroe, CC BY-NC

Standards are hard… but not impossible!



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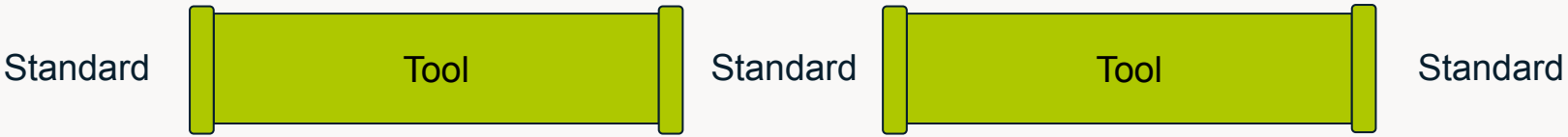

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1. Community engagement

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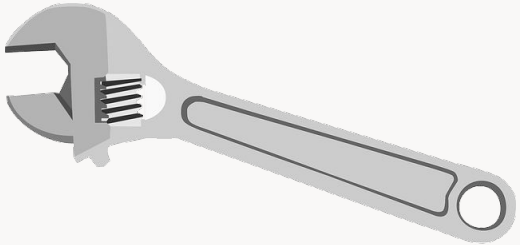
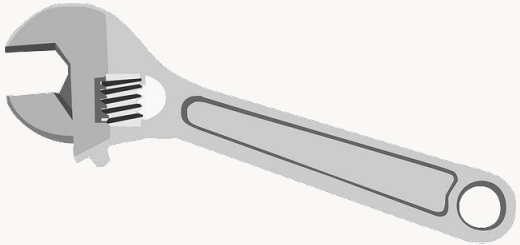


2. Technical strategy

How do we go about this in Epiverse-TRACE?

1. Community engagement



2. Technical strategy

Keep an eye out for links to blog posts with more details!

Technical strategy: S3 classes and methods

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What is S3?

"*S3 is informal and ad hoc, but there is a certain elegance in its minimalism: you can't take away any part of it and still have a useful OO system*." Hadley Wickham

Technical strategy: S3 classes and methods

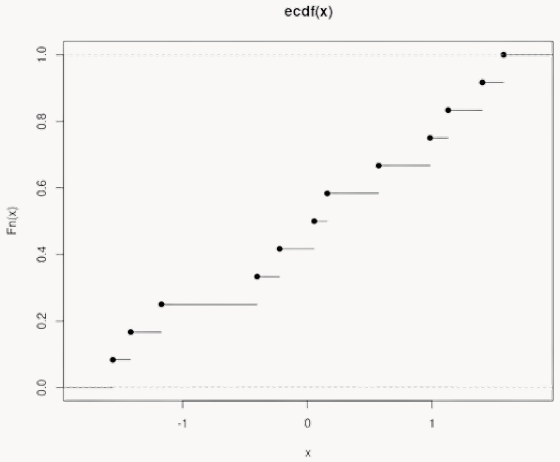
What is S3?

"*S3 is informal and ad hoc, but there is a certain elegance in its minimalism: you can't take away any part of it and still have a useful OO system*." Hadley Wickham

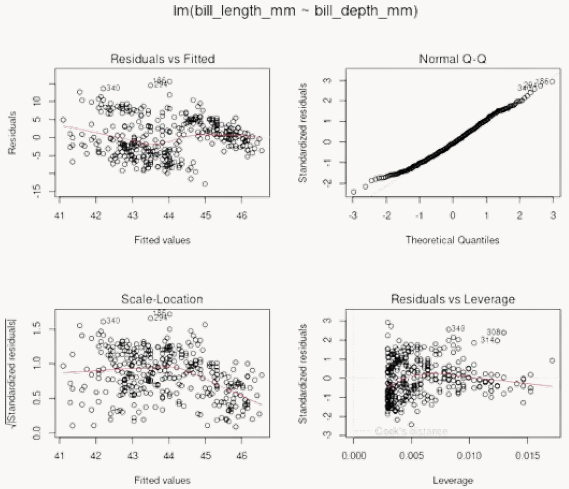
- Mostly an advanced dispatch system based on the presence of the specific attribute
- Used by all R users, even if they don't realize it!

Technical strategy: S3 classes and methods

```r
fn <- ecdf(rnorm(12))
plot(fn)
```




```r
m <- lm(bill_length_mm ~ bill_depth_mm, data = penguins)
plot(m)
```



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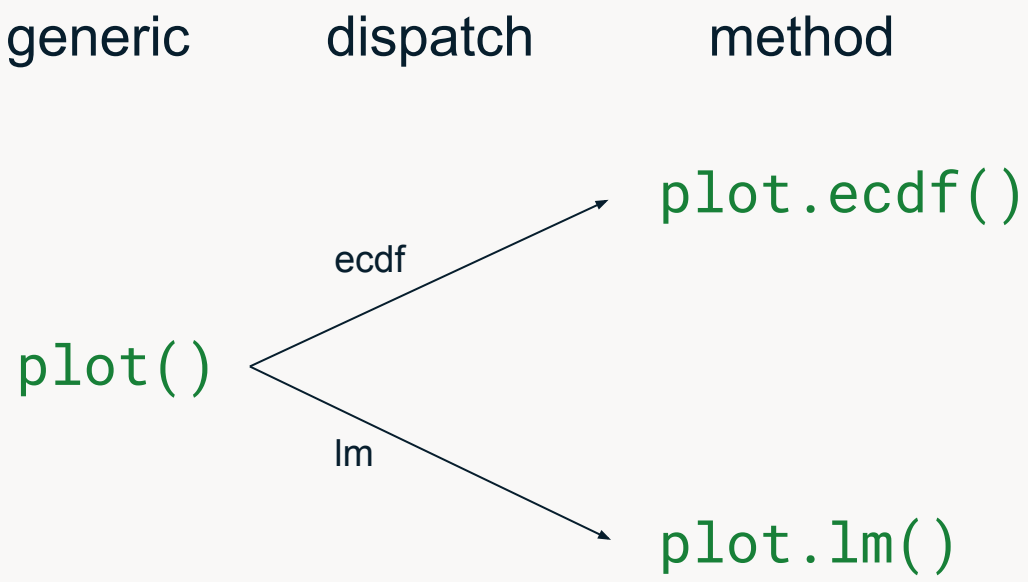

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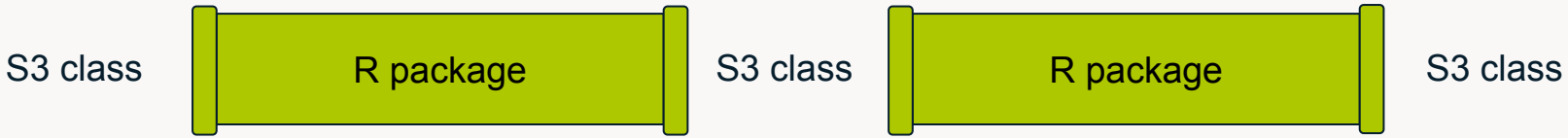

Step 1: Develop standards.

More details at https://epiverse-trace.github.io/posts/parent-class

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⇨ Inherit from `data.frame` where possible

More details at https://epiverse-trace.github.io/posts/parent-class

Step 1: Develop standards.

Go the extra mile to provide support for the tidyverse:

- Support for tibbles as well as data.frames
- Support for dplyr verbs

More details at https://hugogruson.fr/posts/compa-tibble/ & https://epiverse-trace.github.io/posts/extend-dataframes/

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Support for tibbles as well as data.frames:

- Do not rely on implicit `drop` value

```r
mean_col <- function(data, col_index) {
  mean(data[, col_index])
}

mean_col(df, 1)
#> [1] 15.4

mean_col(tbl, 1)
#> Warning in mean.default(data[, col_index]): argument is not numeric or
logical:
#> returning NA
#> [1] NA
```

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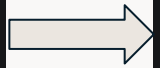

```r
mean_col <- function(data, col_index) {
  mean(data[, col_index, drop = TRUE])
}

mean_col(df, 1)
#> [1] 15.4

mean_col(tbl, 1)
#> [1] 15.4
```

More details at https://hugogruson.fr/posts/compa-tibble/

Step 1: Develop standards.

Support for tibbles as well as data.frames:

- Do not rely on implicit `drop` value
- Do not rely on partial matching (`df$c` instead of `df$col`)

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Support for dplyr verbs:

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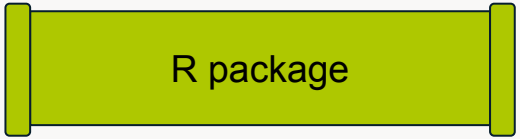
Support for dplyr verbs:

- Methods for `names()<-`, `[<-`, will provide automatic support for most dplyr verbs
- If full compatibility is required, you need extra methods for `dplyr_row_slice()`, `dplyr_col_modify()`, `dplyr_reconstruct()`

More details at https://epiverse-trace.github.io/posts/extend-dataframes/

How to fix both ends of the pipe the R way?

S3 class



How to fix both ends of the pipe without disrupting users?

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Transposition of “**progressive enhancement**” web dev concept.

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How to fix both ends of the pipe without disrupting users?

Transposition of “**progressive enhancement**” web dev concept.

Ensure good experience for all users/packages, even those who don’t support the standards, while allowing enhanced experience and extra features when using the standards.

More details at https://epiverse-trace.github.io/posts/progressive-enhancement/

How to fix both ends of the pipe without disrupting users?

Transposition of “**progressive enhancement**” web dev concept.

Two key ideas:

- Adding a new method is invisible
- Adding a new attribute is invisible

More details at https://epiverse-trace.github.io/posts/progressive-enhancement/

Step 2: Make functions interoperable with standard S3 inputs

How to add S3 support “invisibly”,
without breaking changes?

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```r
#' @export
centroid <- function(coords, weights) {

  # ...

}
```

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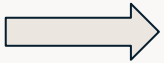

```r
#' @export
centroid <- function(coords, weights) {

  UseMethod("centroid")

}

#' @rdname centroid
#'
#' @export
centroid.default <- function(coords, weights) {

  # ...

}
```

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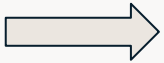

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#' @export
centroid <- function(coords, weights) {

  UseMethod("centroid")

}

#' @rdname centroid
#'
#' @export
centroid.default <- function(coords, weights) {

  # ...

}

#' @rdname centroid
#'
#' @export
centroid.pointset <- function(coords, weights = NULL) {

  centroid(coords$coords, coords$weights)

}
```

More details & caveats at
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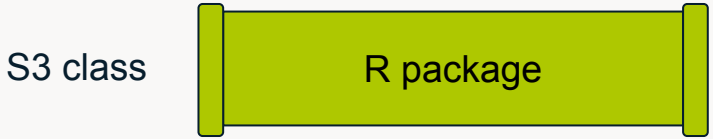


Step 3: Return newly classed input without breaking changes

More details at https://epiverse-trace.github.io/posts/progressive-enhancement/

Step 3: Return newly classed input without breaking changes

- If already returning parent from standard, update to return standard

```r
class(x) <- c("data.frame")
return(x)
```

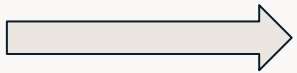
```r
class(x) <- c("subclass", "data.frame")
return(x)
```

More details at https://epiverse-trace.github.io/posts/progressive-enhancement/

Step 3: Return newly classed input without breaking changes

- If already returning parent from standard, update to return standard
- If not possible to update to standard, return a classed output to allow custom dispatch or conversion functions

```
class(x) <- c("data.frame")
return(x)
```



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class(x) <- c("subclass", "data.frame")
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Step 3: Return newly classed input without breaking changes

```r
if (c("subclass", "data.frame") == "data.frame") {
  message("it works!")
}
#> Error in if (c("subclass", "data.frame") == "data.frame") {: the
condition has length > 1
```

For forward-compatibility, class inheritance should never be tested with ==!

More details at https://developer.r-project.org/Blog/public/2019/11/09/when-you-think-class.-think-again/index.html

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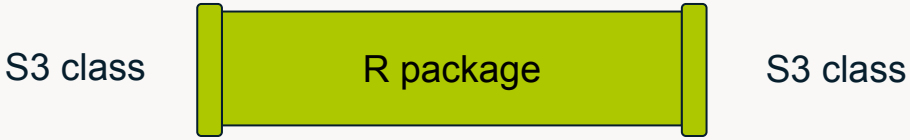

Conclusion

Three steps to add interoperability in an existing ecosystem:

1. Develop standards inheriting from well-established classes (e.g., `data.frame`)
2. Add support for these standards in function inputs by adding new methods
3. Add support for these standards in function outputs

Conclusion

This is not necessarily the ideal way to design and implement S3 support in general.

This approach is specifically thought to add S3 support in an existing ecosystem with minimal disruption.


Thanks to collaborators and for your attention!