AVANT

SYBERIA: A DEVELOPMENT FRAMEWORK FOR R

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Our Initial Problem

- R workflows are typically loosely organized collections of scripts

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- Packages work well for recording abstract solutions to problems, but not for large projects maintained by multiple users tied to solving problems in a specific domain

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- Packages work well for recording abstract solutions to problems, but not for large projects maintained by multiple users tied to solving problems in a specific domain

- Test-driven development is difficult for modeling work that is intended for real-time systems

An Industry-wide Problem

Google

Machine Learning: The High Interest Credit Card of Technical Debt (2014) NIPS 2014 Workshop proceedings

D. Sculley, Gary Holt, Daniel Golovin, et al

“Risk factors include boundary erosion, entanglement, hidden feedback loops, undeclared consumers, data dependencies, changes in the external world, and a variety of system-level anti-patterns.”

Our Initial Problem

Solution: Think like a developer

Inspiration from the Competition

Developers are good at simplifying work that needs to be done down to its core abstractions

What is Syberia?

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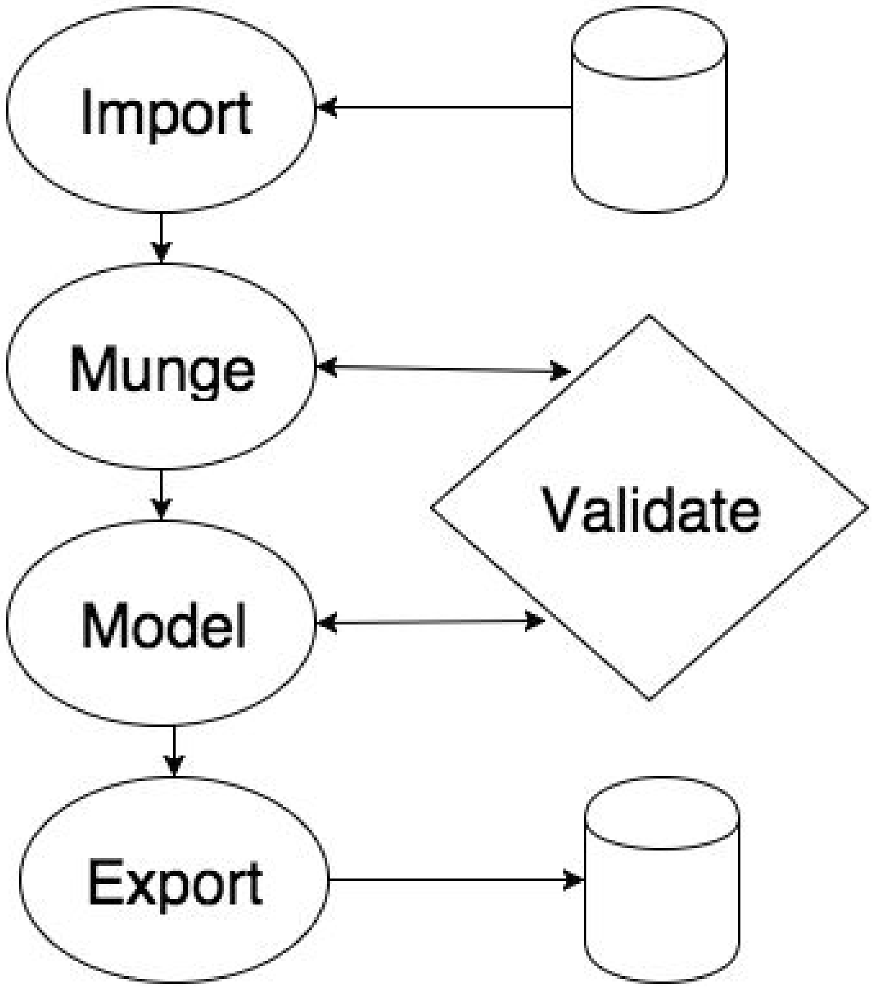
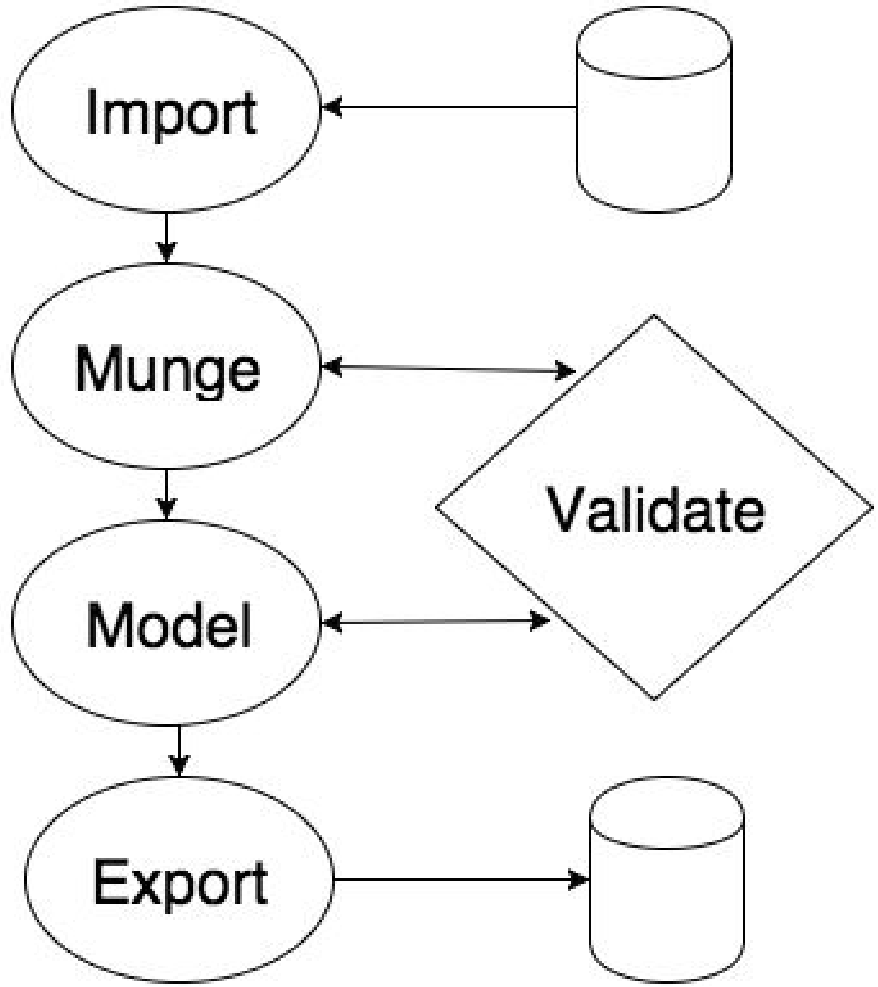
The modular design unit is an **engine**.

Today we are releasing the **modeling engine** for building and deploying production-ready machine learning products in R.

How Does It Work?



How Does It Work?

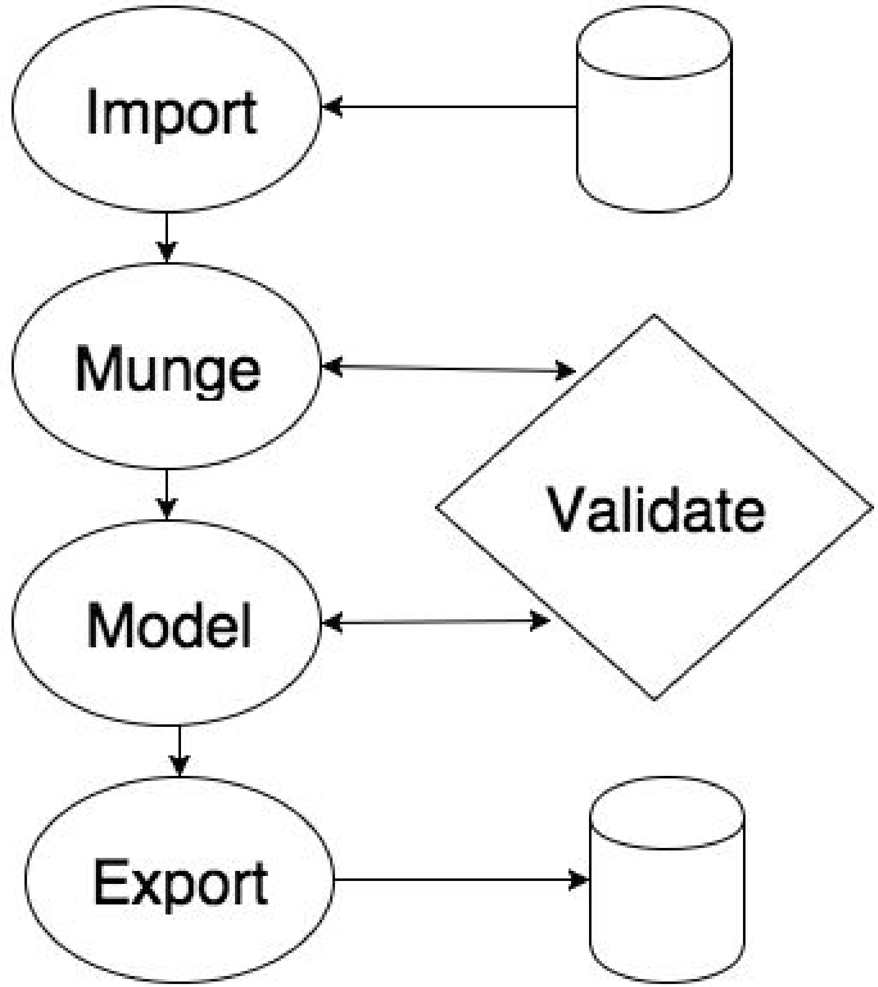


The modeling engine is the boss.

Mungebits package powers feature engineering.

Tundra package powers model containers.

How Does It Work?



The modeling engine is the boss.

Director package holds the project together.

Stagerunner package is the workflow and execution system.

The Basic Structure

```
source(“my_R_script.R”)
```

- Script-driven workflow makes it harder to re-use components
- Testing is not built in unless you move to a package

The Basic Structure

```
resource(“lib/adapters/s3”)
```

- **Basic idea**: Everything is a resource
- All resources must be tested (`test/lib/adapters/s3`)
- Each resource type can have its own “grammar”

The Basic Structure

Task: Let’s import some data using Syberia.

An Example

```
# lib/adapters/s3.R
read <- function(name) {
  s3mpi::s3read(name)
}

write <- function(object, name) {
  s3mpi::s3store(object, name)
}

# package: github.com/robertzk/s3mpi
```

An Example

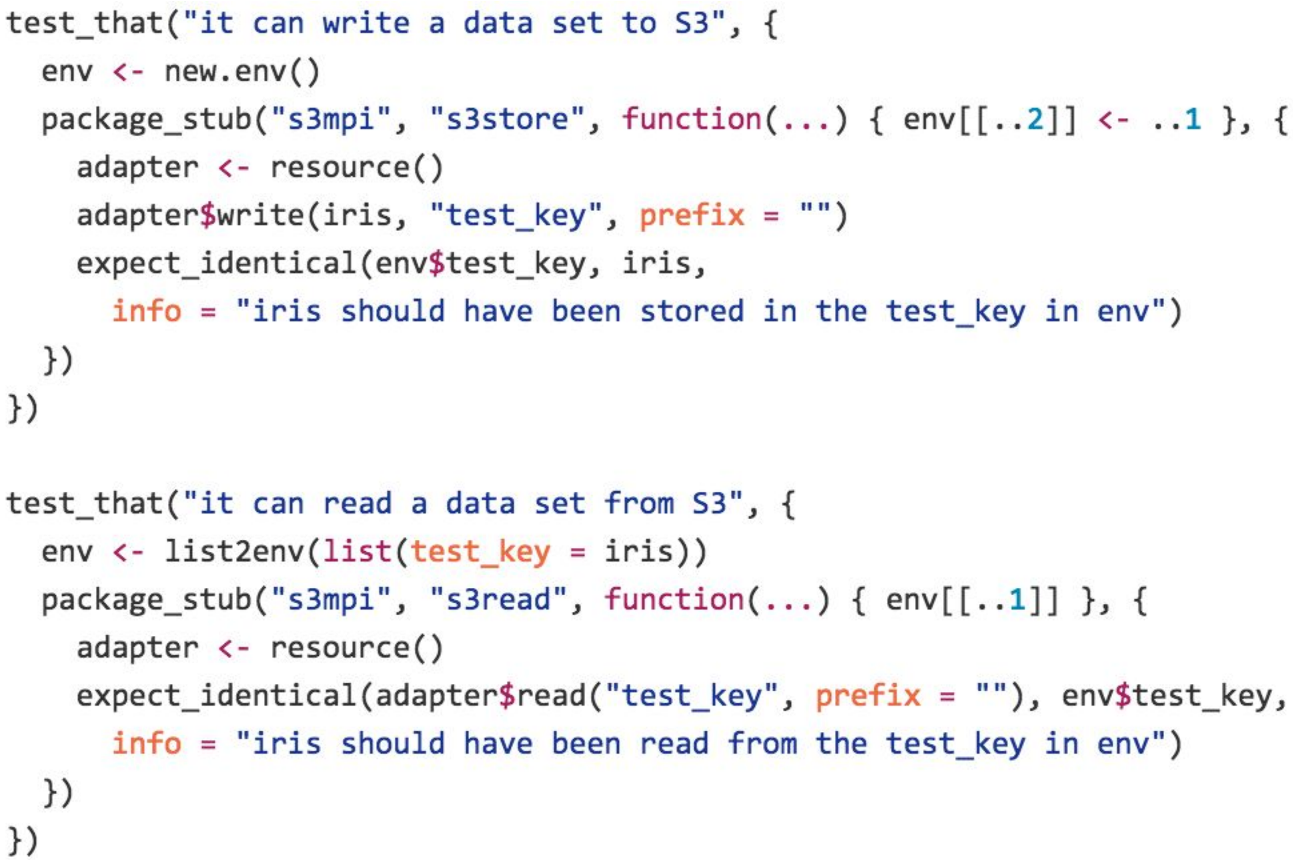
```
# config/routes.R
list(
  "config/global"   = "globals",
  "lib/adapters"    = "adapters",
  "lib/classifiers" = "classifiers",
  "lib/mungebits"   = "mungebits",
         "models"   = "models",
    "test/models"   = "test/models",
           "data"   = "data")
```

The Basic Structure

```
a <- resource(“lib/adapters/s3”)

a$write(iris, “tmp/iris”)

# From a new R session
a <- resource(“lib/adapters/s3”)

identical(
  a$read(“tmp/iris”),
  iris
)
```

An Example

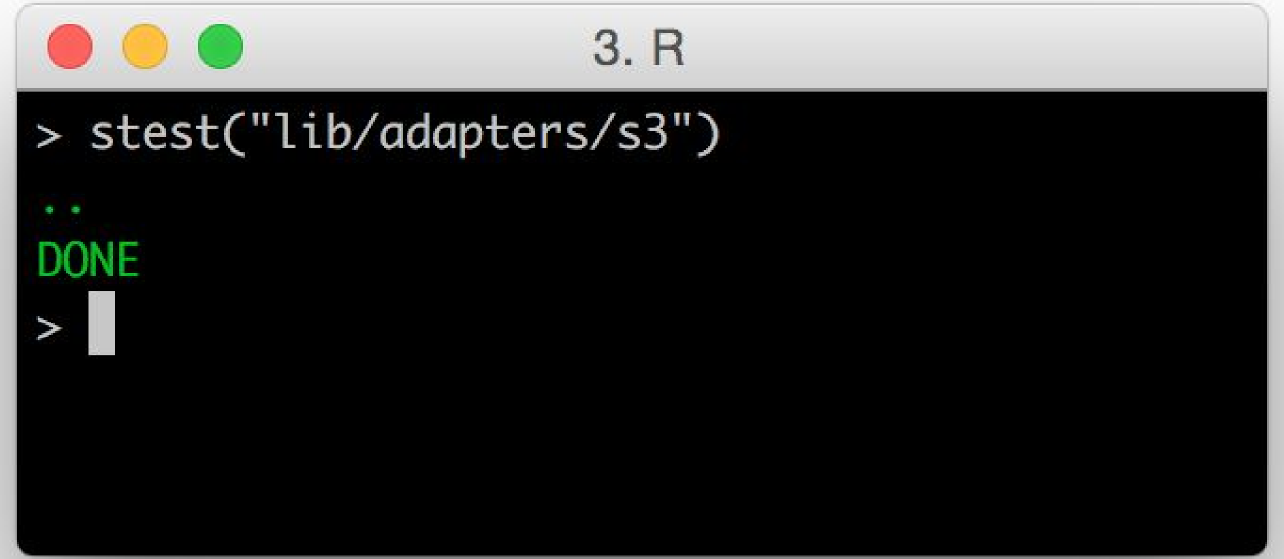
# test/lib/adapters/s3.R



```r
test_that("it can write a data set to S3", {
  env <- new.env()
  package_stub("s3mpi", "s3store", function(...) { env[[..2]] <- ..1 }, {
    adapter <- resource()
    adapter$write(iris, "test_key", prefix = "")
    expect_identical(env$test_key, iris,
      info = "iris should have been stored in the test_key in env")
  })
})

test_that("it can read a data set from S3", {
  env <- list2env(list(test_key = iris))
  package_stub("s3mpi", "s3read", function(...) { env[[..1]] }, {
    adapter <- resource()
    expect_identical(adapter$read("test_key", prefix = ""), env$test_key,
      info = "iris should have been read from the test_key in env")
  })
})
```

An Example



```
> stest("lib/adapters/s3")

..
DONE
> 
```

An Example

```
# config/routes.R
list(
  "config/global"    = "globals",
  "lib/adapters"     = "adapters",
  "lib/classifiers"  = "classifiers",
  "lib/mungebits"    = "mungebits",
         "models"    = "models",
    "test/models"    = "test/models",
           "data"    = "data")
```

An Example

```
# lib/controllers/adapters.R
function(input) {
  adapter_class <- function(r, w) {
    list(read = r, write = w)
  }

  # Construct the adapter object.
  adapter_class(
   input$read,
   input$write
  )
})
```

An Example

```
# lib/adapters/s3.R
read <- function(name) {
  s3mpi::s3read(name)
}

write <- function(object, name) {
  s3mpi::s3store(object, name)
}

# package: github.com/robertzk/s3mpi
```

An Example

Think of how you might write adapters for other storage backends:

- Reading from and writing to a CSV file
- Reading from and writing to a database
- Reading from and writing to a JSON service
- Et cetera

An Example

- Defining “adapters” abstracted away the storage backend from the underlying implementation
- Each adapter has the same interface

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- Each adapter has the same interface

```
adapter <- resource(“lib/adapters/s3”)
adapter$read(“some_key”)
adapter$write(object, “some_key”)
```

An Example

- Defining “adapters” abstracted away the storage backend from the underlying implementation

- Each adapter has the same interface

```
adapter <- resource(“lib/adapters/s3”)
adapter$read(“some_key”)
adapter$write(object, “some_key”)

adapter <- resource(“lib/adapters/file”)
adapter$read(“some_file.rds”)
adapter$write(iris, “some_file.csv”)
```

The Premise of Syberia

- **Everything is a resource**

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- Encourages finding common interfaces and abstractions

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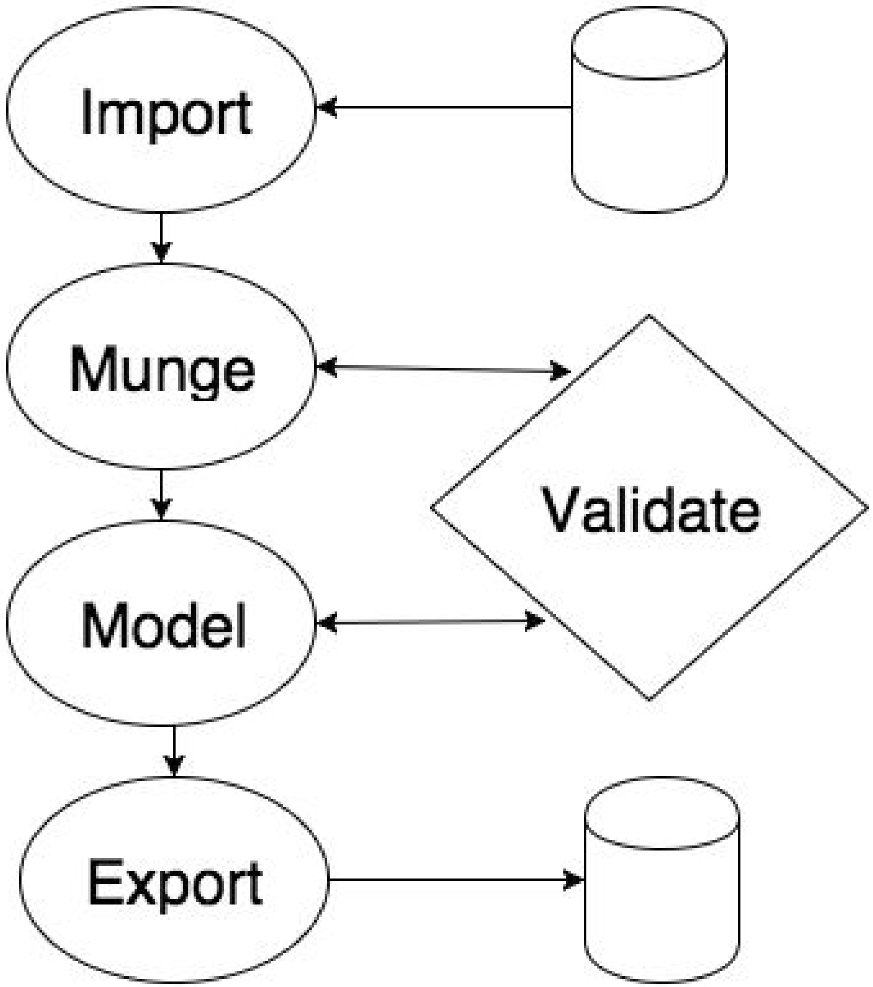
- **Everything is a resource**
- Each resource produces a single R object
- Encourages finding common interfaces and abstractions
- Work becomes easily re-usable instead of locked away in scripts

The Modeling Engine



The Modeling Engine

```
list(
 # Titanic dataset is fairly popular. Here we're downloading it from a public github repo
 import = list(url = "https://raw.githubusercontent.com/haven-jeon/.../master/bicdata/data/titanic.csv"),

 data = list(
   # The left-hand side defines the informal name of a mungebit that you will see when you run this model.
   # The right-hand side is the mungebit invocation.
   "Factor to character"    = list(column_transformation(as.character), is.factor)
   ,"has paren in name"     = list(multi_column_transformation(function(name) grepl("(", fixed = TRUE, name)), "name", "has_paren")
   ,"Name length variable" = list(new_variable, function(name) nchar(name), "name_length")
   # ~40 removed
   ,"Restore levels"        = list(restore_categorical_variables)
   ,"Rename dep_var"        = list(renamer, c("survived" = "dep_var"))
 ),

 model = list('gbm'
   , .id_var             = 'X'
   , distribution        = 'bernoulli'
   , number_of_trees     = 3000
   , shrinkage_factor    = 0.005
 ),

 export = list(R  = 'titanic')
)
```

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 export = list(R  = 'titanic')
)
```

Mungebits

```
# config/routes.R
list(
  "config/global"   = "globals",
  "lib/adapters"    = "adapters",
  "lib/classifiers" = "classifiers",
  "lib/mungebits"   = "mungebits",
         "models"   = "models",
    "test/models"   = "test/models",
           "data"   = "data")
```

Mungebits

Sort data in ascending order by a given column.

```
# lib/mungebits/orderer.R
train <- predict <- function(dataframe, col) {
  dataframe[order(dataframe[[col]]), ]
}

# From R console
m <- resource(“lib/mungebits/orderer”)
stopifnot(all.equal(
  m$run(iris, 1), iris[order(iris[[1]]), ]
))
```

Mungebits

Mean imputation for one column.

```r
# lib/mungebits/simple_impute.R
train <- function(dataframe, col) {
  input$col  <- col
  input$mean <- mean(dataframe[[col]], na.rm=T)
  dataframe[is.na(dataframe[[col]]), col] <-
    input$mean
  dataframe
}
predict <- function(dataframe, ...) {
  col <- input$col
  dataframe[is.na(dataframe[[col]]), col] <-
    input$mean
  dataframe
}
```

Mungebits

```
# In R console
m <- resource(“lib/mungebits/simple_impute”)
iris2 <- iris; iris2[1, 1] <- NA
m$run(iris2, 1)
stopifnot(all.equal(
  m$run(iris2)[[1]],
  c(mean(iris[-1, 1]), iris2[-1, 1])
))
```

Mungebits

```
# lib/controllers/mungebits.R
function(input) {
  if (isTRUE(input$column_transformation)) {
    mungebits2::mungebit$new(
 mungebits2::column_transformation(input$train),
 mungebits2::column_transformation(input$predict))
  } else {
    mungebits2::mungebit$new(
      input$train, input$predict)
  }
}
```

Classifiers

```
# lib/controllers/classifiers.R

function(input) {
 force(input)
 function(munge_procedure = list(), default_args = list(), internal = list()) {
   input <- lapply(as.list(input), full_deflate)
   container <- tundra::tundra_container$new(resource, input$train, input$predict,
     munge_procedure, full_deflate(default_args), full_deflate(internal))

   container$hooks <- lapply(container$hooks, function(fn) {
     environment(fn) <- globalenv(); fn
   })

   if (!is.null(input$read) ||
       !is.null(input$write)) {
     attr(container, "s3mpi.serialize") <- list(read = input$read, write = input$write)
   }
   container
 }
}
```

The Modeling Engine

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list(
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   # ~40 removed
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   , distribution       = 'bernoulli'
   , number_of_trees    = 3000
   , shrinkage_factor   = 0.005
 ),
 export = list(R  = 'titanic')
)
```

The Modeling Engine

```
list(
 # Import and data stage
 model = list('gbm'
   , .id_var                = 'X'
   , distribution           = 'bernoulli'
   , number_of_trees        = 3000
   , shrinkage_factor       = 0.005
 )
 # Export stage
)
```

The Models Controllers

# lib/controllers/**models/models.R**

```r
construct_stage_runner <- Ramd::define("construct_stage_runner")[[1]](resource)
preprocessor <- Ramd::define("preprocessor")[[1]]
function(args, resource, output, director, modified, any_dependencies_modified) {
 parent.env(parent.env(environment(construct_stage_runner))) <- environment()
 if (is.element("raw", names(args))) return(output)
 require(objectdiff)
 message("Loading model: ", resource)
 tests <- file.path('test', resource)
 has_tests <- director$exists(tests)
 has_tests <- FALSE
 if (has_tests) {
   testrunner <- stageRunner$new(new.env(), director$resource(tests))
   testrunner$transform(function(fn) {
     library(testthat); force(fn)
     function(after) fn(cached_env, after)
   })
 }
 model_version <- gsub("^\\w+/", "", resource)
 if (isTRUE(args$fresh) || !identical(resource, director$cache_get("last_model"))) {
   stagerunner <- construct_stage_runner(output, model_version)
 } else if (modified || any_dependencies_modified) {
   message(crayon::yellow("Copying cached environments..."))
   stagerunner <- construct_stage_runner(output, model_version)
   stagerunner$coalesce(director$cache_get("last_model_runner"))
 } else if (!director$cache_exists("last_model_runner")) {
   stagerunner <- construct_stage_runner(output, model_version)
 } else {
   stagerunner <- director$cache_get("last_model_runner")
 }
 if (has_tests) stagerunner$overlay(testrunner, "tests", flat = TRUE)
 director$cache_set("last_model", resource)
 director$cache_set("last_model_runner", stagerunner)
 stagerunner
}
```

# ../**models/preprocessor.R**

```r
preprocessor <- function(resource, director, source_env) {
 source_env$extending <- function(model_version, expr) {
   eval.parent(substitute(within(resource(file.path("models/", model_version), raw = TRUE), { expr })))
 }


 source_env$model_version <- version <- gsub("^[^/]+\\/[^/]+\\/", "", resource)
 source_env$model_name    <- basename(version)
 source_env$output <-
   function(suffix = "", create = TRUE, dir = file.path(director$root(), "tmp")) {
     filename <- file.path(dir, version, suffix)
     if (create && !file.exists(dir <- dirname(filename)))
       dir.create(dir, recursive = TRUE)
     filename
   }
 lexicals <- director$resource("lib/shared/lexicals")
 for (x in ls(lexicals)) source_env[[x]] <- lexicals[[x]]
 director$resource("lib/shared/source_mungebits")(source_env, director)
 model <- source()
 if (nzchar(Sys.getenv("CI"))) {
     model$import <- NULL
   }
 }
 model
}
```

# ../**models/construct_stage_runner.R**

```r
model_env <- function() {
 if (identical(getOption("environment_type"), "environment")) {
```

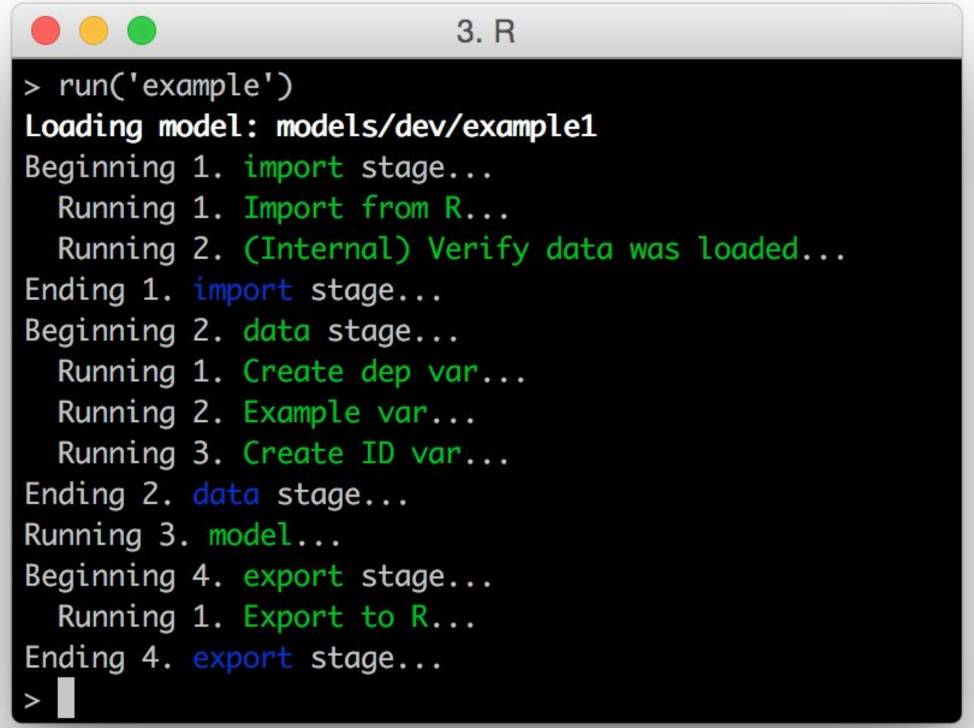
Other Controller Ideas

- Other useful abstractions with their own grammar:
  - **Modules**: Nested bundles of related R functions.
  - **Indicators**: `y ~ x1 + x2` tied to an ETL backend
  - **Stages**: Execution tasks for our stage runner.
  - **Jobs**: Build reports, monitoring checks, etc.
  - **Queries**: “Object-relational mapper” for R

Running A Model

run(“example”) # Runs models/dev/example.R

```
list(
 import = list(R = "iris"),
 data   = list(
   "Create dep var" = list(renamer,
     c("Sepal.Length" = "dep_var")),
   "Example var"    = list(example),
   "Create ID var"  = list(
multi_column_transformation(seq_along),
     "dep_var", "id")
 ),
 model  = list("lm", .id_var = "id"),
 export = list(R = "model")
)
```

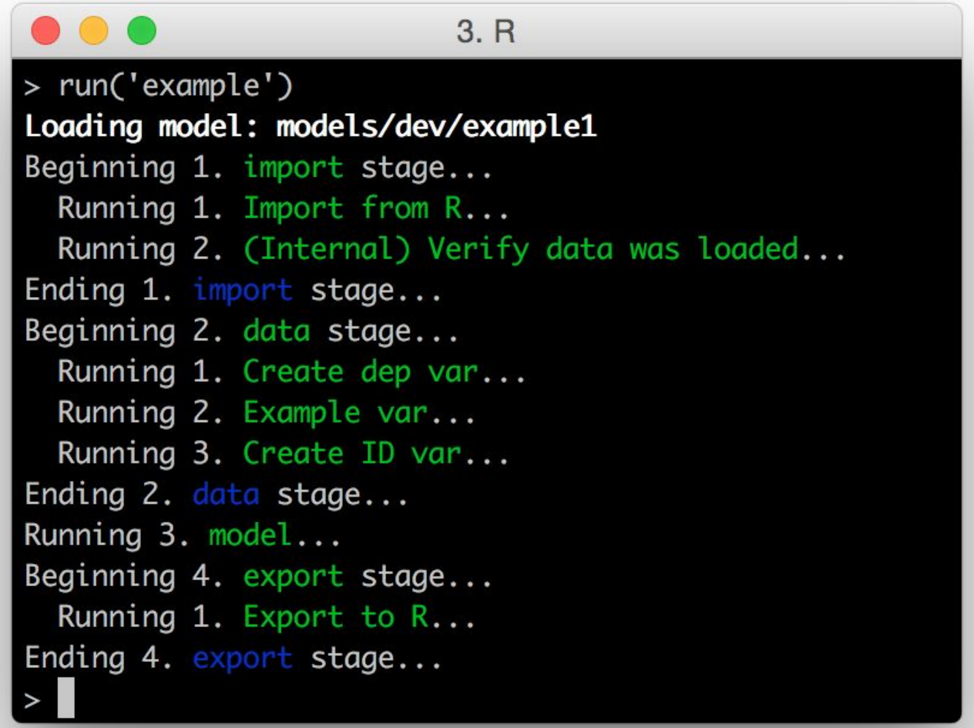


```
> run('example')
Loading model: models/dev/example1
Beginning 1. import stage...
  Running 1. Import from R...
  Running 2. (Internal) Verify data was loaded...
Ending 1. import stage...
Beginning 2. data stage...
  Running 1. Create dep var...
  Running 2. Example var...
  Running 3. Create ID var...
Ending 2. data stage...
Running 3. model...
Beginning 4. export stage...
  Running 1. Export to R...
Ending 4. export stage...
> 
```

Running A Model

```
run(“example”)   # Runs models/dev/example.R
```

```
list(
 import = list(R = "iris"),
 data   = list(
   "Create dep var" = list(renamer,
      c("Sepal.Length" = "dep_var")),
   "Example var"    = list(example),
   "Create ID var"  = list(
multi_column_transformation(seq_along),
      "dep_var", "id")
 ),
 model  = list("lm", .id_var = "id"),
 export = list(R = "model")
)
```



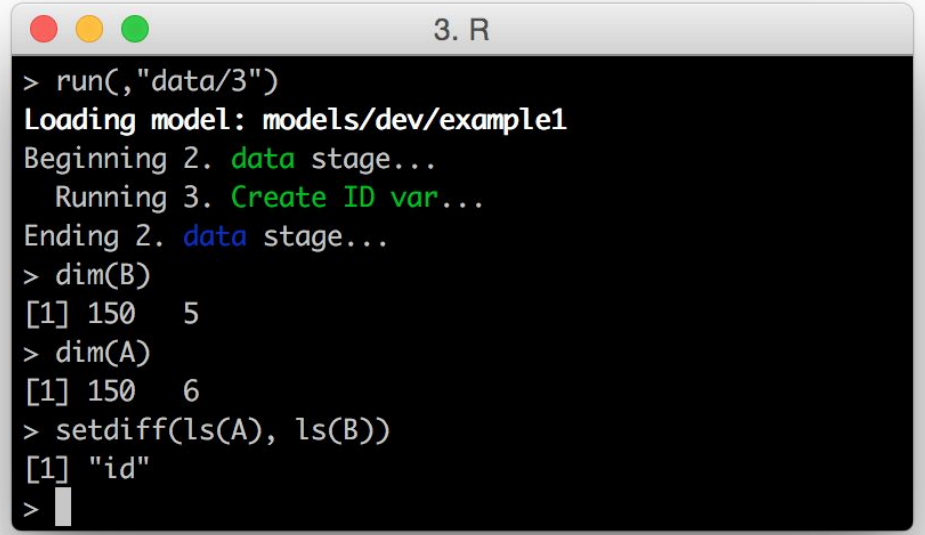
```
> run('example')
Loading model: models/dev/example1
Beginning 1. import stage...
  Running 1. Import from R...
  Running 2. (Internal) Verify data was loaded...
Ending 1. import stage...
Beginning 2. data stage...
  Running 1. Create dep var...
  Running 2. Example var...
  Running 3. Create ID var...
Ending 2. data stage...
Running 3. model...
Beginning 4. export stage...
  Running 1. Export to R...
Ending 4. export stage...
> 
```

```
model$predict(iris) # [1] 5.005 4.757 4.890 ...
```

Running A Model

run(, “data/3”) # Re-runs one munge step

```
list(
 import = list(R = "iris"),
 data   = list(
   "Create dep var" = list(renamer
      c("Sepal.Length" = "dep_var")),
   "Example var"    = list(example),
   "Create ID var"  = list(
multi_column_transformation(seq_along),
      "dep_var", "id")
 ),
 model  = list("lm", .id_var = "id"),
 export = list(R = "model")
)
```



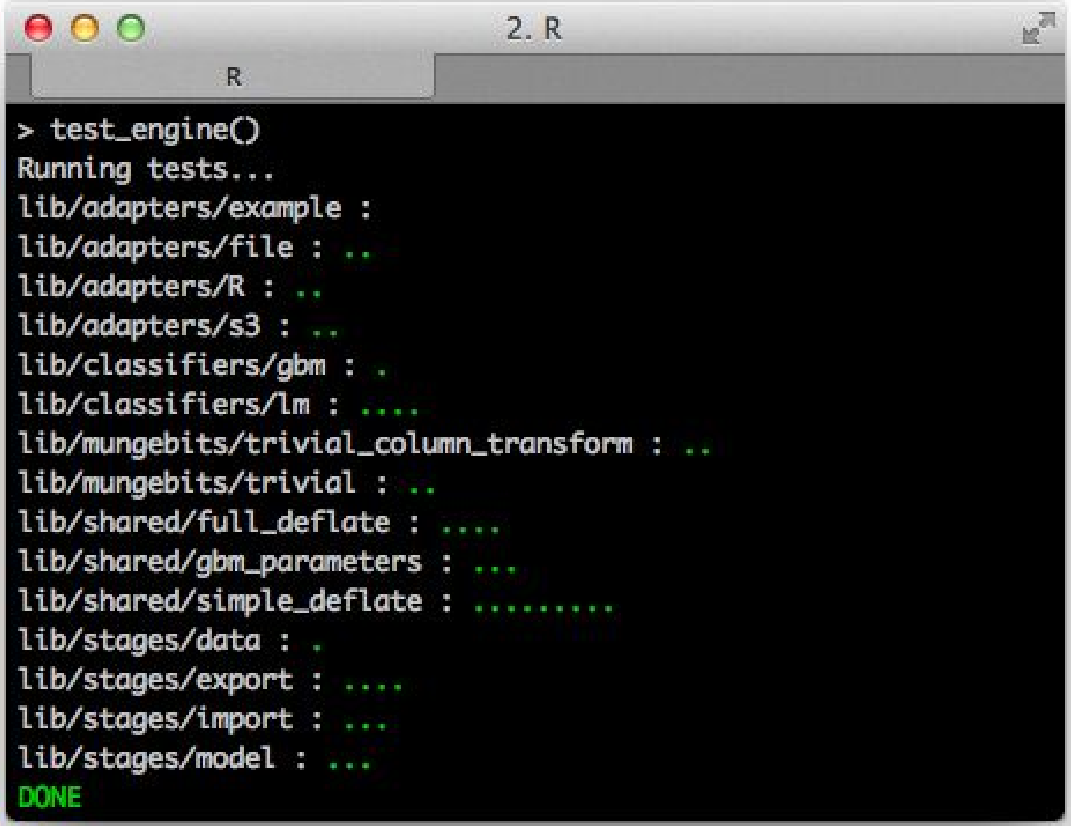
```
> run(,"data/3")
Loading model: models/dev/example1
Beginning 2. data stage...
  Running 3. Create ID var...
Ending 2. data stage...
> dim(B)
[1] 150   5
> dim(A)
[1] 150   6
> setdiff(ls(A), ls(B))
[1] "id"
> 
```

setdiff(ls(B), ls(A)) # [1] “id”

Testing Built In

Each resource requires an accompanying test

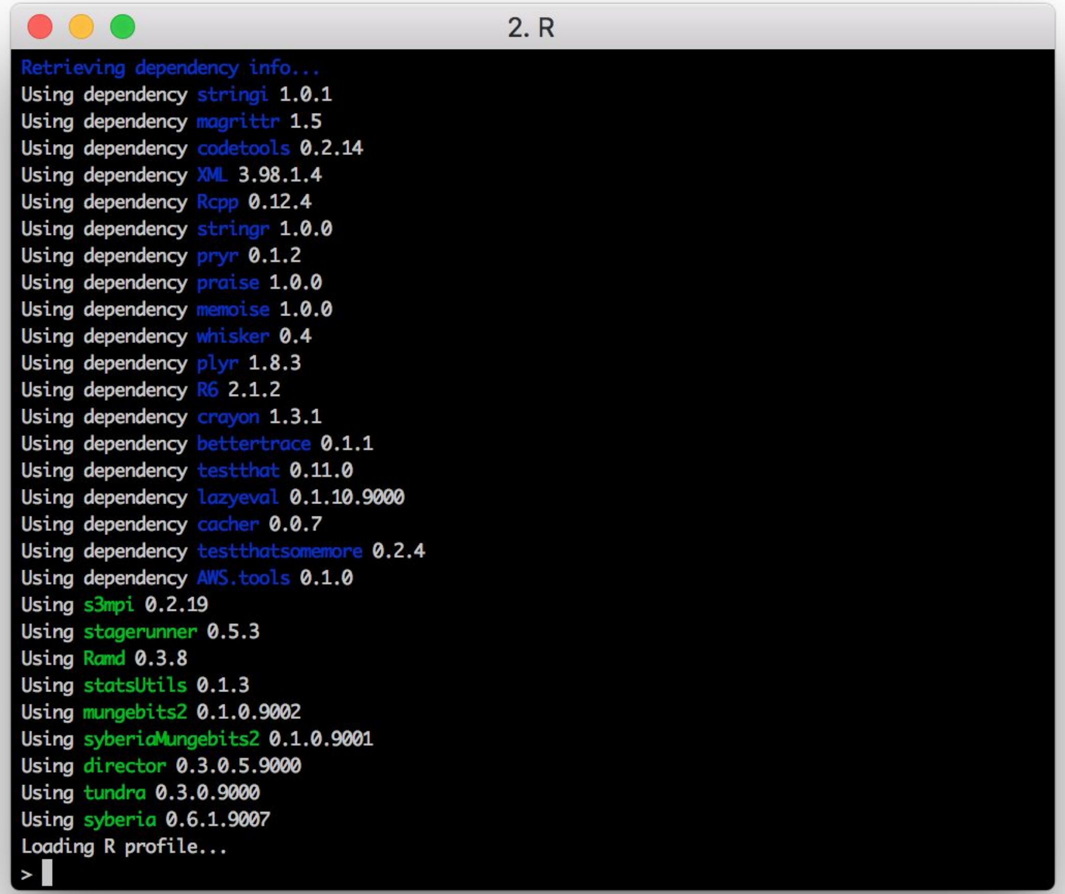
`test_project()`



```
> test_engine()
Running tests...
lib/adapters/example :
lib/adapters/file : ..
lib/adapters/R : ..
lib/adapters/s3 : ..
lib/classifiers/gbm : .
lib/classifiers/lm : ....
lib/mungebits/trivial_column_transform : ..
lib/mungebits/trivial : ..
lib/shared/full_deflate : ....
lib/shared/gbm_parameters : ...
lib/shared/simple_deflate : .........
lib/stages/data : .
lib/stages/export : ....
lib/stages/import : ...
lib/stages/model : ...
DONE
```

Dependency Management

Everyone working on the project has the same set of dependencies



2. R

```
Retrieving dependency info...
Using dependency stringi 1.0.1
Using dependency magrittr 1.5
Using dependency codetools 0.2.14
Using dependency XML 3.98.1.4
Using dependency Rcpp 0.12.4
Using dependency stringr 1.0.0
Using dependency pryr 0.1.2
Using dependency praise 1.0.0
Using dependency memoise 1.0.0
Using dependency whisker 0.4
Using dependency plyr 1.8.3
Using dependency R6 2.1.2
Using dependency crayon 1.3.1
Using dependency bettertrace 0.1.1
Using dependency testthat 0.11.0
Using dependency lazyeval 0.1.10.9000
Using dependency cacher 0.0.7
Using dependency testthatsomemore 0.2.4
Using dependency AWS.tools 0.1.0
Using s3mpi 0.2.19
Using stagerunner 0.5.3
Using Ramd 0.3.8
Using statsUtils 0.1.3
Using mungebits2 0.1.0.9002
Using syberiaMungebits2 0.1.0.9001
Using director 0.3.0.5.9000
Using tundra 0.3.0.9000
Using syberia 0.6.1.9007
Loading R profile...
>
```

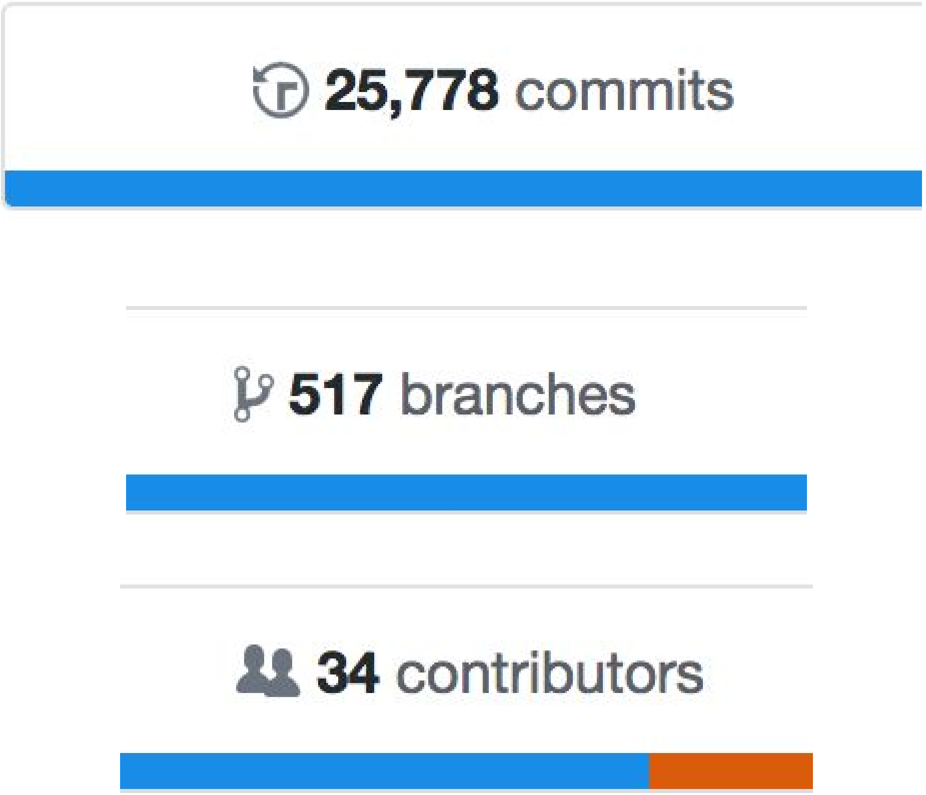
Dependency Management

syberia/lockbox

```
# lockfile.yml
packages:
 -
   name: devtools
   version: 1.12.0
   repo: hadley/devtools
   ref: v1.12.0
 -
   name: checkr
   version: 0.1.4
   repo: syberia/checkr
 -
   name: s3mpi
   version: 0.2.40
   repo: robertzk/s3mpi
 -
   name: objectdiff
   version: 0.2.3.9003
   repo: robertzk/objectdiff
 -
   name: stagerunner
   version: 0.5.6
   repo: syberia/stagerunner
 -
   name: Ramd
   version: 0.3.8
   repo: robertzk/Ramd
 -
   name: statsUtils
   version: 0.1.4
   repo: robertzk/statsUtils
 -
   name: mungebits2
   version: 0.1.0.9014
   repo: syberia/mungebits2
 -
   name: syberiaMungebits2
   version: 0.1.2.9002
   repo: syberia/syberiaMungebits2
 -
   name: director
   version: 0.3.0.5.9000
   repo: syberia/director
 -
   name: tundra
   version: 0.3.0.9000
   repo: syberia/tundra
 -
   name: syberia
   version: 0.6.1.9009
   repo: syberia/syberia
   ref: 0.6.1.9009
```

Arbitrarily Large Projects

Scales to large teams of contributors working on **thousands of R models**



25,778 commits

517 branches

34 contributors

The Future

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- Modeling engine
- Base engine (dependency of modeling engine)

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- Push to FPGA arrays and trade realtime

Shoutouts!

A huge **thank you** to all Avantees that contributed to making Syberia happen:

- Abel Castillo
- David Feldman
- Jason French
- Kirill Sevastyanenko
- Peter Hurford
- Ryland Ely
- Tong Lu

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