DataDeps.jl

and other foundational tools for data driven research (Especially NLP)

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Thanks

Christof Stocker (@evizero): Prompted this whole thing with a discussion a few years ago; and supported it with code reviews and numerous further discussions.

Sebastin Santy: who has spent most of his GSOC connecting repository APIs to DataDepsGenerators.jl.

Australian Research Council Grants: DP150102405 and LP110100050.

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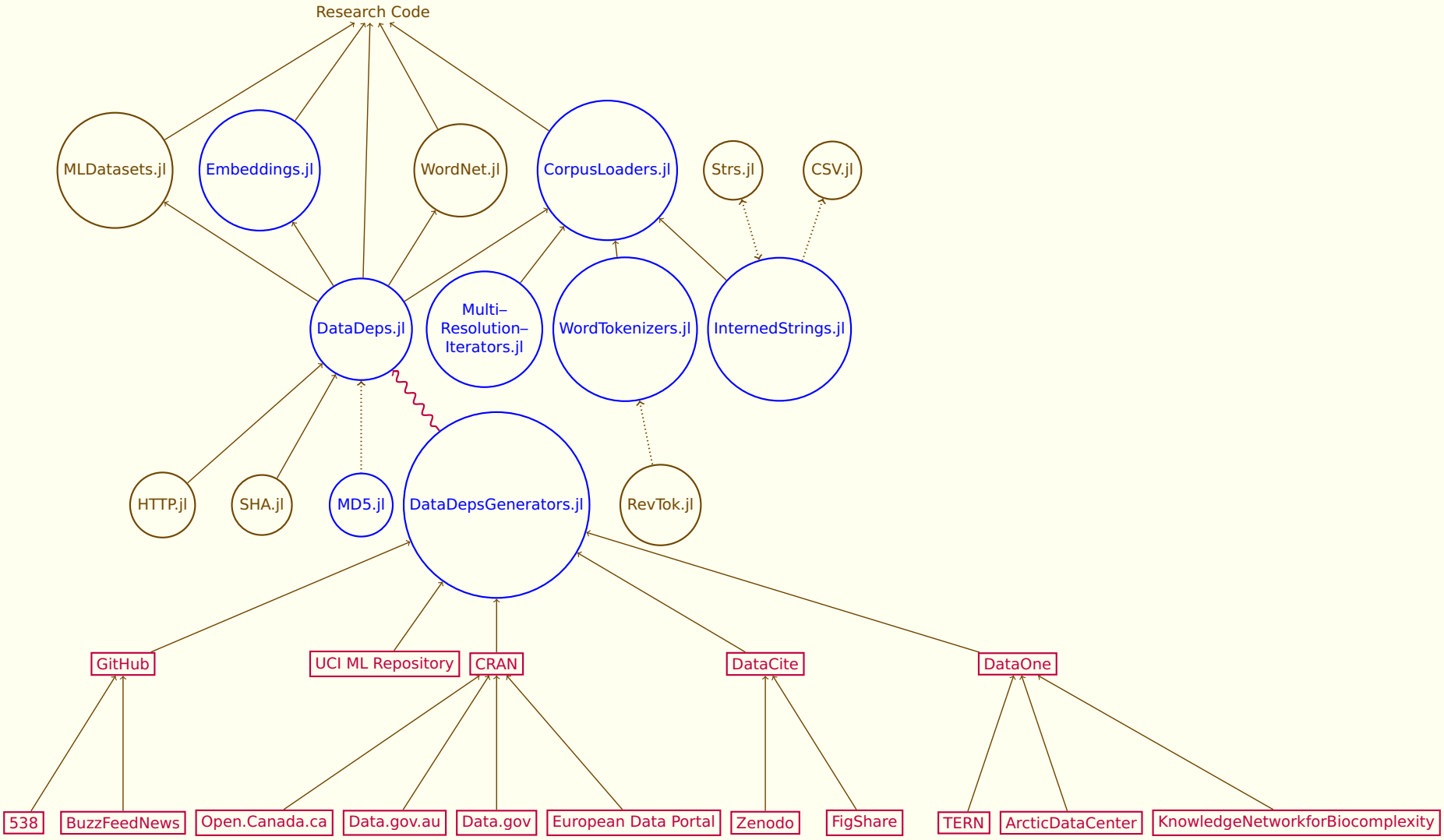
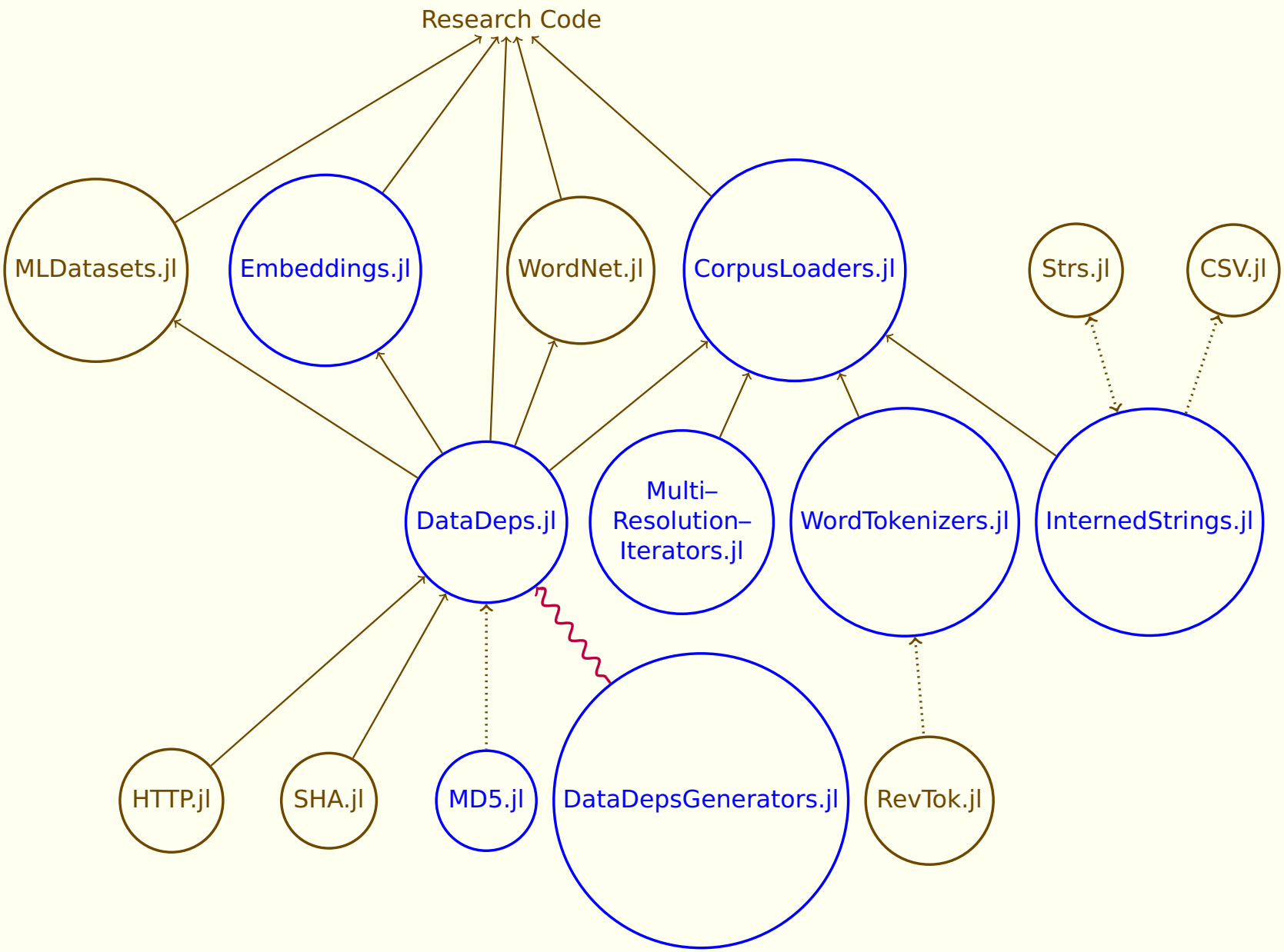
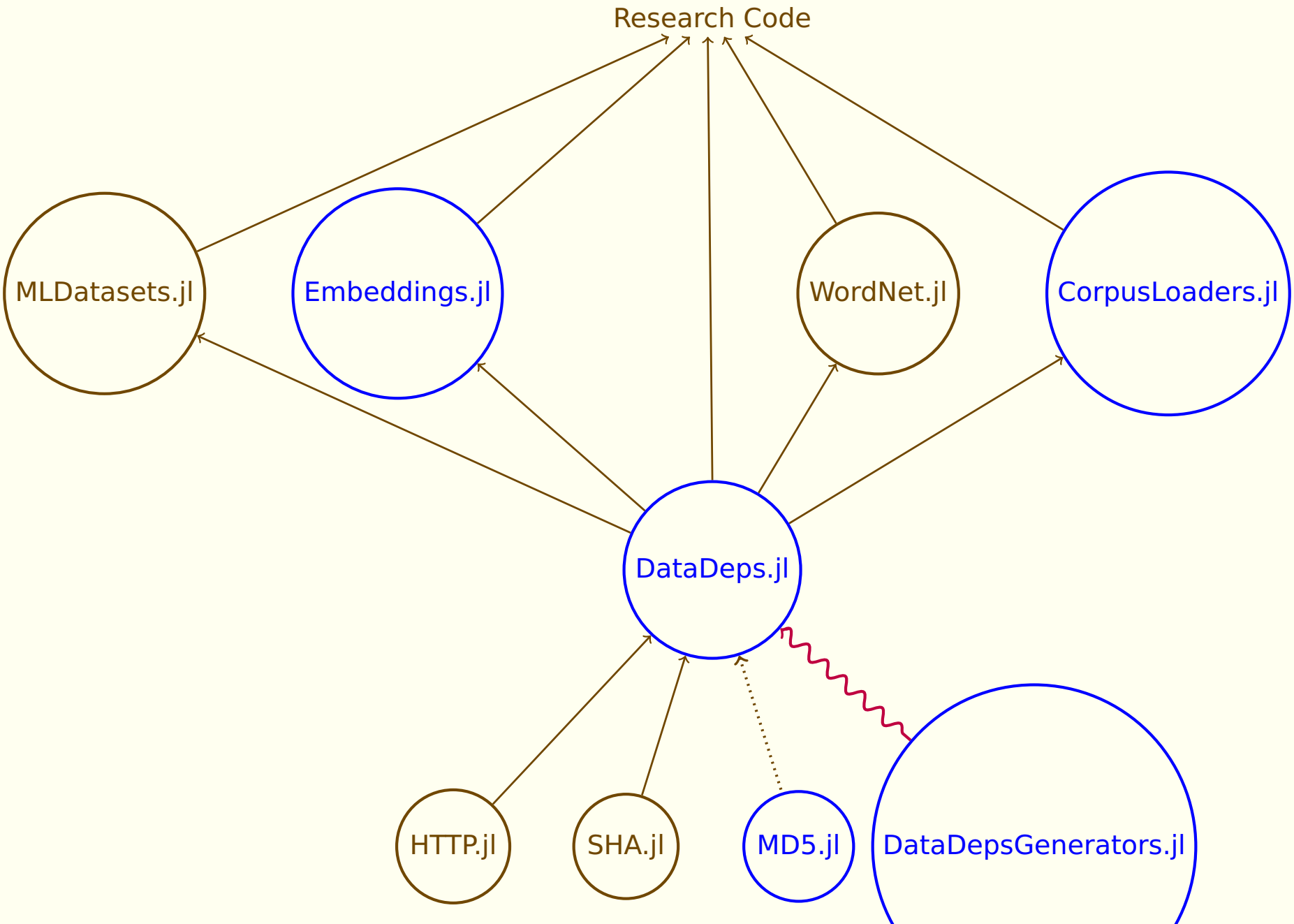
Big Picture


Research Code
MLDatasets.jl
Embeddings.jl
WordNet.jl
CorpusLoaders.jl
Strs.jl
CSV.jl
DataDeps.jl
Multi–
Resolution–
Iterators.jl
WordTokenizers.jl
InternedStrings.jl
HTTP.jl
SHA.jl
MD5.jl
DataDepsGenerators.jl
RevTok.jl
GitHub
UCI ML Repository
CRAN
DataCite
DataOne
538
BuzzFeedNews
Open.Canada.ca
Data.gov.au
Data.gov
European Data Portal
Zenodo
FigShare
TERN
ArcticDataCenter
KnowledgeNetworkforBiocomplexity

Julia Packages



DataDeps.jl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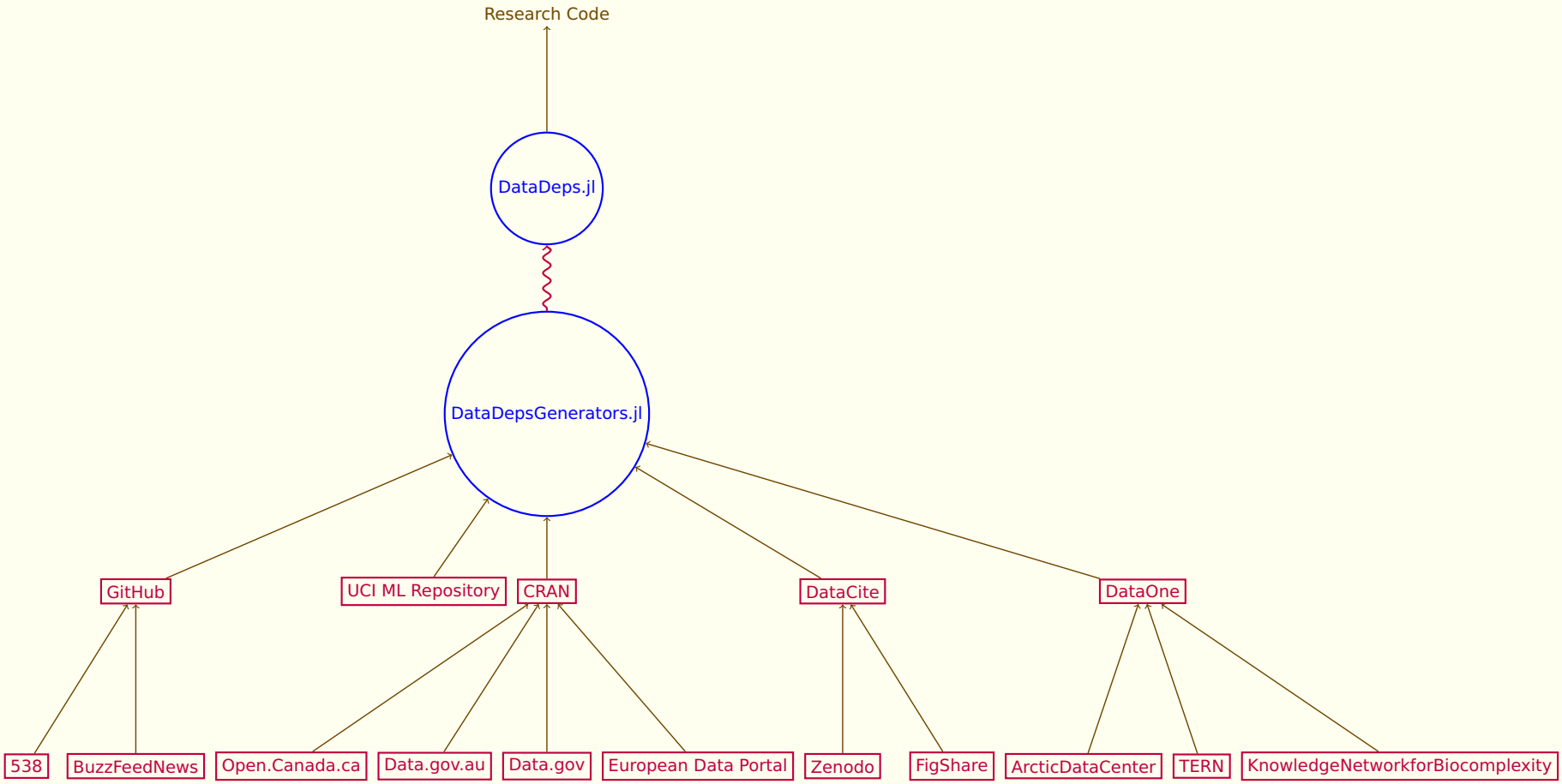
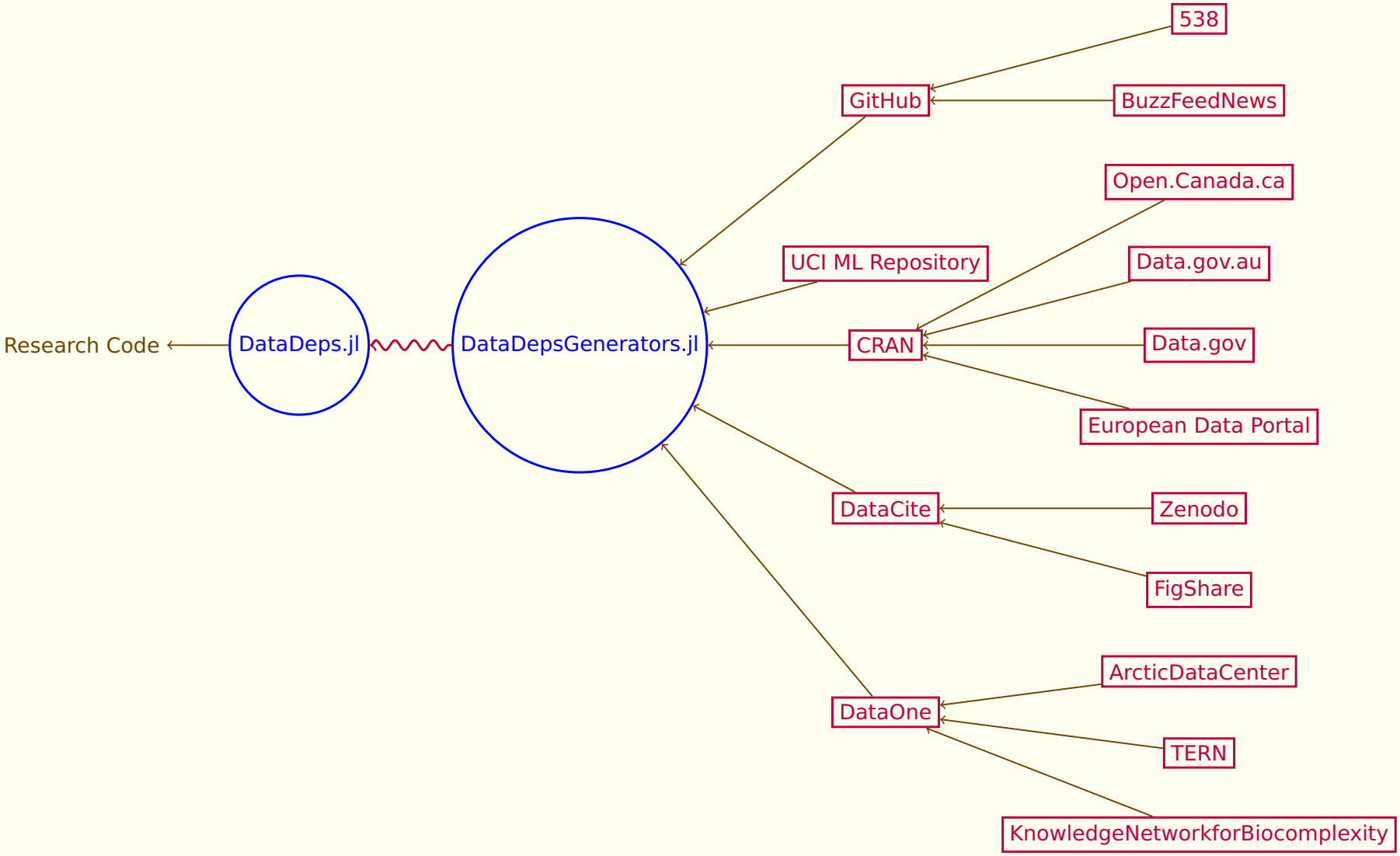
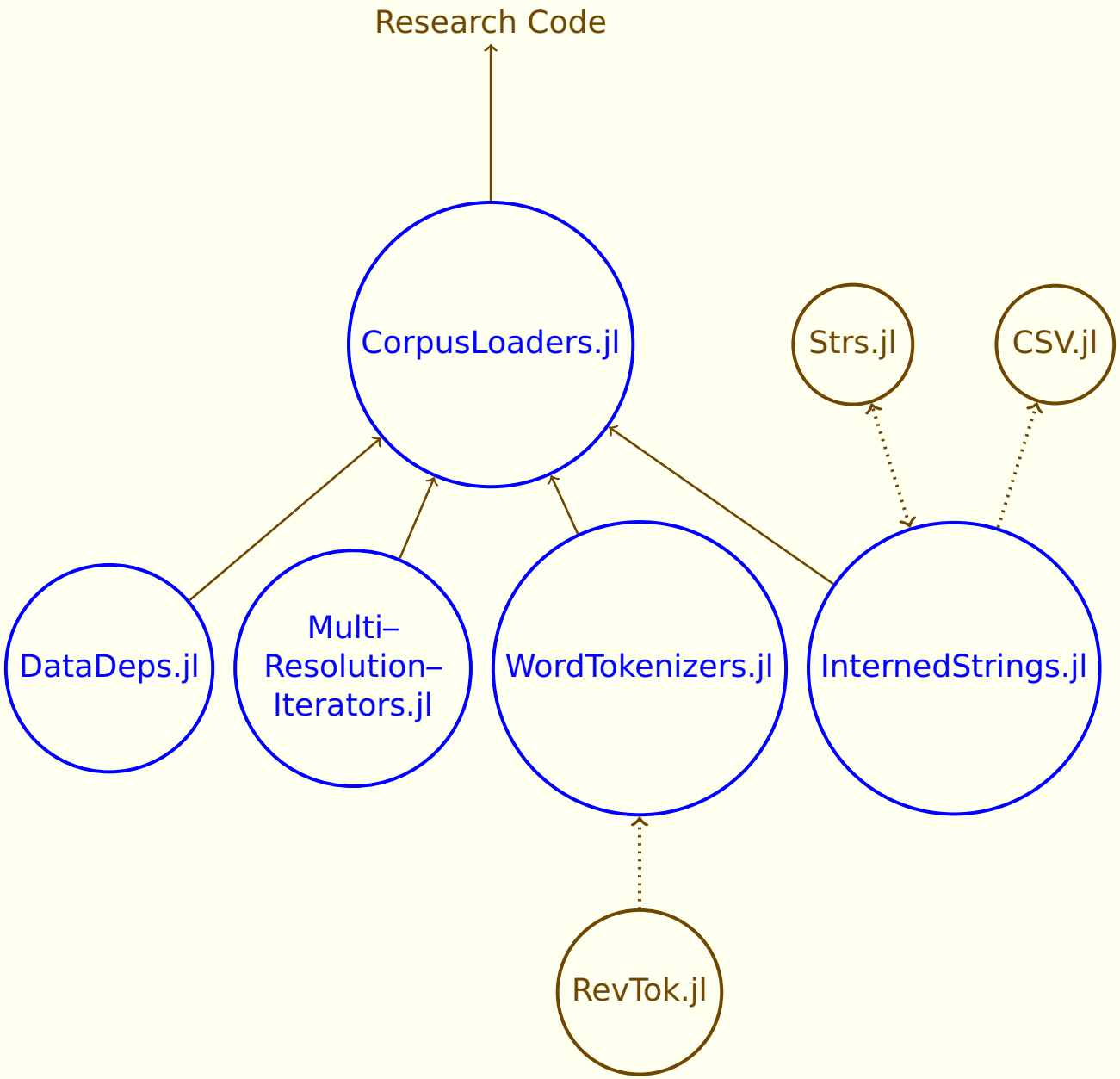


DataDepsGenerators.jl



CorpusLoaders.jl



Code depends on data
Especially research code

- To manage your julia dependencies you use
  - Pkg
- To manage your binary dependencies you use
  - BinDeps,
  - Conda etc
  - or preferably BinaryProvider

How are you managing your data dependencies?

- Instructions in the README.md
  - So how does your CI work out?

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  - So it gets downloaded even if not used?

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  - I am glad it isn’t too large for git.

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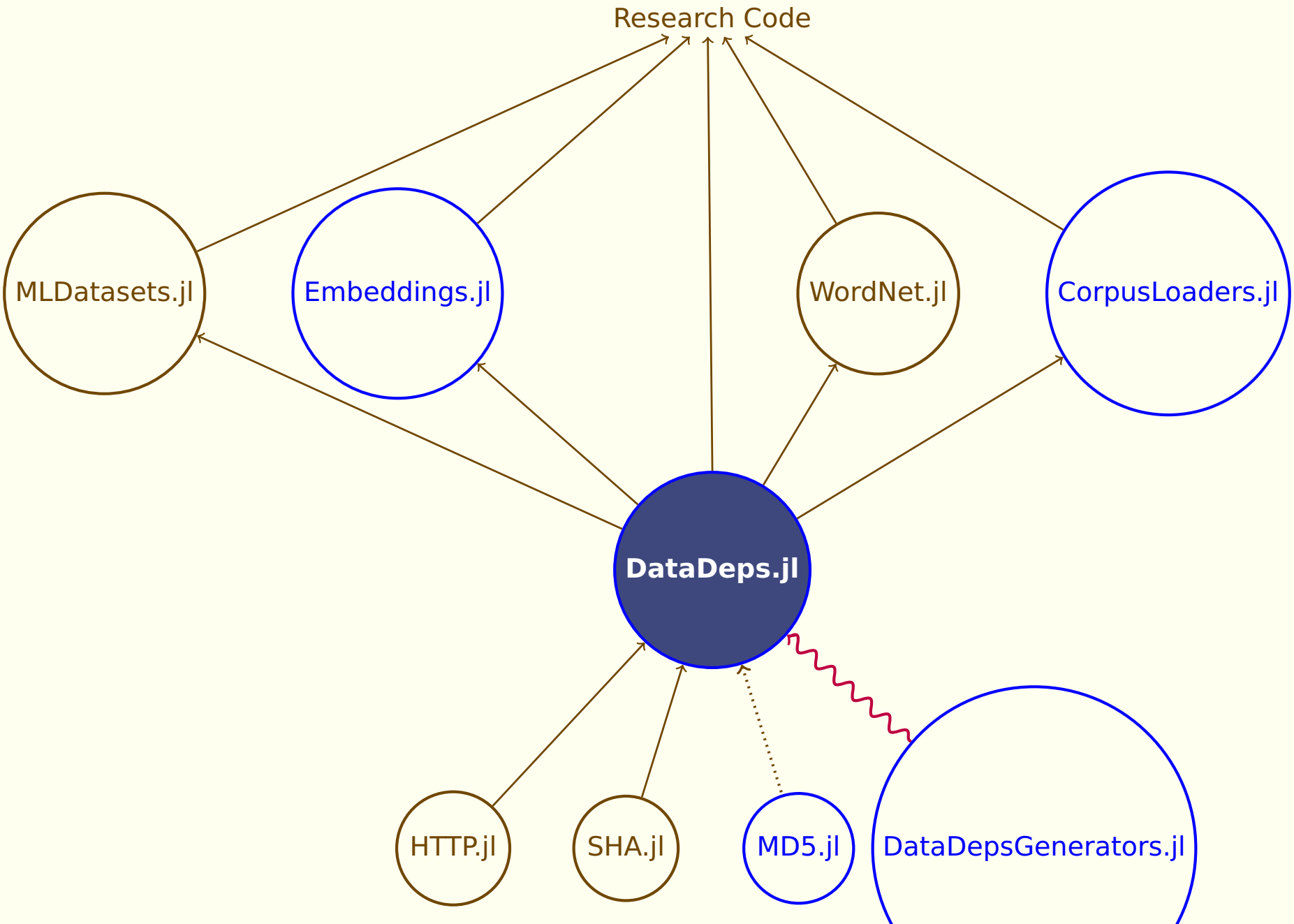
These are all options.
But can we do better?

DataDeps.jl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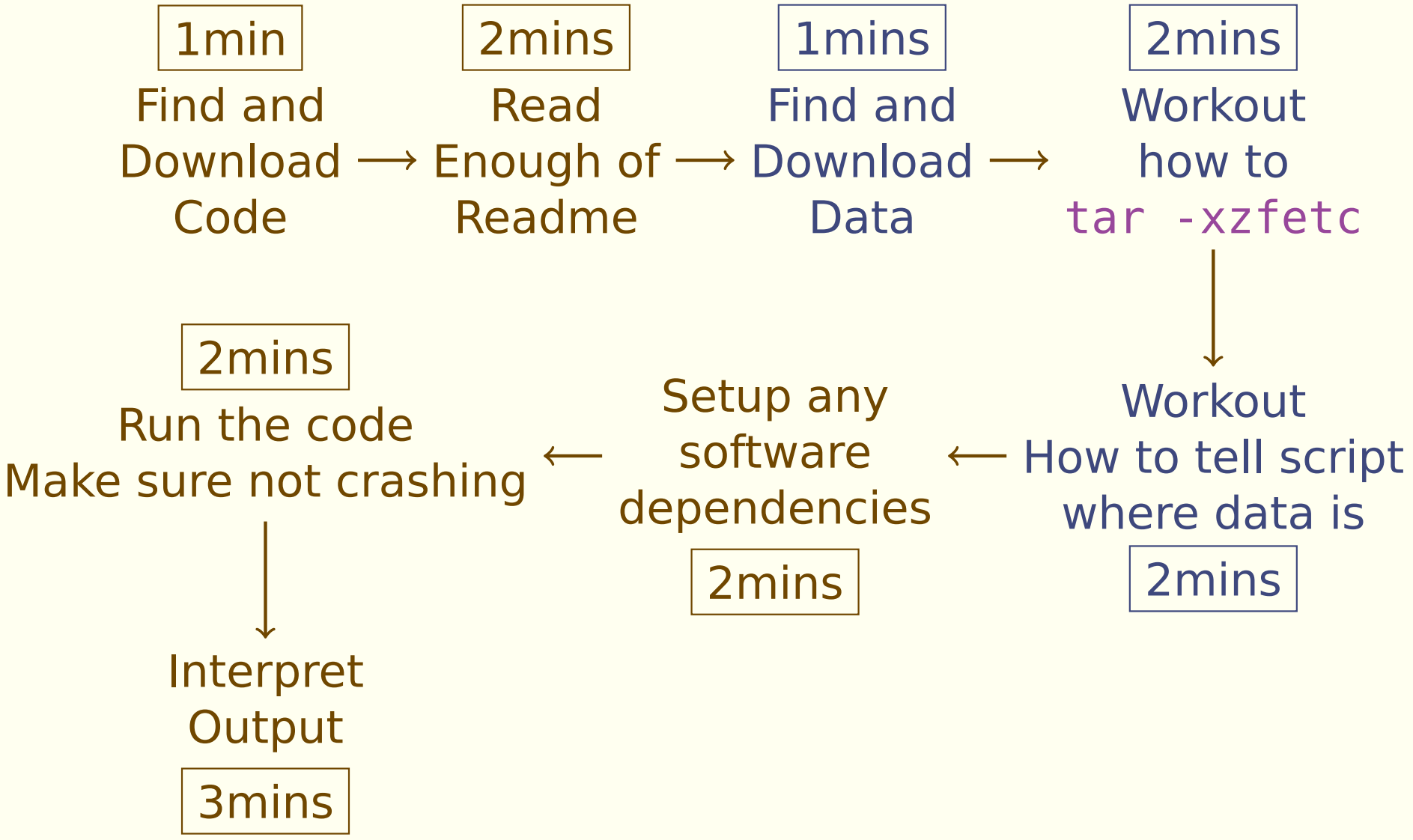
Vabdewakke's 6 Degree's of Replicability

1. The results cannot seem to be reproduced.
2. The results could be reproduced by, requiring extreme effort.
3. The results can be reproduced, requiring considerable effort.
4. The results can be easily reproduced with at most **15 minutes** of user effort, requiring some proprietary source packages (MATLAB, etc.).
5. The results can be easily reproduced with at most **15 min** of user effort, requiring only standard, freely available tools (C compiler, etc.).

Vandewalle, Kovacevic, and Vetterli (2009),
"Reproducible research in signal processing"

What happens when I try and run someone's research code?



3 Key Questions about Data: #1 Storage Location

- Where do I put it? Should it be on the local disk (small) or the network file-store (slow)?
- If I move it, am I going to have to reconfigure things?
- What if I put it all in the git repo?

3 Key **Answers** about Data: #1 Storage Location

- Where do I put it? Should it be on the local disk (small) or the network file-store (slow)?
  - Anywhere on the DataDeps Load Path will work
- If I move it, am I going to have to reconfigure things?
  - Not if you are using a datadep path
- What if I put it all in the git repo?
  - git does not like large binary files.
    50KB `.csv` is ok; 50MB `.jld` is not.

3 Key Questions about Data: #2 Redistribution

- I don’t own this data
- Am I allowed to redistribute it?
- How will I give credit, and ensure the users know who the original creator was?

3 Key **Answers** about Data: #2 Redistribution

- I don’t own this data
  - but any one can download it from it’s authors site.
- Am I allowed to redistribute it?
  - IANAL, but linking should be fine.
- How will I give credit, and ensure the users know who the original creator was?
  - Tell them with a prompt when it is downloaded

3 Key Questions about Data: #3 Replication

- How can I be sure that someone running my code has the same data?
- What if they download the wrong data, or extract it incorrectly?
- What if it gets corrupted or has been modified and I am unaware?

3 Key **Answers** about Data: #3 Replication

- How can I be sure that someone running my code has the same data?
  - Make automatic data fetching part of the code
- What if they download the wrong data, or extract it incorrectly?
  - They can’t make mistakes if it is automated
- What if it gets corrupted or has been modified and I am unaware?
  - Check the file hashes. SHA256, MD5 etc.

How do you use DataDeps.jl?

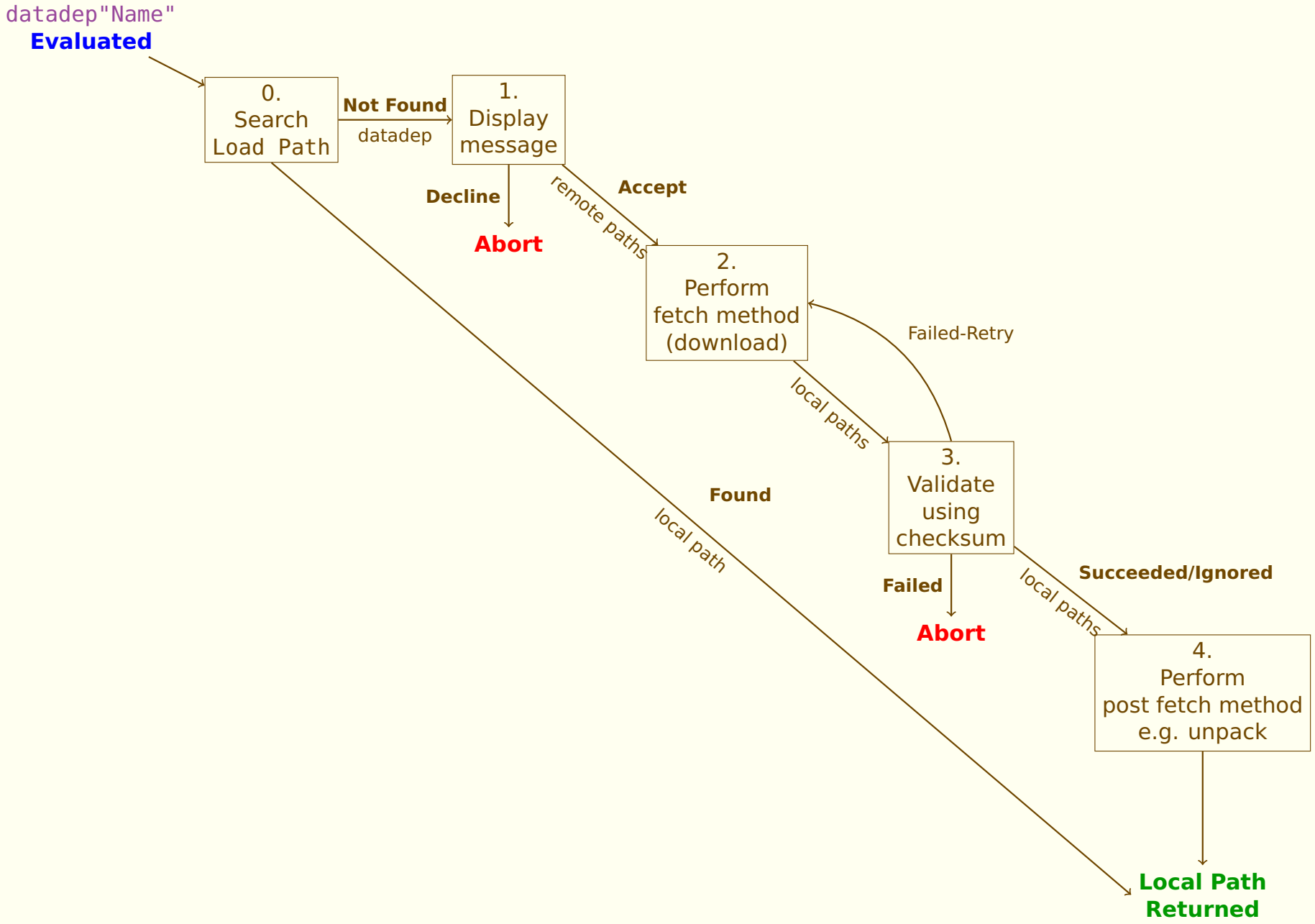
Developer/Researcher

- Writes a DataDep registration block in the `__init__()` function.
- uses `datadep"Name/file.ext"` anywhere they would want a path to be input

User/Replicater

- Uses the package / runs the code
- Data is automatically downloaded when and if need
- User is prompted to agree to download the data.

What happens when you use a datadep?



`datadep"Census 2018/populations.csv"`
A path you can trust

- Always resolves to an absolute path to that file
- Even if that means it has to download it first
- But before resorting to downloading checks a large number of places
  - `<PKG>/deps/data`,
  - `~/.julia/datadeps`,
  - `/usr/share/datadeps`, etc.
- You know that if you use a datadep path it will resolve to a file that exists.

Note that every datadep corresponds to a folder.

Automatic fetching is really convenient

Some things that have happened to me lately:

- Supervisor tells me shared workstation hard-drive is dangerously full
  - I delete all my datadeps folders
  - knowing that the ones I am still using will be fetched as required.

Automatic fetching is really convenient

Some things that have happened to me lately:

- Supervisor tells me shared workstation hard-drive is dangerously full
- I wanted to start up a copy of my work on another server to run an extra set of experiments in parallel.
  - Literally, I just cloned the project repo
  - knowing the data will make its own way there

Automatic fetching is really convenient

Some things that have happened to me lately:

- Supervisor tells me shared workstation hard-drive is dangerously full
- I wanted to start up a copy of my work on another server to run an extra set of experiments in parallel.
- I realized that I've modified one of the data files by mistake
  - `rm(datadep"Foo", recursive=true)`
  - Next time it is needed a new copy will be downloaded.

DataDeps.jl is for data with the following properties.

DataDeps.jl

Requirements

Static (preferred)

Public (preferred)

File-Based

Any Format

Any Size

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Any Size

Static

No automatic redownloading

Can’t check file hash

DataDeps.jl is for data with the following properties.

DataDeps.jl Requirements

Static (preferred)

Public (preferred)

File-Based

Any Format

Any Size

Public

Default `fetch_method` has no inbuilt knowledge of auth-systems.

It is just HTTP[/S]

DataDeps.jl is for data with the following properties.

DataDeps.jl Requirements

Static (preferred)

Public (preferred)

File-Based

Any Format

Any Size

File Based

DataDeps.jl is for files.

Any Files

If your data is from an API then use it?

DataDeps.jl is for data with the following properties.

DataDeps.jl Requirements		Git Requirements
Static	(preferred)	Dynamic
Public	(preferred)	Public or Private
File-Based		File-Based
Any Format		Plain Text Formats
Any Size		<50MB

How does DataDeps handle files of any type?

Answer: It doesn’t

It is only about getting you the files
How can it know what arcane format you used?

Interpreting that data is left to you and FileIO.jl etc.

DataDep Registration Block

```
register(DataDep("DataDepName",
"""
Free text message displayed to user before download.
Use to give credit, and tell people about licensing.
Or other messages.
""",
"http:// Download URL",
"file hash (will be printed if not provided)";
post_fetch_method = function to run on downloaded files
))
```

Registration Block Example

```
register(DataDep("WordNet 3.0",
"""
Dataset:  WordNet 3.0
Website:  https://wordnet.princeton.edu/wordnet

George A. Miller (1995).
WordNet:  A Lexical Database for English.
Communications of the ACM Vol.  38, No.  11:  39-41.

License:
This software and database is being provided to you,
the LICENSEE, by Princeton University under
the following license...
""",
"http://wordnetcode.princeton.edu/3.0/WNdb-3.0.tar.gz",
"658b1ba191f5f98c2e9bae3e25...";
post_fetch_method = unpack
))
```

Registration Block: Recursive Example

```
using MD5

register(DataDep("DataDepNameRec",
"""
Warning these files are all together 39.8GB
""",
["http://example.com/readme.txt",
    ["http://example.com/data1.zip",
     "http://example.com/data2.tar.gz",
    ]
],
(md5, "d41d8cd98f00b204e9800998ecf8427e")
post_fetch_method = [identity, unpack]
))
```

ManualDataDep

- A manual datadep registration consists just of a name and a message.

```
register(ManualDataDep("DataDepName",
"""
Free text prompt.  As well as credit etc
should include instructions.
""",
))
```

- It lets you use `datadep"Paths"` for locating data without any automation
- If locating the file fails, it prompts the user with the message on how to install it.

`ManualDataDep`, using DataDeps.jl with git and other uses

- Note that for every package the directory `<PKG>/deps/data` is on the datadeps load path
- So for files that a good fit for git you can include them in the Repo.
- This means a `ManualDataDep` will find them, so the user will not have to take any manual actions.

`ManualDataDep`, using DataDeps.jl with git and other uses

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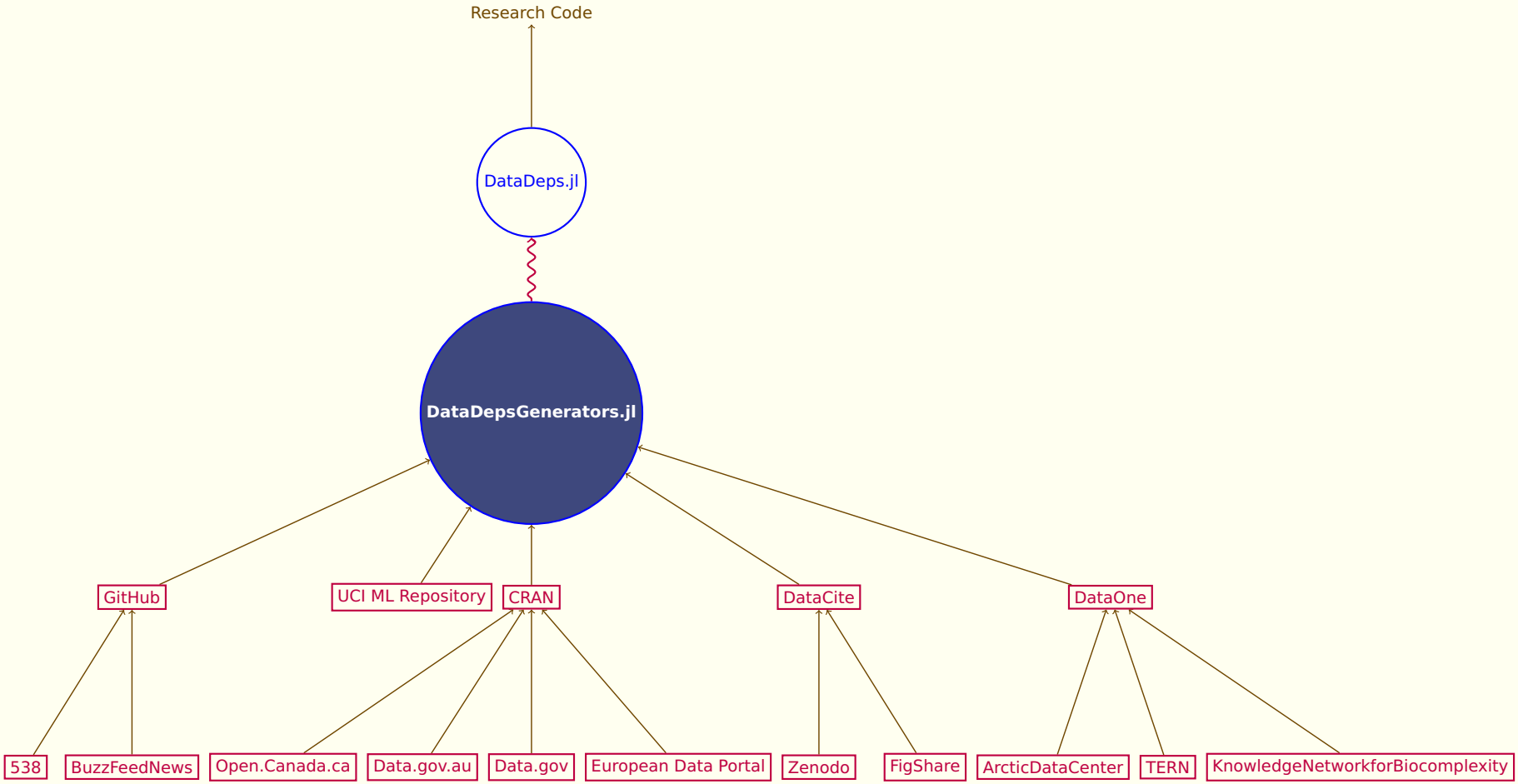
- So for files that a good fit for git you can include them in the Repo.
- This means a `ManualDataDep` will find them, so the user will not have to take any manual actions.
- `ManualDataDeps` also good for working with dynamic data and private data
  - as the syncing mechanism is external to DataDeps.jl

Handling private data, with specific `fetch_method` method

```
using HTTP, OAUTH2
const appid="ProjectXYZ:apps:datadeps:support"
function authed_download(url, local)
    authtok = getauthtok("https://evil.eg.au/auth"
            ENV["USER_ID"], appid, !ENV["APPSECRET"])
    HTTP.download(url, local, ["Authorization"=>authtok])
end

register(DataDep("Secret Science Data",
"Evil world domination plans.  Do not share."
["https://evil.eg.au/files/deathray.stl",
 "https://evil.eg.au/files/EvilLeageOfEvil_letter.md"]
"d41d8cd98f00b204e9800998ecf8427e";
fetch_method = authed_download
))
```

DataDepsGenerators.jl



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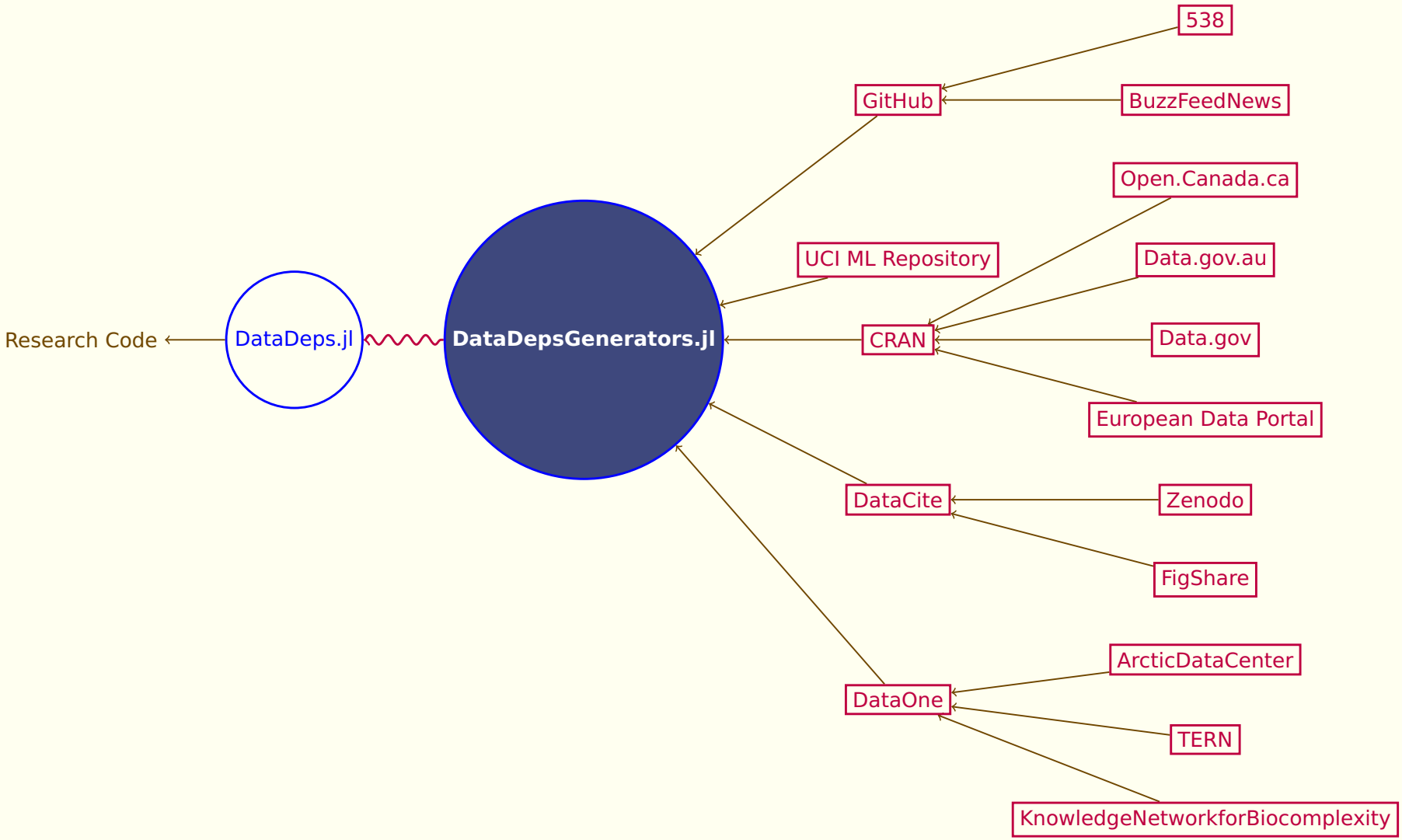
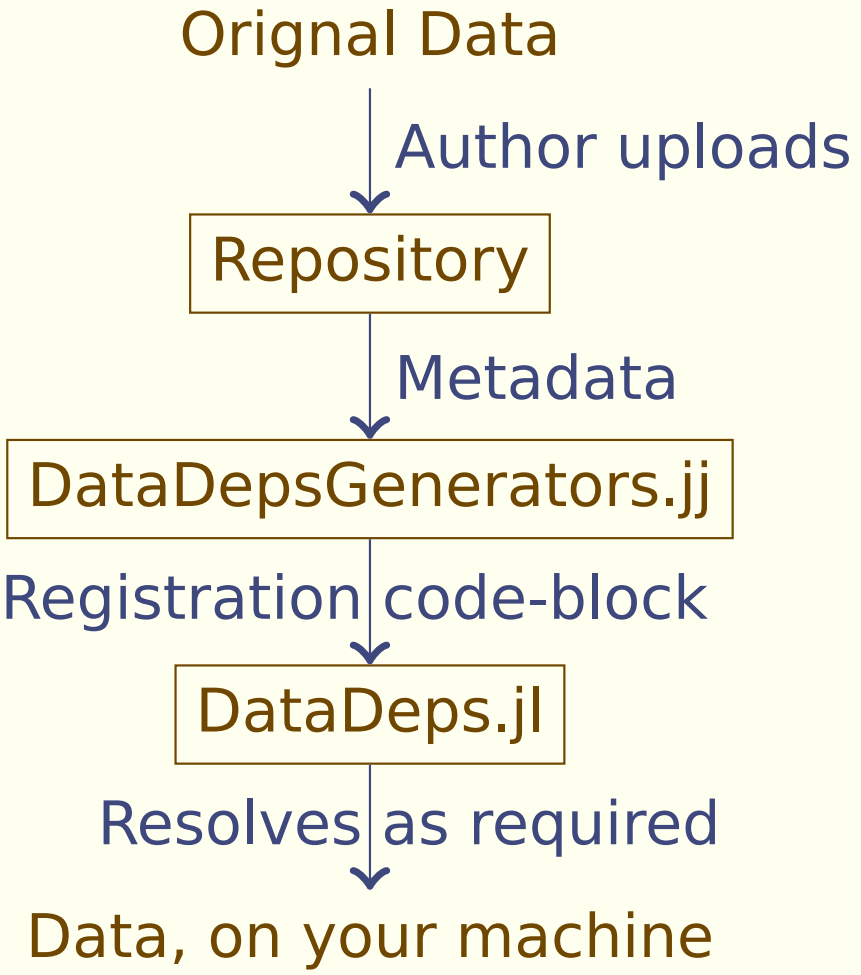


Developers still have to write registration blocks

- DataDeps.jl shifts the work from manually to automatic
- But it still has to be done at once.
- Writing a registration block normally means copy-and-pasting from a website.
  - Even copy pasting a dozen URLs is annoying
  - Enough information for data providence needs more

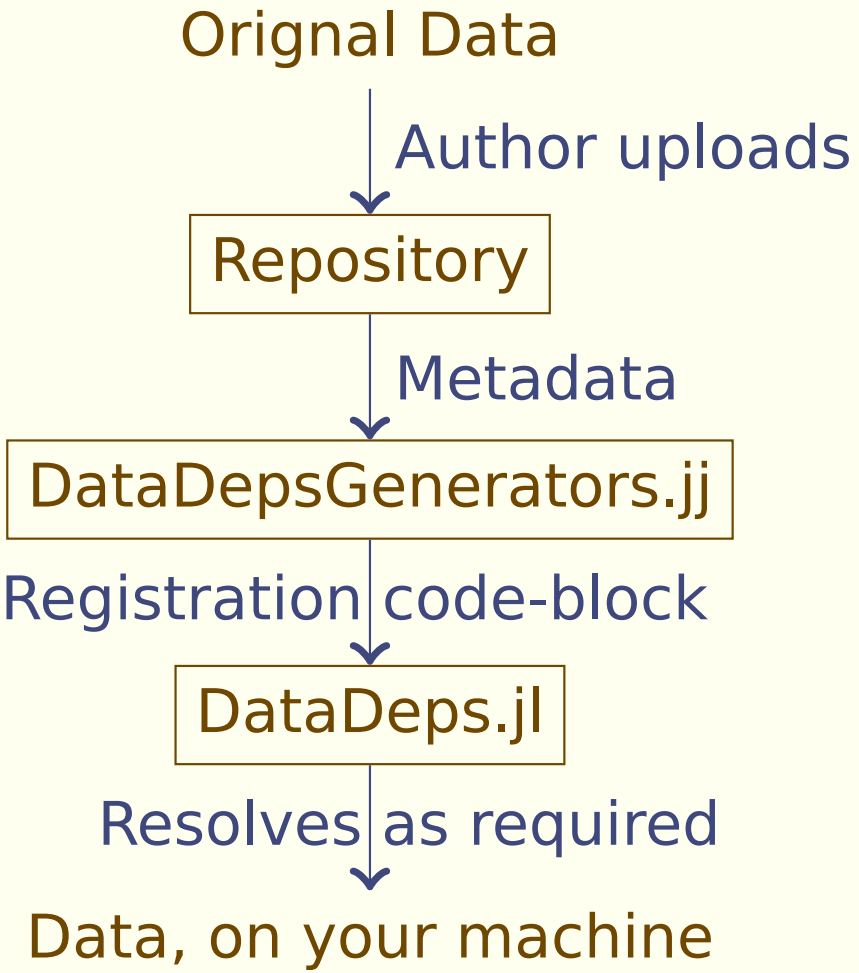
For published data this information is available from some API

- Title
- Author Name
- Publication Date
- Licensing info
- Description
- Citation for the linked journal paper
- Download URLs
- File Hashes



DataDepsGenerators creates static code

- This avoids propagating DataDepsGenerator's many heavy dependencies.
- Avoids issue unstability of repo APIs/websites



Many datasets have multiple possible APIs

For example something that points at Figshare

```
generate("https://doi.org/10.23640/07243.5525476.v1")
```

1. DataCite API
2. JSON-LD DOI Content Negotiation service
3. It is a URL
4. Embedded JSON-LD element
5. FigShare API

Many others will be tried and will error out

Many datasets have multiple possible APIs

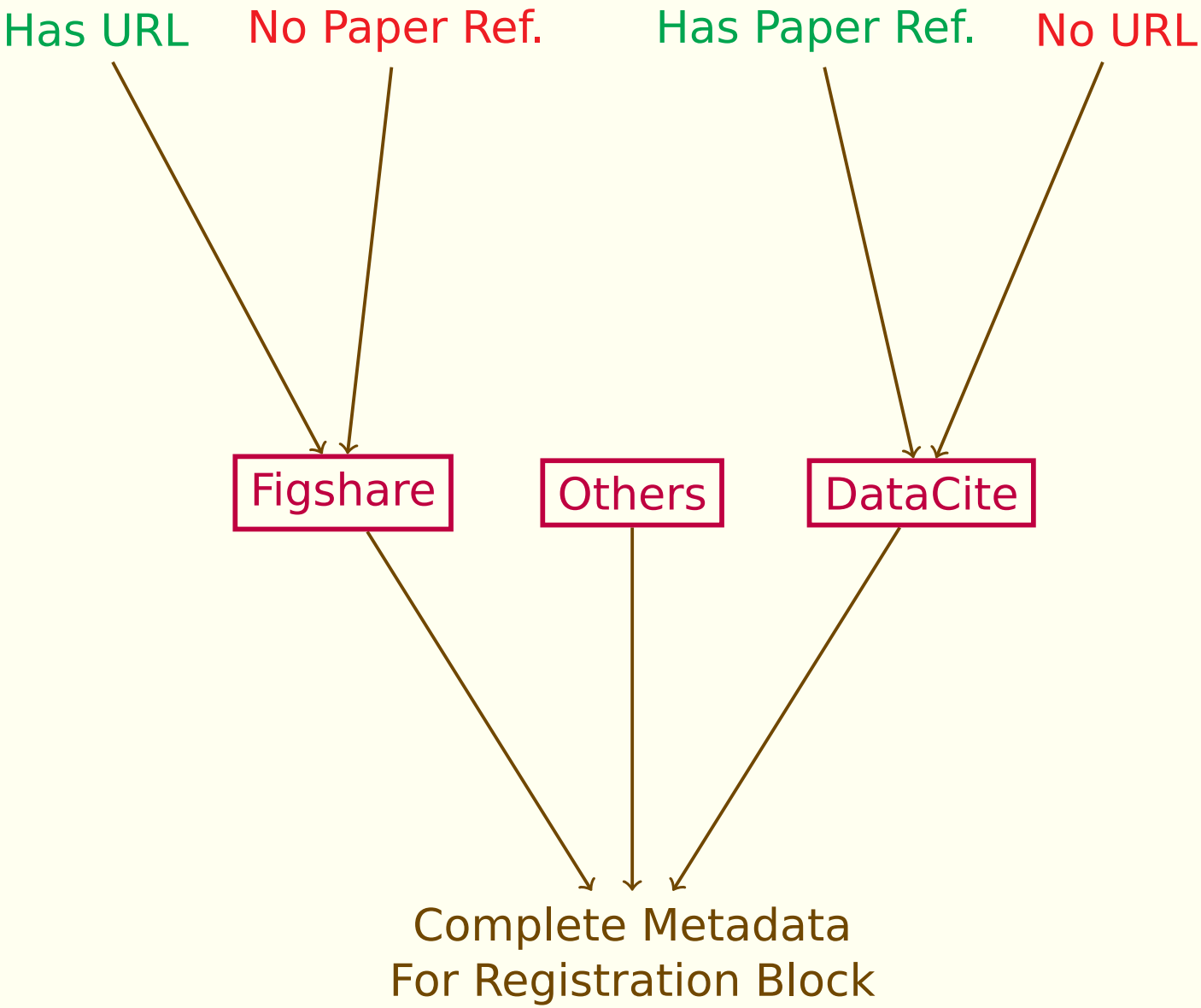
For example something points at DataDryad

```
generate(
"http://datadryad.org/resource/doi:10.5061/dryad.gj651")
```

1. DataCite API
2. JSON-LD DOI Content Negotiation service
3. Embedded JSON-LD element
4. DataDryad Webscraper
5. DataOneV1 API

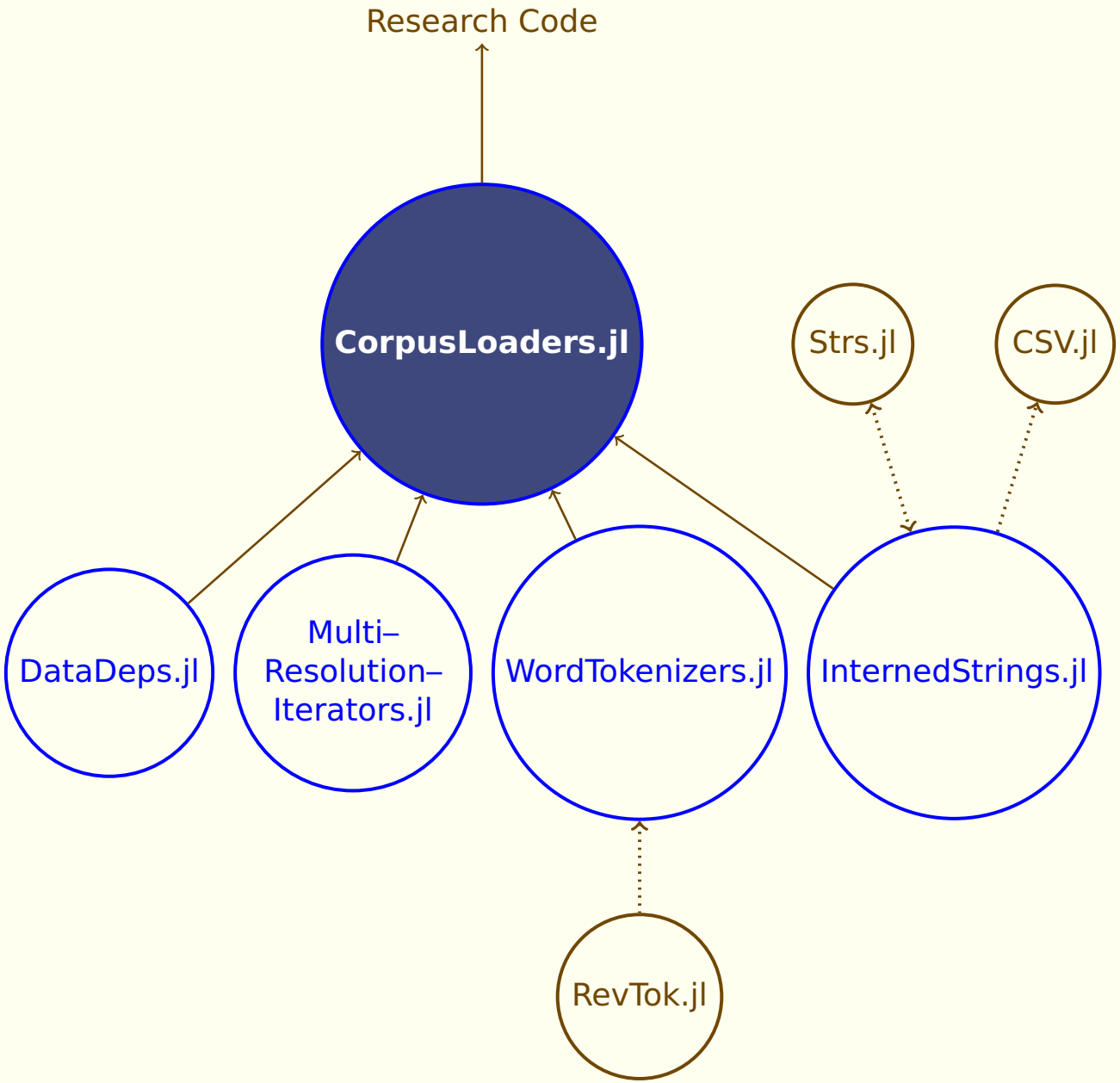
Many others will be tried and will error out

DataDepsGenerators combines all the Metadata Sources



We are now going to take a very short break

CorpusLoaders.jl

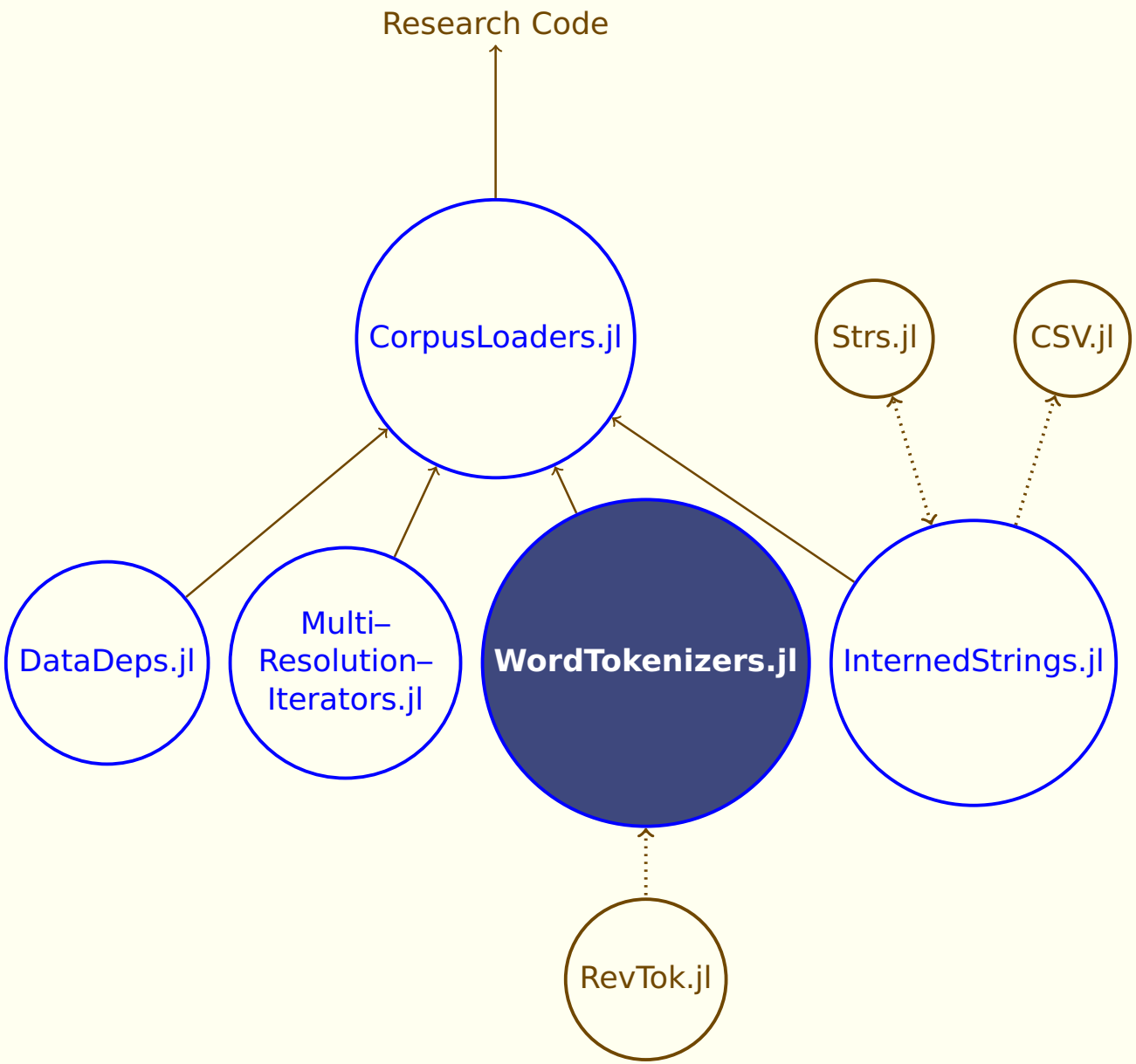


CorpusLoaders.jl

- In it itself.
- Just a couple of parsers for a few formats
  - I'ld like to have more.
- and the DataDep registrations for the corresponding data.
- Mostly interesting as a vessel for driving development its dependencies.

- Notable differences from MLDatasets.jl
  - Everything is lazy-loaded from disk via `Channels`.
  - Everything is Multi-Resolution

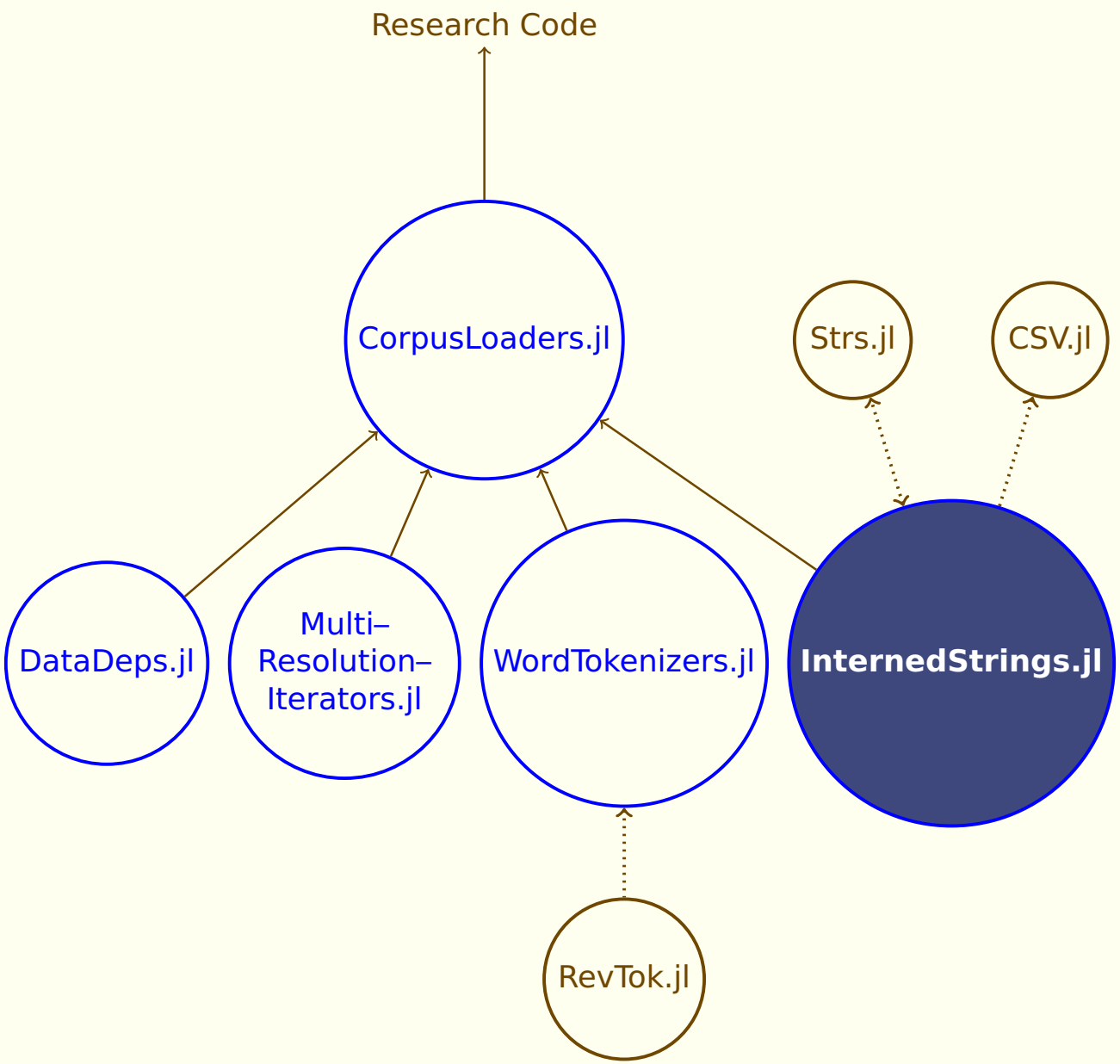
CorpusLoaders.jl



WordTokenizers.jl

- Configurable `tokenizer` and `sentence_segmenter`.
  - Can set which tokenizer / segmenter to use
  - including something external like RevTok.jl
- Code ported from existing sources
  - Especially NLTK
  - Most of these are Regex scripts that have been kicking around for a long time.
- Uses metaprogramming to generate julia AST from sedscripts

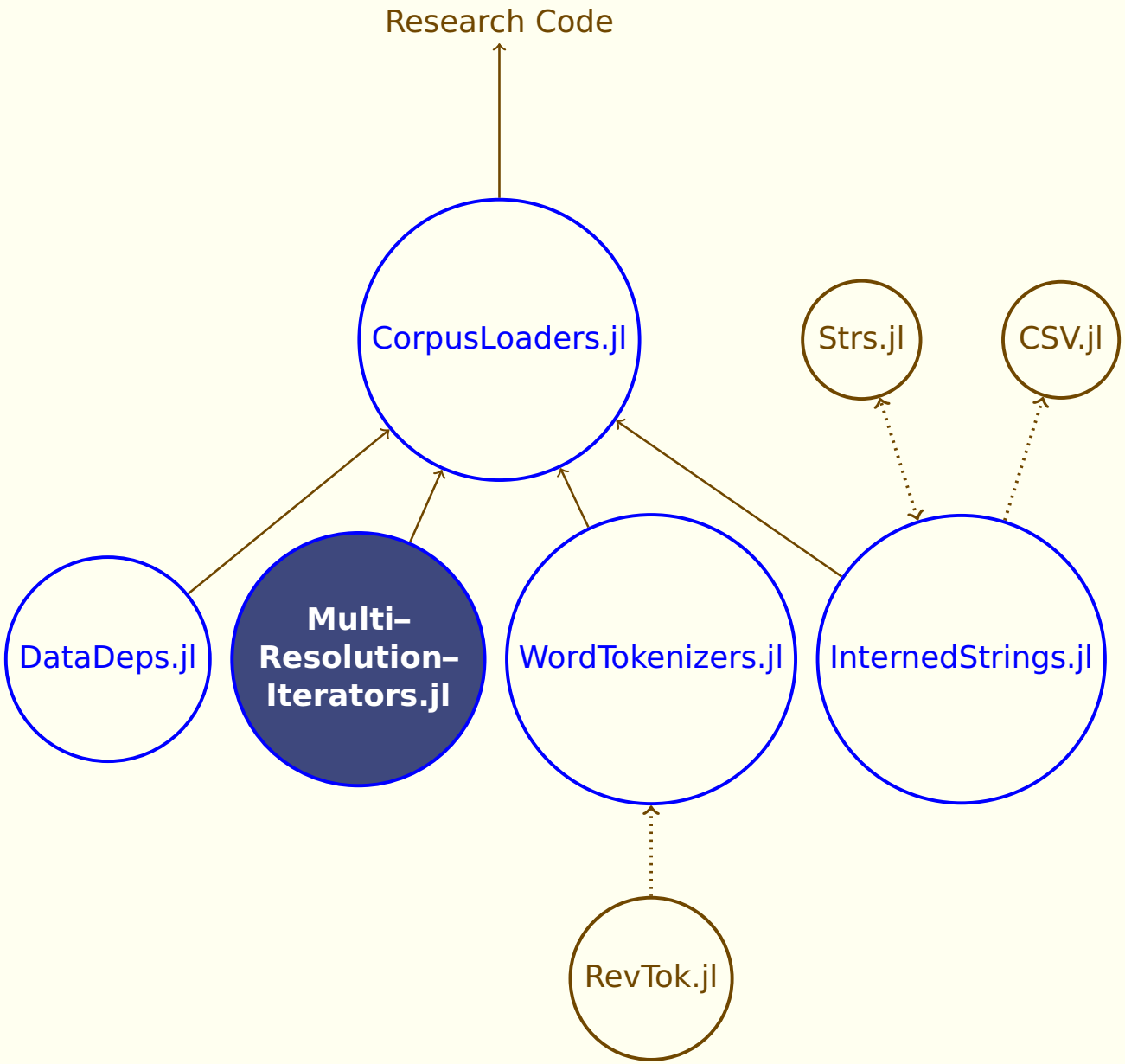
CorpusLoaders.jl



InternedStrings.jl: All these duplicate strings are using all my memory

- Strings are immutable, so we only need one copy of each
- We can maintain a pool of `WeakRef`s to each string allocated.
- `str = intern(str)`
  - Add the `str` to the pool if not already
  - replace `str` with an element of the pool
- Because the pool only has `WeakRef`s strings can still be garbage collected.

CorpusLoaders.jl



MultiResolutionIterators.jl: The structure of a Corpus

- Corpus
- made up of: Documents
- made up of: Paragraphs
- made up of: Sentences
- made up of: Words or Tokens
- made up of: Letters or Characters

MultiResolutionIterators.jl: Not everyone wants every level of structure

Full corpus structure is
Documents ►Paragraphs ►Sentences ►Words ►Letters

A Corpus Linguist may want
a stream of: Sentences ►Words

An Information Retrieval researcher may want
a stream of: Documents ►Words

A char-RNN Topic Modelling wants
a stream of: Documents ►Letters

MultiResolutionIterators.jl: example

```
julia> animal_info = [
[   ["Turtles", "are", "reptiles", "."],
    ["They", "have", "shells", "."],
    ["They", "live", "in", "the", "water", "."]],
[   ["Cats", "are", "mammals", "."],
    ["They", "live", "on", "the", "internet", "."]]
]
2-element Array{Array{Array{String,1},1},1}

julia>  struct AnimalTextIndexer end;
julia>  levelname_map(::AnimalTextIndexer) = [
    :documents=>1,
    :sentences=>2,
    :words=>3, :tokens=>3,
    :characters=>4, :letters=>4
]
```

Information Retrieval wants Documents ►Words

```
julia> flatten_levels(animal_info, 2)
```

~ Or ~

```
julia> flatten_levels(animal_info,
           lvls(indexer, :sentences))
```

~ Or ~

```
julia> flatten_levels(animal_info,
           (!lvls)(indexer, :documents, :words))

julia> full_consolidate(ans)

2-element Array{Array{String,1},1}:
String["Turtles", "are", ".", ...,  "the", "water", "."]
String["Cats", "are", ..., "the", "internet", "."]
```

Char-RNN Topic Modelling wants Documents ►Words

```
julia> join_levels(animal_info,
            lvls(indexer,Dict(
                :words=>" ",
                :sentences=>" ")
             )
        )

julia> full_consolidate(ans)

2-element Array{String,1}:
"Turtles are reptiles ... They live in the water ."
"Cats are mammals . They live on the internet ."
```

MultiResolutionIterators.jl

Mix and match operations as needed

Easy to define any iterator function to work at levels

Overload `apply` to customize behaviour with particular iterator-types.

E.g. could make `MyVector` eager and type preserving via

```
apply(f, v::MyVector) = MyVector(collect(f(v)))
```

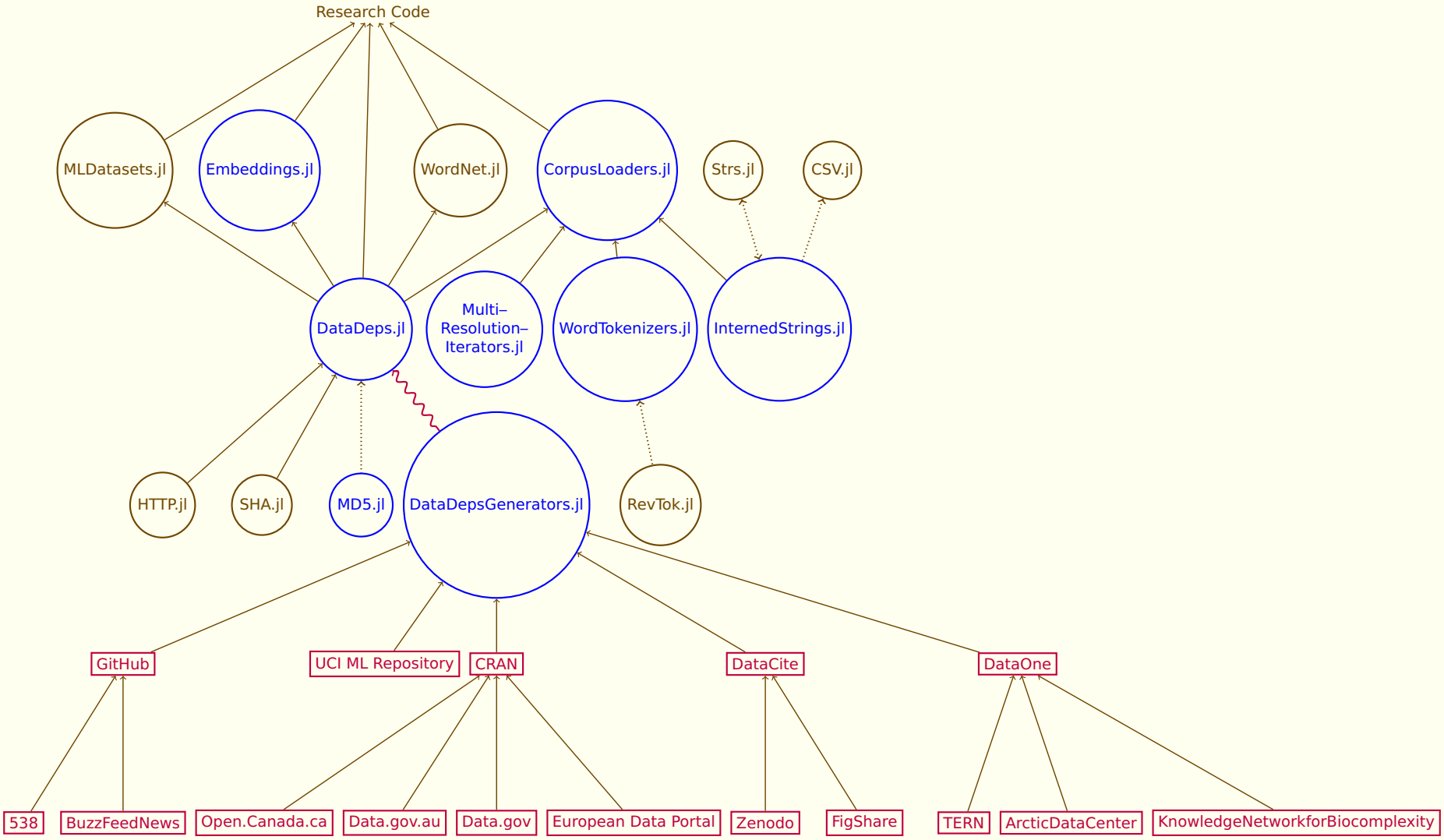
What have we learned?

- Data is important
- Simplify your data management with DataDeps.jl
- Simplify your DataDeps definitions with DataDepsGenerators.jl

What have we learned?

- Data is important
- Simplify your data management with DataDeps.jl
- Simplify your DataDeps definitions with DataDepsGenerators.jl
- Data is useful for NLP
- Packages exist to make working with NLP shaped data easier.

Big Picture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MD5.jl
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RevTok.jl
GitHub
UCI ML Repository
CRAN
DataCite
DataOne
538
BuzzFeedNews
Open.Canada.ca
Data.gov.au
Data.gov
European Data Portal
Zenodo
FigShare
TERN
ArcticDataCenter
KnowledgeNetworkforBiocomplexity

Appendix / Spare Rants

Current Usages of DataDeps.jl

MLDatasets.jl

- Provides easy access to a bunch of ML datasets
- `xs, ys = MNIST.traindata()`
- Gives you regular julia arrays

CorpusLoaders.jl

- Provides easy access to linguistic corpora
- `corpus_gen = load(WikiCorpus())`
- gives you a multi-resolution iterator

Current Usages of DataDeps.jl

Embeddings.jl

- Provides access to hundreds of pretrained word embedding models.
- `load_embeddings(FastText_Text{:fr})`
- gives you a table of French word embeddings.

WordNet.jl

- Look up lexical relations and definitions.
- `lemma = db['a', "glad"]`
- `antonyms(db, synsets(db, lemma)[1])`

DataDeps doesn’t protect you from link breakages.
But at least you know when it is broken

- Nothing can truly protect against link-rot
  - Not even DOIs
  - The data must physically exist somewhere on a hard-disk. And someone must be maintainingthat

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  - The data must physically exist somewhere on a hard-disk. And someone must be maintainingthat
- If you are downloading your data automatically you can check it is still there via automated testing
  - TravisCI and AppVeyor offer scheduled testing options.

Why DOI's alone are not the answer to broken dataset links:

- When we say DOI's are persistent we mean they never expire.
  - Unlike web URL, you do not have to pay to renew.
  - It won't be sold to someone else. It will always refer to your object.
- DOI's point to landing pages, not data/paper downloads
  - DOI's have attached metadata, but not direct links to the data (not even DataCite DOIs (yet))
- A key reason DOI's don't point data/papers is because not all are available online
  - Some obviously are pay walled
  - But some can't be digitalized at all. E.g. DOI's have been issued to laboratory samples, or to data centres.

DOI's are not the solution, but they are probably part of the solution

- The landing page is still just a website, it's domain name can expire
  - The data hosting is can expire (and hard-drives can fail).
- Did I mention under normal circumstances you can't go from DOI to data URL at all anyway?
- Still persistent metadata is also kind of nice to have
  - At least if the data goes down you know what was lost, so we can seek it else-where.
- Really, though we need to be applying periodic automatic link checking to all URLs we need not to break.
  - DataDeps.jl makes that pretty easy, you can just set it up as part of `runtests.jl` and set Travis or AppVeyor to run scheduled tests.

You can’t trust hardcoded paths; but they are nice to work with.

- Ideally we’ld just use hard-coded, absolute paths
- Absolute paths work with all applications
- Hard-coding the paths in code means user doesn’t have to input them.
- But they break if anything is moved.

You could making the path be passed in as an argument. But...

- Now user has to be typing it in to run it.
- So it is harder to use.
- You could include a bash-script that invokes it with the path, but now you’re just hard-codingit somewhere else

GitHub

- 85×10^6 repositories
  - Some of them are data, (most are not)
  - Not a great place for data, but commonly used
- BuzzFeedNews:
  - 1 Repo per dataset
- fivethirtyeight:
  - 1 shared Repo with a folder for each dataset
- We generate URLs pointing at `cdn.rawgit.com`
  - This is backed by StackPath CDN
  - It is generated to point at the latest commit at generation time

DataOne

- Data Observation Network for Earth
  - ~40 Earth and Environment Science repositories
  - 1.2×10^6 Data Files
  - Seems to have iffy metadata, varying between nodes.

Others

- DataDryad
  - Ecological research data
  - 7.1×10^4 Data Files
  - 2.2×10^4 Data Packages
- Figshare
  - Mostly Figures and Datasets
  - 8×10^5 Files
- UCI ML Repository
  - 437 Datasets
  - Very commonly used in benchmarking basic ML
  - Awful website, zero API

DataCite

- 11×10^6 DOIs issued
  - Mostly to datasets, though they count also figures as data
  - If you have a DOI and it points at data, it is probably from DataCite
- Problem is all their metadata is missing download URLs
  - So user has to add them manually after
- This is effectively the final fallback for anything with a DOI.

Australia, it is quiet far away