Performing Large-scale Mining Studies, From Start to Finish

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Tutorial Schedule

2:00 Introduction (5 mins) (RD+SF)
2:05 Introduction to the Boa Language (20 mins) (RD)
2:25 Using Boa in VS Code (10 mins) (RD)
2:35 Hands-on Task 0: Boa+VS Code (20 mins) (SF)
2:55 Overview of the Boa Study Template (15 mins) (SF)
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3:30 Break (30 mins)

4:00 Hands-on Task 2: Adding a Second Query (30 mins) (RD+SF)
4:30 Hands-on Task 3: Analyzing Boa Outputs with Pandas (45 mins)
5:15 Publishing Replication Packages (15 mins) (RD)
5:30 Finished

These Slides

https://go.unl.edu/fse22-slides

Today's Material

https://cse.unl.edu/~rdyer/boa-fse-tutorial.zip

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Boa Website and Credentials

For today, everyone will be given a Boa user/password (handed out).

https://go.unl.edu/boamsr

Install the Boa VS Code Extension

https://go.unl.edu/vscode

https://go.unl.edu/boa-vscode

NOTE: If you are having problems, Sam will be around to try and help.

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The Boa Language and Infrastructure

What is actually practiced

Keep doing what works

To find better designs

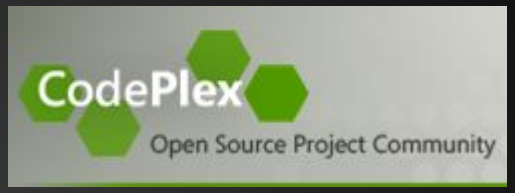
Empirical validation

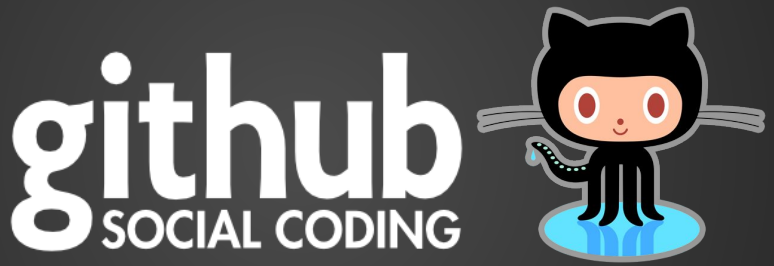
Spot (anti-)patterns

Why mine software repositories?

Learn from the past → **Inform the future**

Open source repositories





Open source repositories

1,000,000+ projects

1,000,000,000+ lines of code

10,000,000+ revisions

3,000,000+ issue reports

Open source repositories

1,000,000+ projects

What is the most used PL?

1,000,000,000+ lines of code

How many methods are named "test"?

10,000,000+ revisions

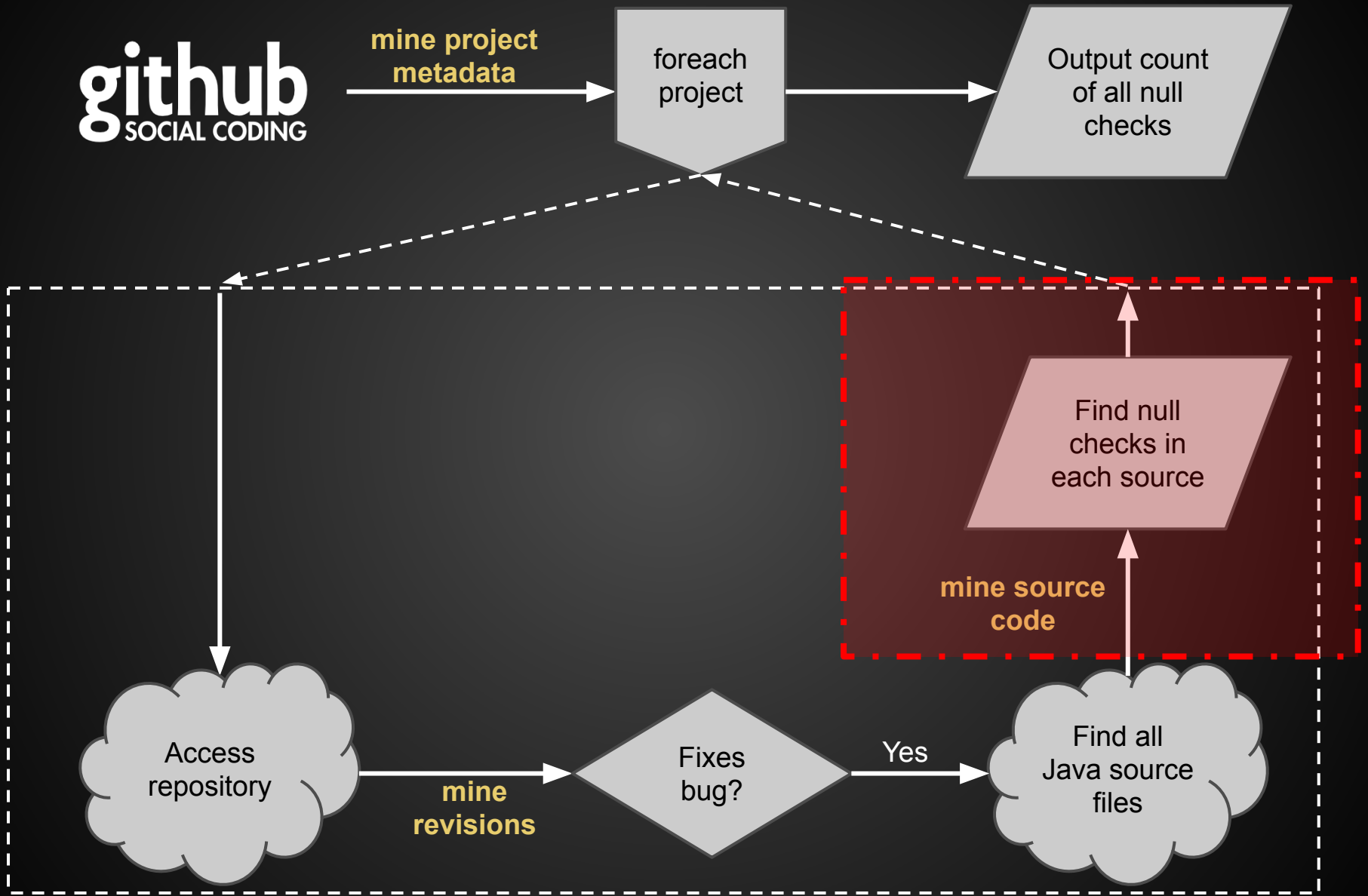
How many words are in log messages?

3,000,000+ issue reports

How many issue reports have duplicates?

Consider a task to answer

"*How many bug fixes add checks for null?*"


github
SOCIAL CODING
mine project metadata
foreach project
Output count of all null checks
Find null checks in each source
mine source code
Access repository
mine revisions
Fixes bug?
Yes
Find all Java source files

A solution in Java...

```
class AddNullCheck {
    static void main(String[] args) {
        ... /* create and submit a Hadoop job */
    }
    static class AddNullCheckMapper extends Mapper<Text, BytesWritable, Text, LongWritable> {
        static class DefaultVisitor {
            ... /* define default tree traversal */
        }
        void map(Text key, BytesWritable value, Context context) {
            final Project p = ... /* read from input */
            new DefaultVisitor() {
                boolean preVisit(Expression e) {
                    if (e.kind == ExpressionKind.EQ || e.kind == ExpressionKind.NEQ)
                        for (Expression exp : e.expressions)
                            if (exp.kind == ExpressionKind.LITERAL && exp.literal.equals("null")) {
                                context.write(new Text("count"), new LongWritable(1));
                                break;
                            }
                    }
                }.visit(p);
            }
        }
    }
    static class AddNullCheckReducer extends Reducer<Text, LongWritable, Text, LongWritable> {
        void reduce(Text key, Iterable<LongWritable> vals, Context context) {
            int sum = 0;
            for (LongWritable value : vals)
                sum += value.get();
            context.write(key, new LongWritable(sum));
        }
    }
```

Too much code!
Do not read!

Full program
over 140 lines of code

Uses ***JSON, JGit, and Eclipse JDT libraries***

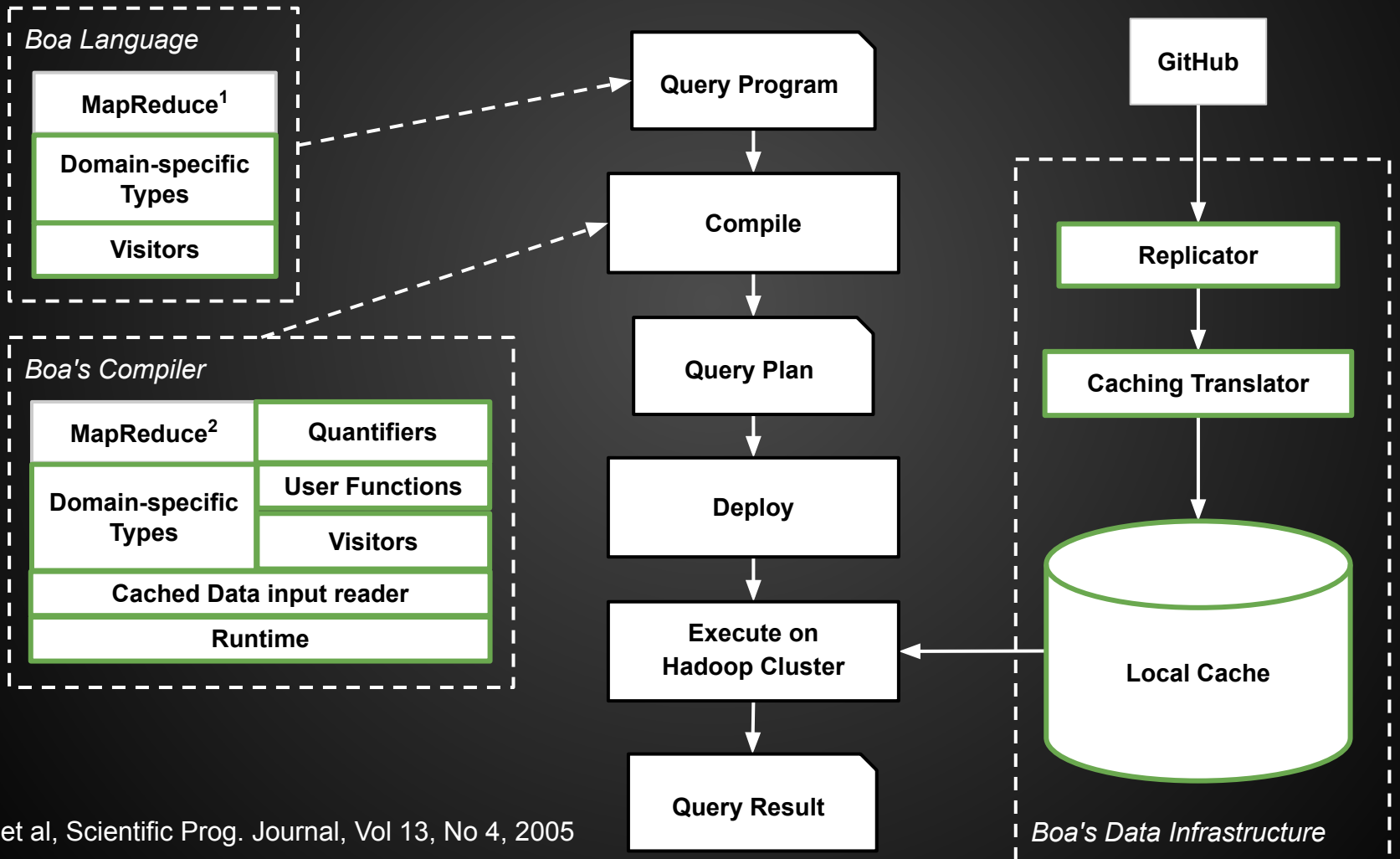
Uses ***Hadoop framework***

Explicit/manual
parallelization

The Boa language and data-intensive infrastructure

https://boa.cs.iastate.edu/

Boa architecture



[1] Pike et al, Scientific Prog. Journal, Vol 13, No 4, 2005

[2] Anthony Urso, http://github.com/anthonyu/Sizzle

Recall: A solution in Java...

```
class AddNullCheck {
    static void main(String[] args) {
        ... /* create and submit a Hadoop job */
    }
    static class AddNullCheckMapper extends Mapper<Text, BytesWritable, Text, LongWritable> {
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            ... /* define default tree traversal */
        }
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            new DefaultVisitor() {
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                    if (e.kind == ExpressionKind.EQ || e.kind == ExpressionKind.NEQ)
                        for (Expression exp : e.expressions)
                            if (exp.kind == ExpressionKind.LITERAL && exp.literal.equals("null")) {
                                context.write(new Text("count"), new LongWritable(1));
                                break;
                            }
                    return true;
                }
            }.visit(p);
        }
    }
    static class AddNullCheckReducer extends Reducer<Text, LongWritable, Text, LongWritable> {
        void reduce(Text key, Iterable<LongWritable> vals, Context context) {
            int sum = 0;
            for (LongWritable value : vals)
                sum += value.get();
            context.write(key, new LongWritable(sum));
        }
    }
}
```

Too much code!
Do not read!

Full program
over 140 lines of code

Uses ***JSON, JGit, and Eclipse JDT libraries***

Uses ***Hadoop framework***

Explicit/manual
parallelization

A better solution...

```
count: output sum of int;

visit(input, visitor {
    before e: Expression ->
        if (e.kind == ExpressionKind.EQ || e.kind == ExpressionKind.NEQ)
            exists (i: int; isliteral(e.expressions[i], "null"))
                count << 1;
});
```

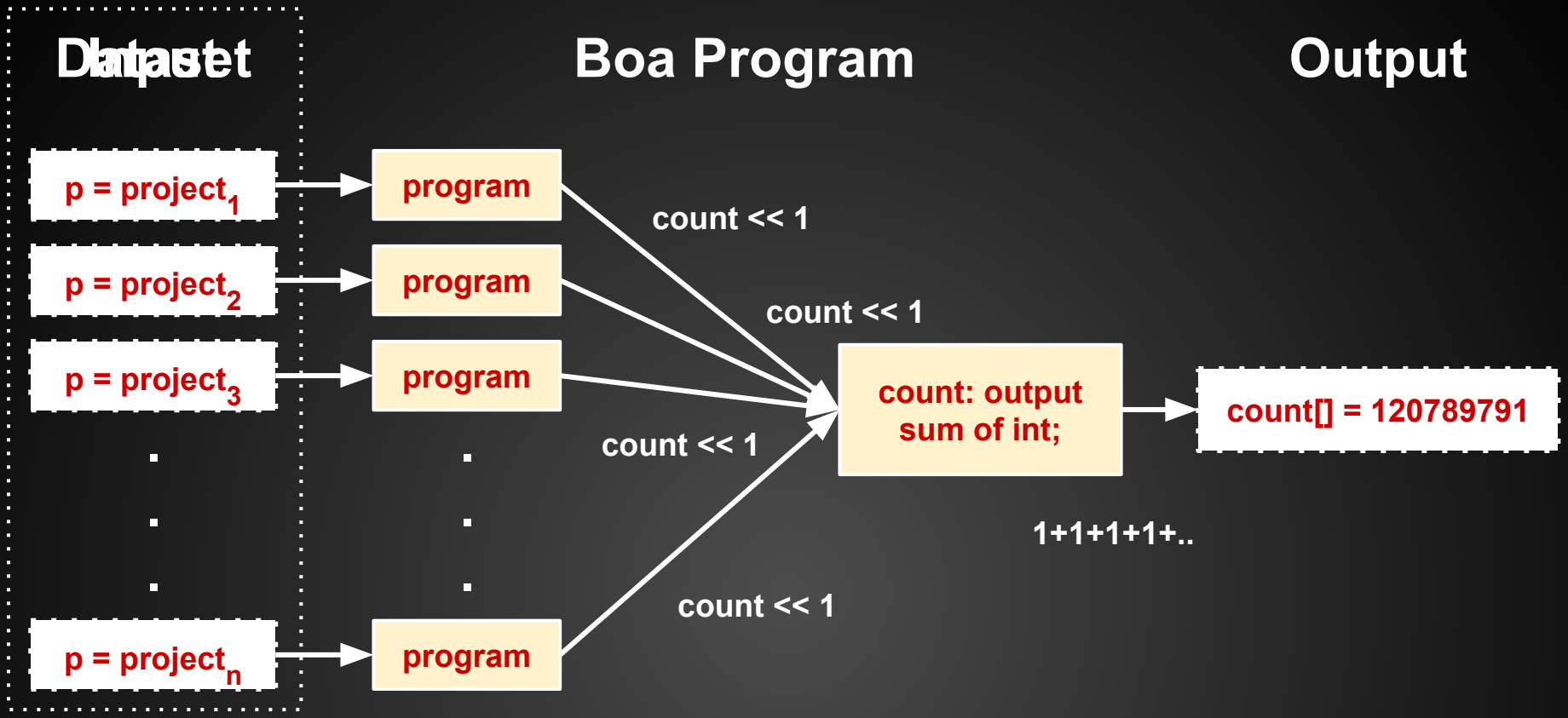
Full program **7 lines of code**!

Automatically parallelized!

No external libraries needed!

Analyzes **128.6 million** source files in about **17 minutes**!

(only 8 ***micro***seconds each!)




```
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count: output sum of int;

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     before e: Expression ->
          if (e.kind == ExpressionKind.EQ || e.kind == ExpressionKind.NEQ)
               exists (i: int; isliteral(e.expressions[i], "null"))
                    count << 1;
});
```

Domain-specific types

http://boa.cs.iastate.edu/docs/dsl-types.php

```
p: Project = input;
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visit(p, visitor {
    before e: Expression ->
        if (e.kind == ExpressionKind.EQ || e.kind == ExpressionKind.NEQ)
            exists (i: int; isliteral(e.expressions[i], "null"))
                count << 1;
});
```

Abstracts details of *how* to mine software repositories

Domain-specific types

http://boa.cs.iastate.edu/docs/dsl-types.php

Project

```
id                  : string
name                : string
description         : string
homepage_url        : string
programming_languages : array of string
licenses            : array of string
maintainers         : array of Person
....
code_repositories   : array of CodeRepository
```

Domain-specific types

http://boa.cs.iastate.edu/docs/dsl-types.php

CodeRepository

```
url       : string
kind      : RepositoryKind
revisions : array of Revision
```

Revision

```
id          : string
author      : Person
committer   : Person
commit_date : time
log         : string
files       : array of File
```

File

```
name   : string
kind   : FileKind
change : ChangeKind
```

Domain-specific functions

http://boa.cs.iastate.edu/docs/dsl-functions.php

```
iskind := function (pat: string, k: dsl_type) : bool {
    return match(format(`^%s`, pat), string(k));
};
```

Matches a ‘kind’ (like ChangeKind or FileKind) against a string pattern. Can be very useful for things like testing if something is a source file:

```
iskind("SOURCE_", cf.kind)
```

User-defined functions

http://boa.cs.iastate.edu/docs/user-functions.php

```
id := function (a1: t1, ..., an: tn) [: ret] {
    ... # body
    [return ...;]
};
```

Return type is optional

- Allows for complex algorithms and code re-use
- Users can provide their own mining algorithms

Quantifiers

http://boa.cs.iastate.edu/docs/quantifiers.php

```
foreach (i: int; condition...)
    body;
```

For *each* value of **i**,

if **condition** holds

then

run **body** (with i bound to the value)

Quantifiers

http://boa.cs.iastate.edu/docs/quantifiers.php

```
exists (i: int; condition...)
    body;
```

For *some* value of **i**,

if **condition** holds

then

run **body** *once* (with i bound to the value)

Quantifiers

http://boa.cs.iastate.edu/docs/quantifiers.php

```
ifall (i: int; condition...)
    body;
```

For *all* values of **i**,

if **condition** holds

then

run **body** *once* (with i not bound)

Output and aggregation

http://boa.cs.iastate.edu/docs/aggregators.php

```
p: Project = input;
count: output sum of int;

visit(p, visitor {
    before e: Expression ->
        if (e.kind == ExpressionKind.EQ || e.kind == ExpressionKind.NEQ)
            exists (i: int; isliteral(e.expressions[i], "null"))
                count << 1;
});
```

- Output defined in terms of predefined data aggregators
  - sum, set, mean, maximum, minimum, etc
- Values sent to output aggregation variables
- Output can be indexed

Declarative Visitors in Boa

http://boa.cs.iastate.edu/

Basic Syntax

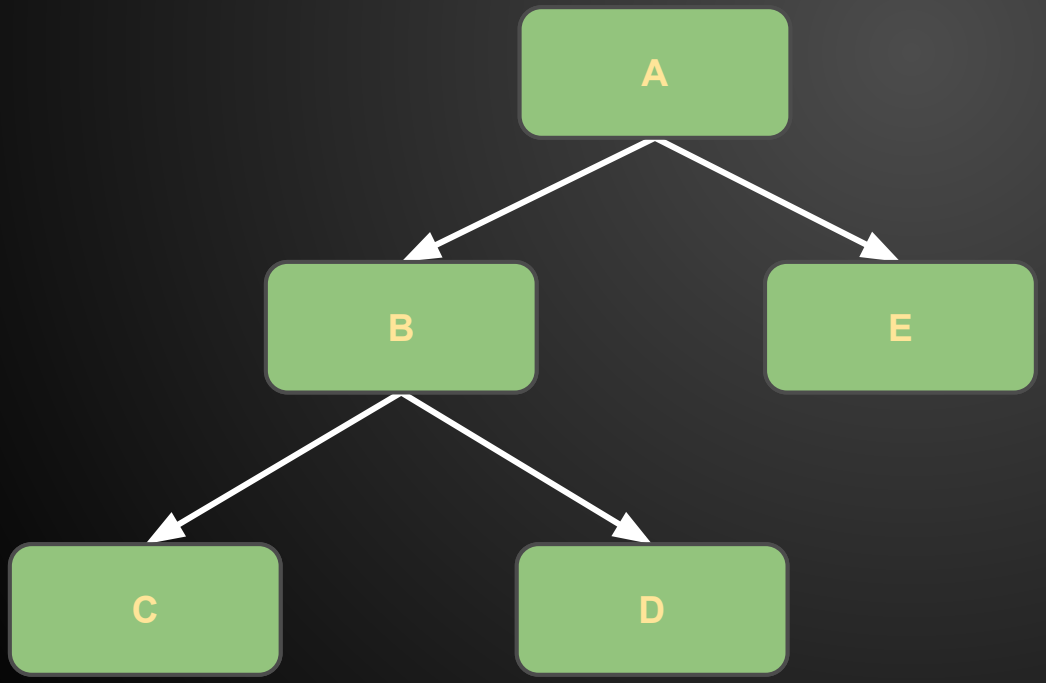
```
id := visitor {
   before id:T -> statement
   after  id:T -> statement
   ...
};
visit(startNode, id);
```

Execute **`statement`** either **`before`** or **`after`** visiting the children of a node of type **`T`**

Depth-First Traversal

Provides a default, depth-first traversal strategy

A -> B -> C -> D -> E




```
before A -> statement
before B -> statement
before C -> statement
after  C -> statement
before D -> statement
after  D -> statement
after  B -> statement
before E -> statement
after  E -> statement
after  A -> statement
```

Type Lists and Wildcards

```
visitor {
   before id:T     -> statement
   after T2,T3,T4  -> statement
   after _         -> statement
}
```

Single type (with identifier)

Attributes of the node available via identifier

Type Lists and Wildcards

```
visitor {
   before id:T      -> statement
   after T2,T3,T4   -> statement
   after _          -> statement
}
```

Type list (no identifier)

Executes **`statement`** when visiting nodes of type **`T2`**, **`T3`**, or **`T4`**

Type Lists and Wildcards

```
visitor {
   before id:T     -> statement
   after T2,T3,T4  -> statement
   after _         -> statement
}
```

Wildcard (no identifier)

Executes **`statement`** for any node not already listed in another similar clause (e.g., T but not T2/T3/T4)

Provides ***default*** behavior

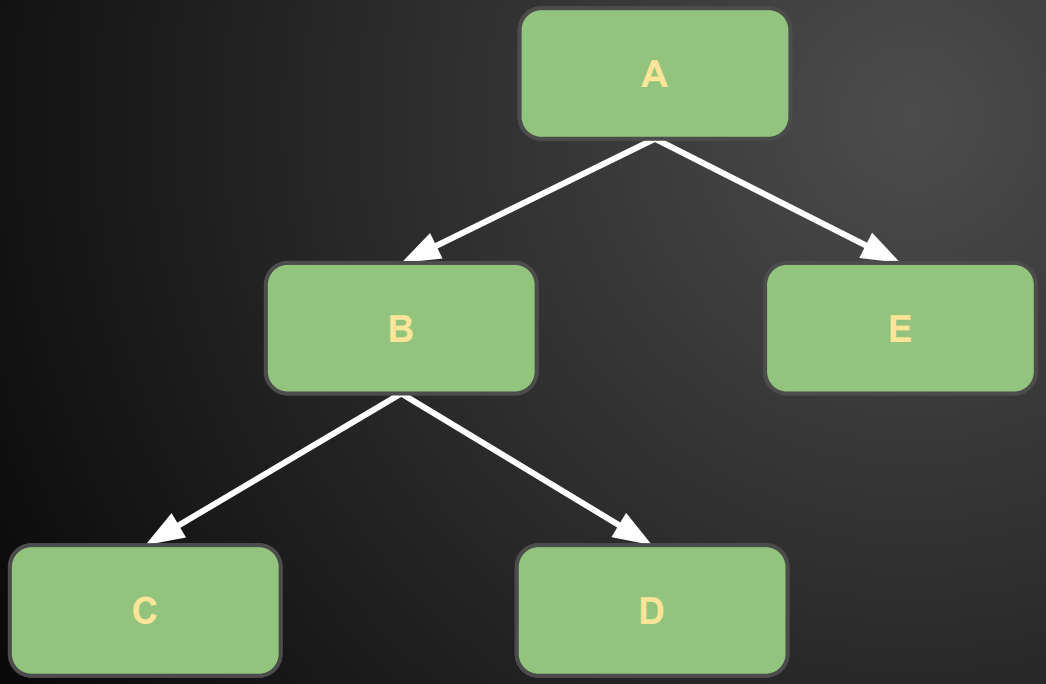
Type Lists and Wildcards

```
visitor {
   before id:T     -> statement
   after T2,T3,T4  -> statement
   after _         -> statement
}
```

Types can be matched by **at most 1 *before* clause** and **at most 1 *after* clause**

Custom Traversals

A -> E -> B -> C -> D




```
before n: A -> {
   visit(n.E);
   visit(n.B);
   stop;
}
```

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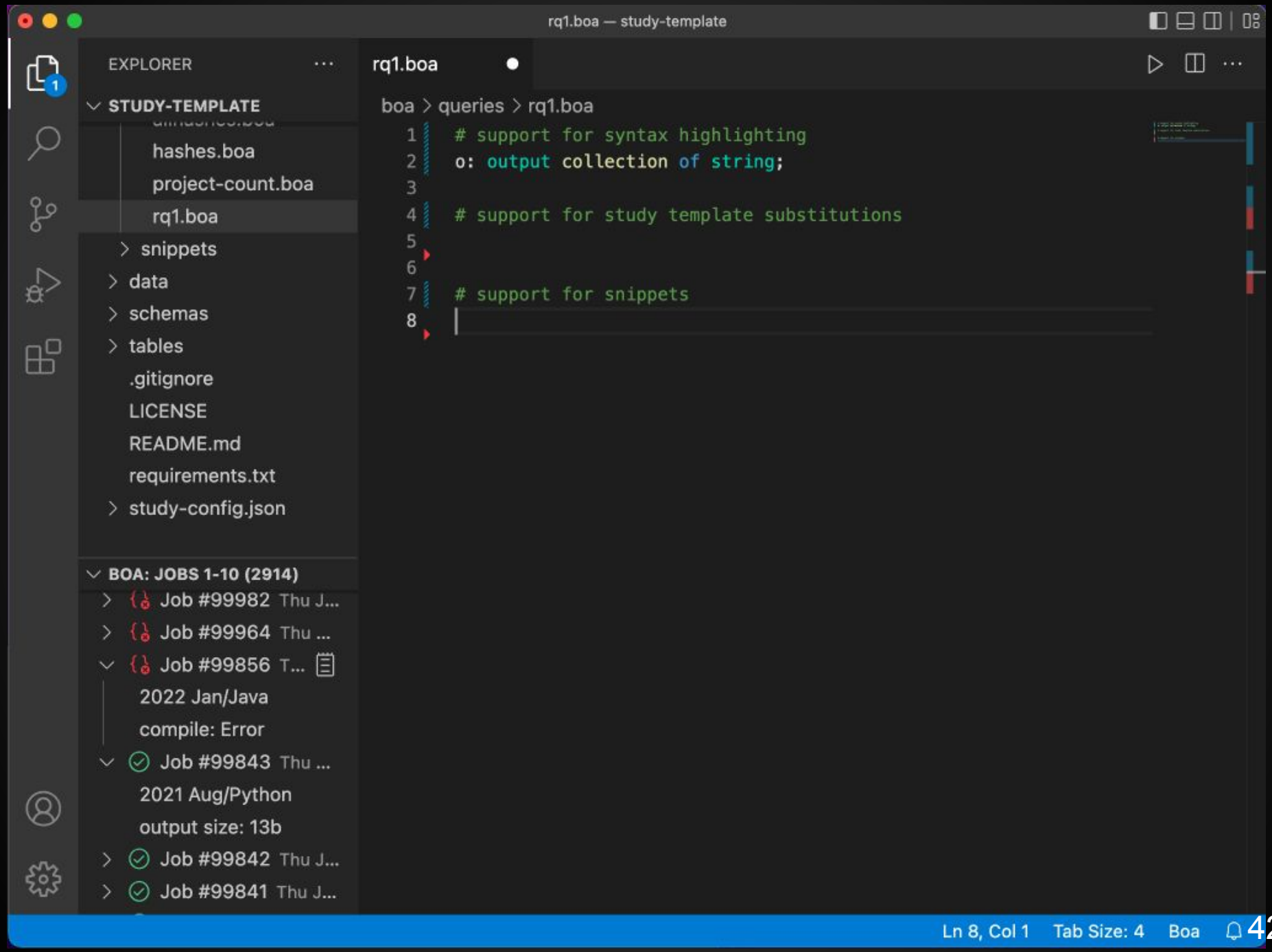
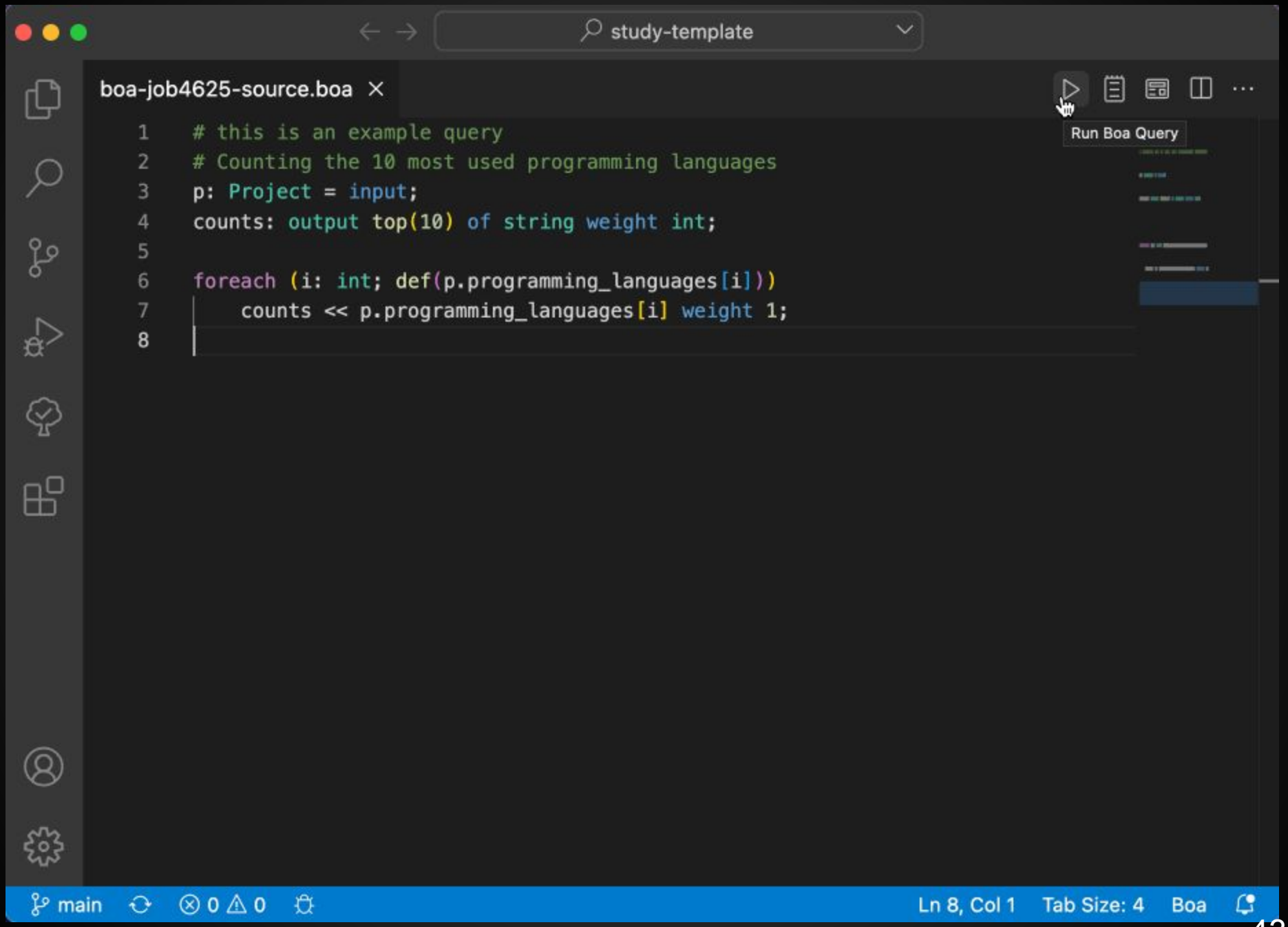
Install the Boa VS Code Extension

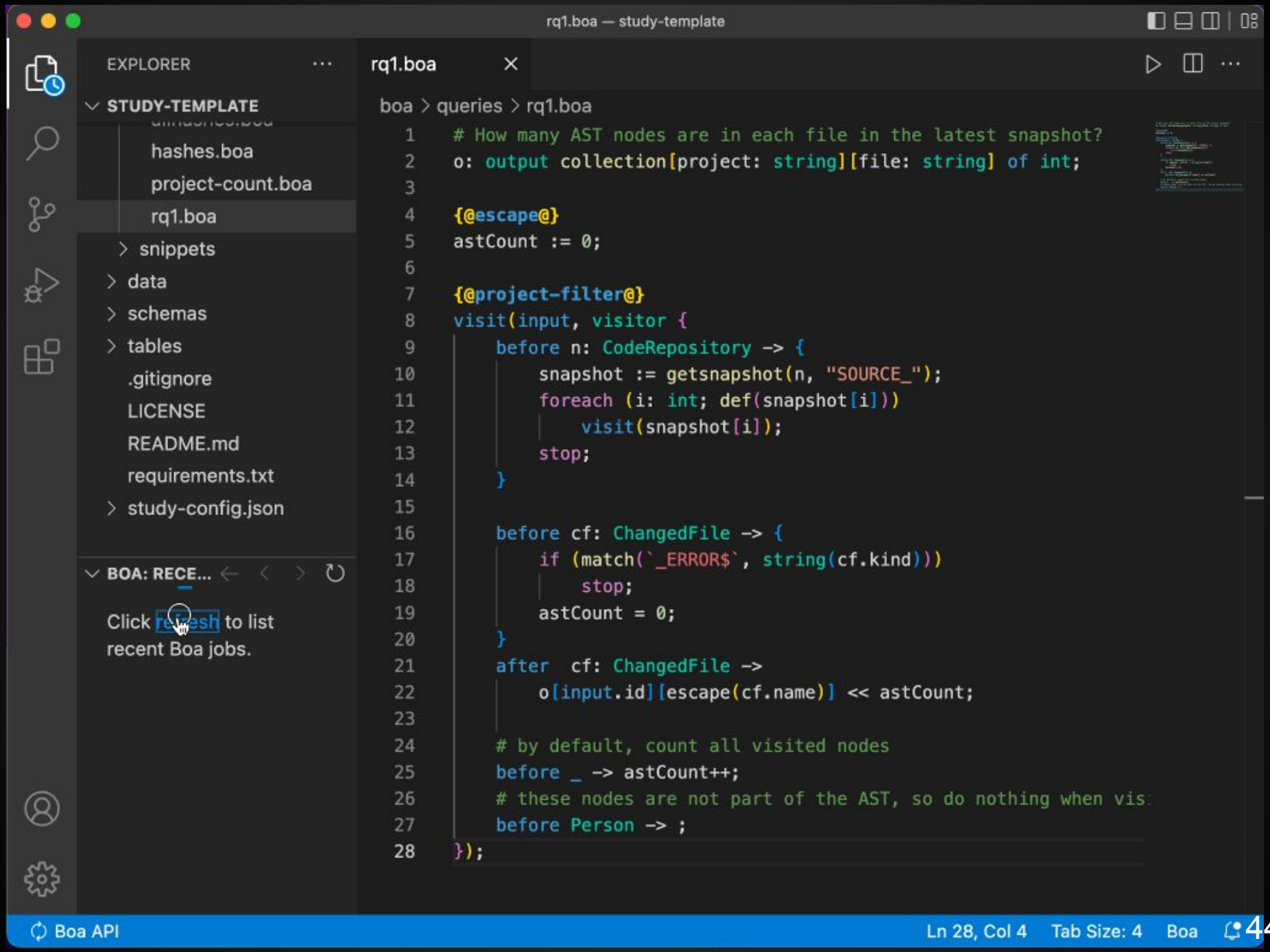
https://go.unl.edu/vscode

https://go.unl.edu/boa-vscode

NOTE: If you are having problems, Sam will be around to try and help.


rq1.boa — study-template
EXPLORER
rq1.boa
STUDY-TEMPLATE
hashes.boa
project-count.boa
rq1.boa
snippets
data
schemas
tables
.gitignore
LICENSE
README.md
requirements.txt
study-config.json
BOA: JOBS 1-10 (2914)
Job #99982 Thu J...
Job #99964 Thu ...
Job #99856 T...
2022 Jan/Java
compile: Error
Job #99843 Thu ...
2021 Aug/Python
output size: 13b
Job #99842 Thu J...
Job #99841 Thu J...
boa > queries > rq1.boa
1 # support for syntax highlighting
2 o: output collection of string;
3
4 # support for study template substitutions
5
6
7 # support for snippets
8
Ln 8, Col 1
Tab Size: 4
Boa


study-template
boa-job4625-source.boa
Run Boa Query
1 # this is an example query
2 # Counting the 10 most used programming languages
3 p: Project = input;
4 counts: output top(10) of string weight int;
5
6 foreach (i: int; def(p.programming_languages[i]))
7 counts << p.programming_languages[i] weight 1;
8
main
0 0
Ln 8, Col 1
Tab Size: 4
Boa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EXPLORER
STUDY-TEMPLATE
hashes.boa
project-count.boa
rq1.boa
snippets
data
schemas
tables
.gitignore
LICENSE
README.md
requirements.txt
study-config.json
BOA: RECE...
Click refresh to list recent Boa jobs.
rq1.boa
boa > queries > rq1.boa
1 # How many AST nodes are in each file in the latest snapshot?
2 o: output collection[project: string][file: string] of int;
3
4 {@escape@}
5 astCount := 0;
6
7 {@project-filter@}
8 visit(input, visitor {
9 before n: CodeRepository -> {
10 snapshot := getsnapshot(n, "SOURCE_");
11 foreach (i: int; def(snapshot[i]))
12 visit(snapshot[i]);
13 stop;
14 }
15
16 before cf: ChangedFile -> {
17 if (match(`_ERROR$`, string(cf.kind)))
18 stop;
19 astCount = 0;
20 }
21 after cf: ChangedFile ->
22 o[input.id][escape(cf.name)] << astCount;
23
24 # by default, count all visited nodes
25 before _ -> astCount++;
26 # these nodes are not part of the AST, so do nothing when vis
27 before Person -> ;
28 });
Boa API
Ln 28, Col 4
Tab Size: 4
Boa
44

<<demo>>

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5:30 Finished

Putting it all together

(running the motivating example)

http://boa.cs.iastate.edu/

Install the Boa VS Code Extension

https://go.unl.edu/vscode

https://go.unl.edu/boa-vscode

NOTE: If you are having problems, Sam will be around to try and help.

Authentication to Boa

- IDE will ask for user/pw

- Also needed in `.env`:

```
BOA_API_USER='USERNAME_HERE'
BOA_API_PW='PASSWORD_HERE'
```

- Can also use system keychain for the password - just add the user to your .env

Install Necessary Python Modules

Run:

```
pip3 install -r requirements.txt
```

in the tutorial directory.

If you have issues, let us know, we have a Docker-based option available.

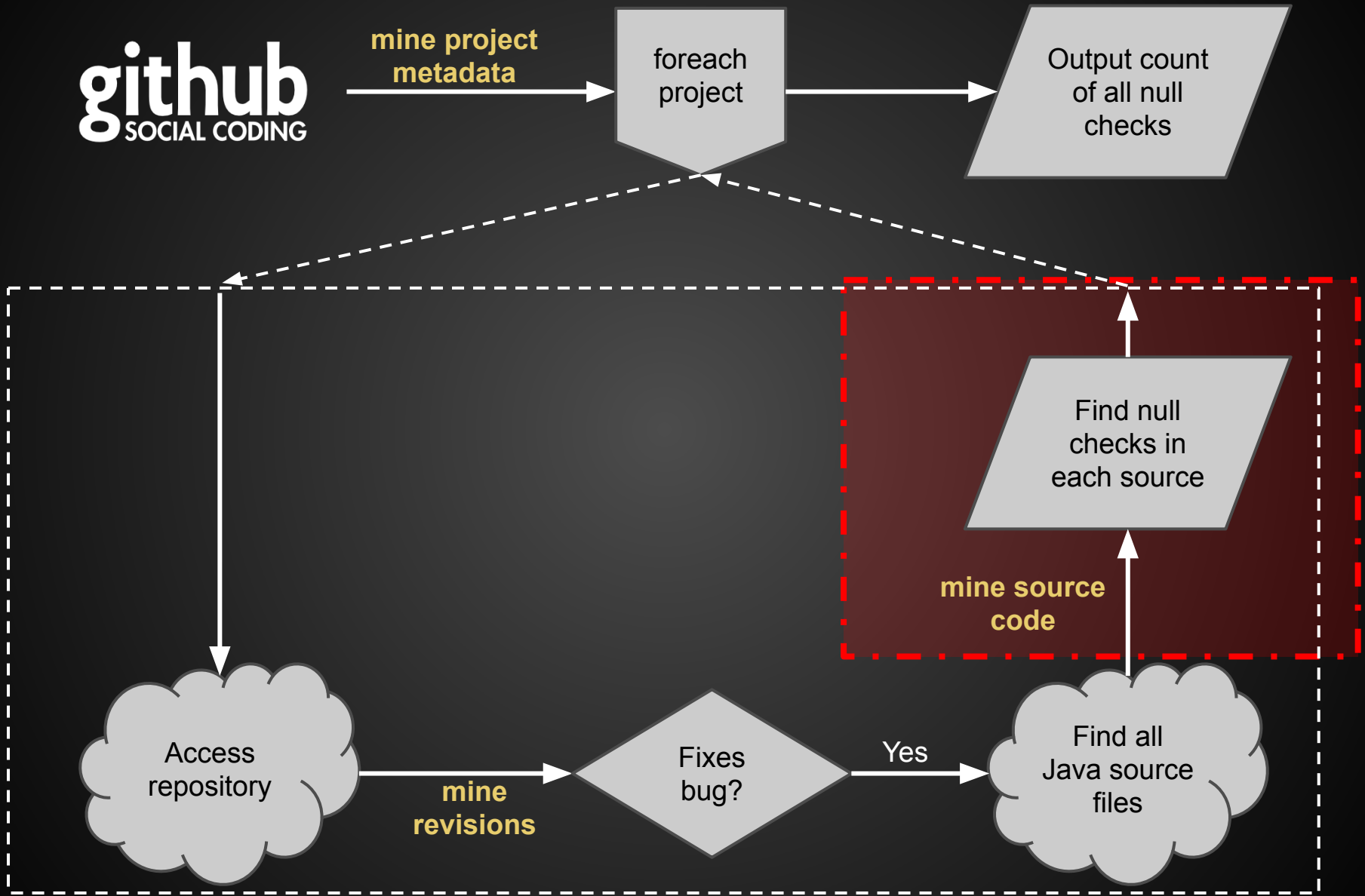
Hands-on Task 0

Open the files “boa/queries/task0/part1.boa”
and “boa/queries/task0/part2.boa”

We will use these files for the first activity

Recall the task is to answer

"*How many bug fixes add checks for null?*"


github
SOCIAL CODING
mine project metadata
foreach project
Output count of all null checks
Find null checks in each source
mine source code
Access repository
mine revisions
Fixes bug?
Yes
Find all Java source files

Step 1: Declare input and visitor

```
p: Project = input;

    visitor {

    };
```

Step 2: Finding null checks

```
p: Project = input;

    visitor {
        # look for expressions of the form:
        #   null == expr OR expr == null
        #   null != expr OR expr != null

    };
```

Step 2: Finding null checks

```
p: Project = input;


    visitor {
        # look for expressions of the form:
        #    null == expr OR expr == null
        #    null != expr OR expr != null
        before exp: Expression ->


    };
```

Step 2: Finding null checks

```
p: Project = input;



    visitor {
        # look for expressions of the form:
        #    null == expr OR expr == null
        #    null != expr OR expr != null
        before exp: Expression ->
            if (exp.kind == ExpressionKind.EQ || exp.kind == ExpressionKind.NEQ)


    };
```

Step 2: Finding null checks

```
p: Project = input;



    visitor {
        # look for expressions of the form:
        #    null == expr OR expr == null
        #    null != expr OR expr != null
        before exp: Expression ->
            if (exp.kind == ExpressionKind.EQ || exp.kind == ExpressionKind.NEQ)
                exists (i: int; isliteral(exp.expressions[i], "null"))

    };
```

Step 3: Output null checks count

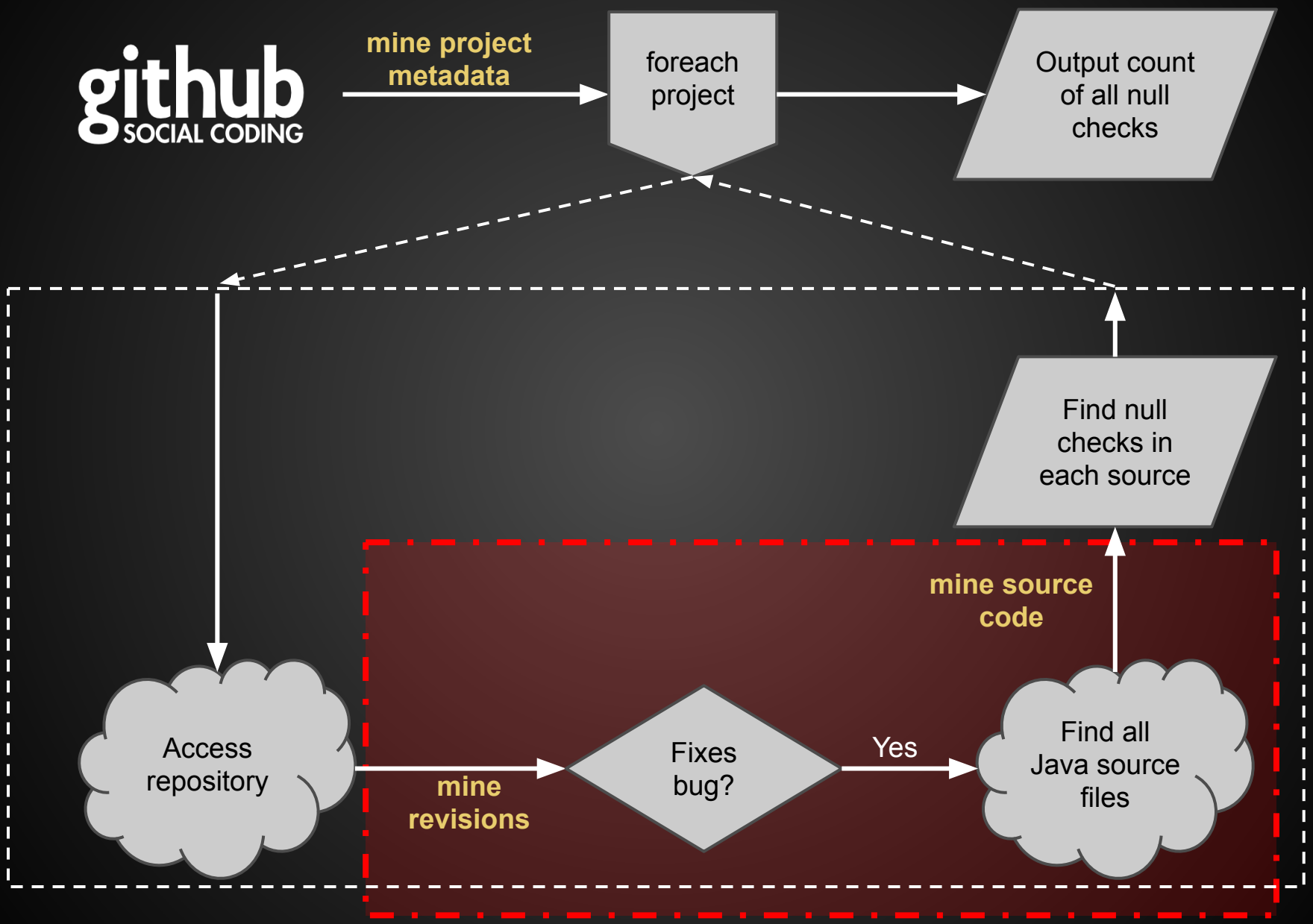
```
p: Project = input;
NullChecks: output sum of int;


    visitor {
        # look for expressions of the form:
        #    null == expr OR expr == null
        #    null != expr OR expr != null
        before exp: Expression ->
            if (exp.kind == ExpressionKind.EQ || exp.kind ==
ExpressionKind.NEQ)
                exists (i: int; isliteral(exp.expressions[i], "null"))
                    NullChecks << 1;
    };
```

Step 4: Name and call the visitor

```
p: Project = input;
NullChecks: output sum of int;

nullCheckVisitor :=
    visitor {
        # look for expressions of the form:
        #   null == expr OR expr == null
        #   null != expr OR expr != null
        before exp: Expression ->
            if (exp.kind == ExpressionKind.EQ || exp.kind ==
ExpressionKind.NEQ)
                exists (i: int; isliteral(exp.expressions[i], "null"))
                    NullChecks << 1;
    };

visit(p, nullCheckVisitor);
```

Let's see it in action!

```
p: Project = input;
NullChecks: output sum of int;

nullCheckVisitor :=
    visitor {
        # look for expressions of the form:
        #    null == expr OR expr == null
        #    null != expr OR expr != null
        before exp: Expression ->
            if (exp.kind == ExpressionKind.EQ || exp.kind == ExpressionKind.NEQ)
                exists (i: int; isliteral(exp.expressions[i], "null"))
                    NullChecks << 1;
    };

visit(p, nullCheckVisitor);
```


github
SOCIAL CODING
mine project metadata
foreach project
Output count of all null checks
Find null checks in each source
mine source code
Access repository
mine revisions
Fixes bug?
Yes
Find all Java source files

Recall the visitor

```
nullCheckVisitor :=
                                visitor {
                    # look for expressions of the form:
                    #    null == expr OR expr == null
                    #    null != expr OR expr != null
                    before exp: Expression ->
                        if (exp.kind == ExpressionKind.EQ
                                || exp.kind == ExpressionKind.NEQ)
                            exists (i: int; isliteral(exp.expressions[i], "null"))
                                NullChecks << 1;
                }
```

Step 5: Make visitor more specific

```
nullCheckVisitor := visitor {
    before stmt: Statement ->
        # increase the counter if there is an IF statement
        if (stmt.kind == StatementKind.IF)
            visit(stmt.expression, visitor {
                # where the boolean condition is of the form:
                #    null == expr OR expr == null
                #    null != expr OR expr != null
                before exp: Expression ->
                    if (exp.kind == ExpressionKind.EQ
                            || exp.kind == ExpressionKind.NEQ)
                        exists (i: int; isliteral(exp.expressions[i], "null"))
                            NullChecks << 1;
            });
};
```

Step 6: Make visitor reusable

```
count := 0;
nullCheckVisitor := visitor {
    before stmt: Statement ->
        # increase the counter if there is an IF statement
        if (stmt.kind == StatementKind.IF)
            visit(stmt.expression, visitor {
                # where the boolean condition is of the form:
                #   null == expr OR expr == null
                #   null != expr OR expr != null
                before exp: Expression ->
                    if (exp.kind == ExpressionKind.EQ
                            || exp.kind == ExpressionKind.NEQ)
                        exists (i: int; isliteral(exp.expressions[i], "null"))
                            count++;
            });
};
```

Step 7: Visitor to compare revisions

```
files: map[string] of ChangedFile;

visit(p, visitor {
    before cf: ChangedFile -> {
        if (haskey(files, cf.name)                                    )
            analysis(cf, files[cf.name]); # TODO

        if (cf.change == ChangeKind.DELETED)
            remove(files, cf.name);
        else
            files[cf.name] = cf;
        stop;
    }
});
```

Step 8: Check for bug fixes

```
files: map[string] of ChangedFile;

visit(p, visitor {
    before cf: ChangedFile -> {
        if (haskey(files, cf.name)  && isfixingrevision(current(Revision).log))
            analysis(cf, files[cf.name]); # TODO

        if (cf.change == ChangeKind.DELETED)
            remove(files, cf.name);
        else
            files[cf.name] = cf;
        stop;
    }
});
```

Step 9: Define the analysis

```
analysis := function(cf: ChangedFile, prevCf: ChangedFile) {
    # count how many null checks were previously in the file
    count = 0;
    visit(prevCf, nullCheckVisitor);
    last := count;

    # count how many null checks are currently in the file
    count = 0;
    visit(cf, nullCheckVisitor);

    # if there are more null checks, output
    if (count > last)
        NullChecks << 1;
};
```

This solves the ENTIRE task!

Let’s see it in action!

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3:30 Break (30 mins)

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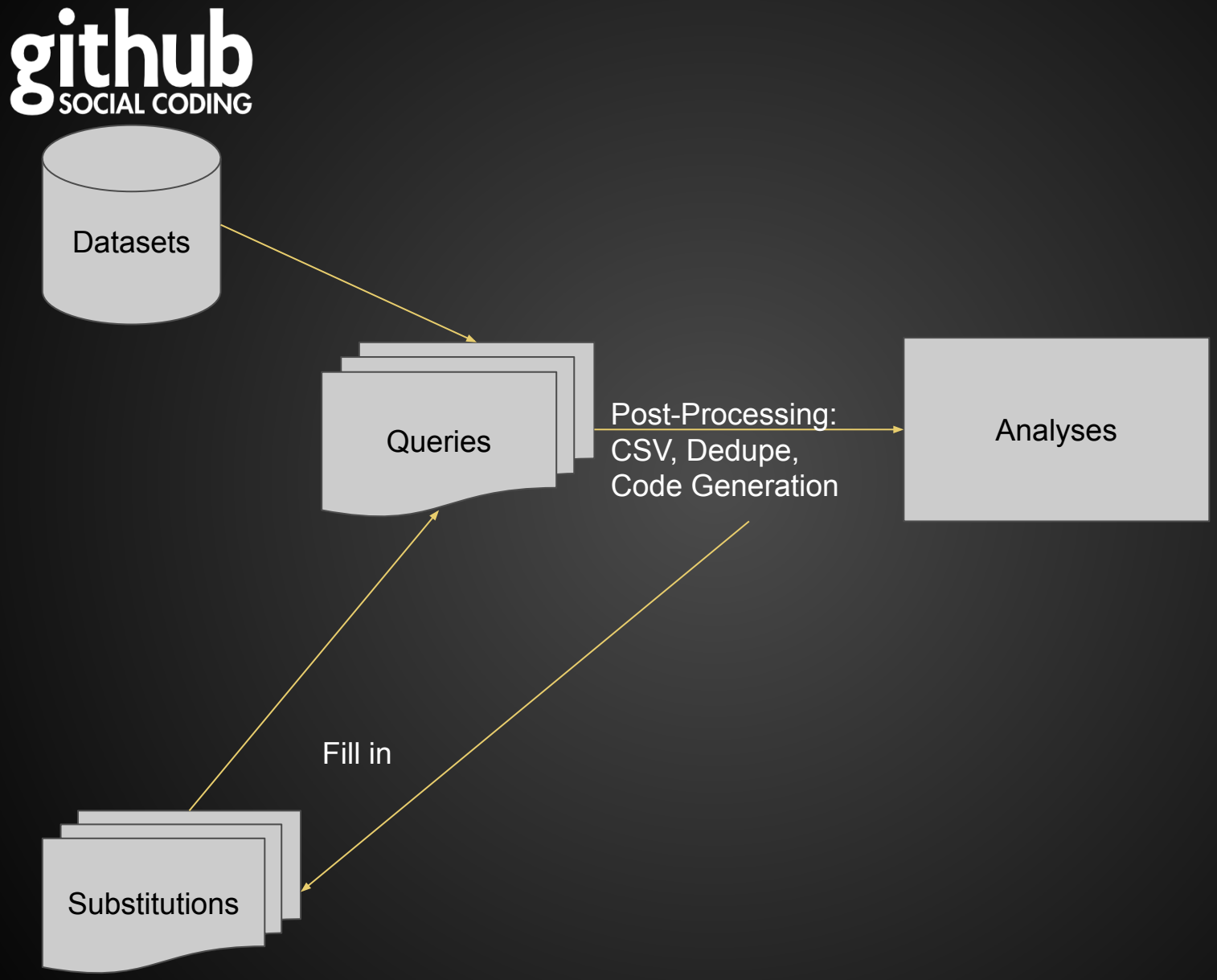
5:15 Publishing Replication Packages (15 mins) (RD)
5:30 Finished

Code from Task 0 looked different

It has `{@findNullExps@}` instead of a visitor

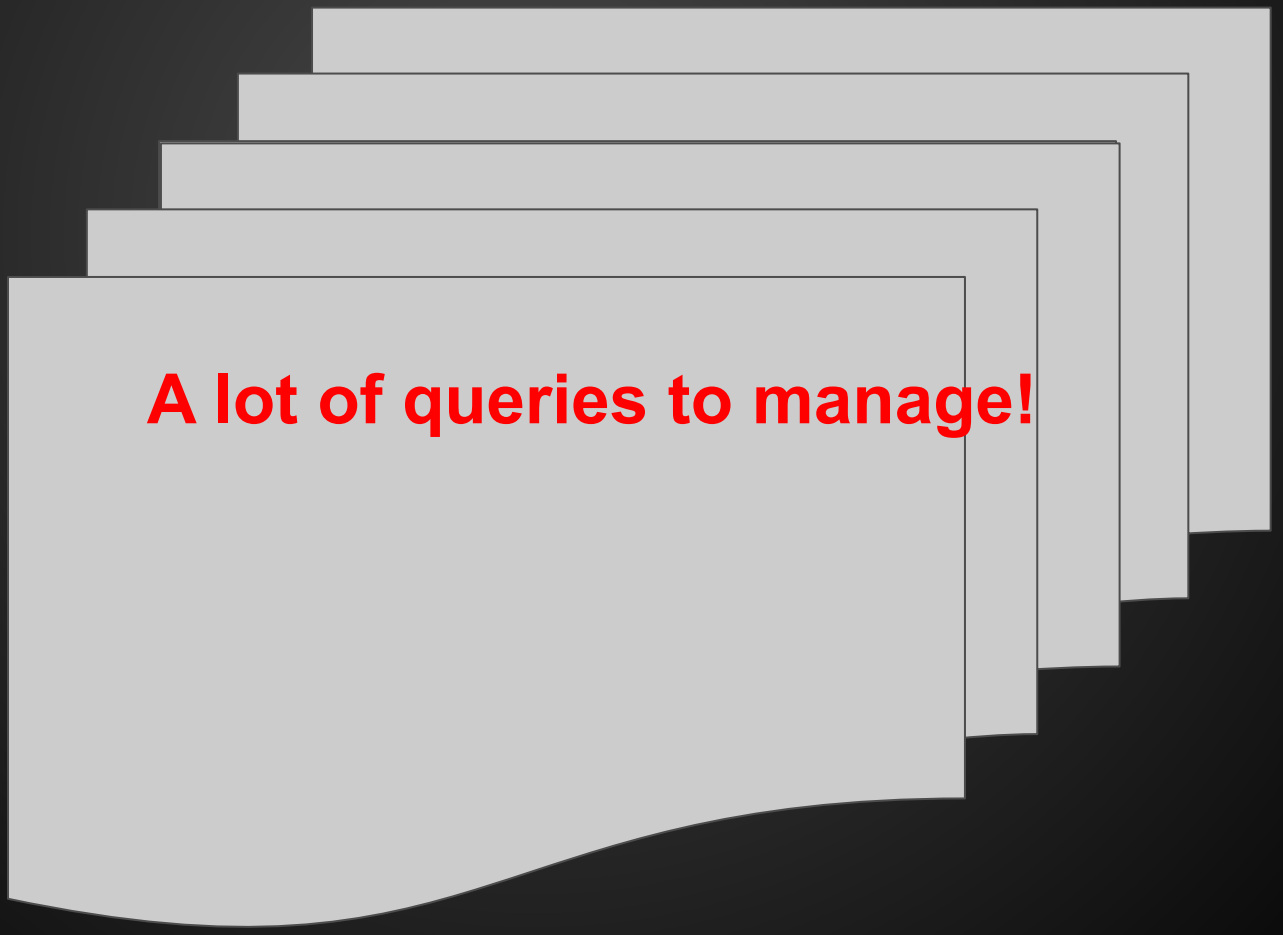
```
p: Project = input;
NullChecks: output sum of int;

nullCheckVisitor := {@findNullExps@};

visit(p, nullCheckVisitor);
```

That's a *substitution* from the study template


github
SOCIAL CODING
Datasets
Queries
Post-Processing:
CSV, Dedupe,
Code Generation
Analyses
Fill in
Substitutions

Research is more than one question!

And questions can require multiple queries.



Queries have common elements

Enter Substitutions!

```
p: Project = input;
NullChecks: output sum of int;

nullCheckVisitor := {@findNullExps@};

visit(p, nullCheckVisitor);
```

- Reuse code and avoid copying
- Declared in `study-config.json`

Boa Output is an unusual format

```
o[1168615][src/java/Foo/Bar.java] = 7
…
```

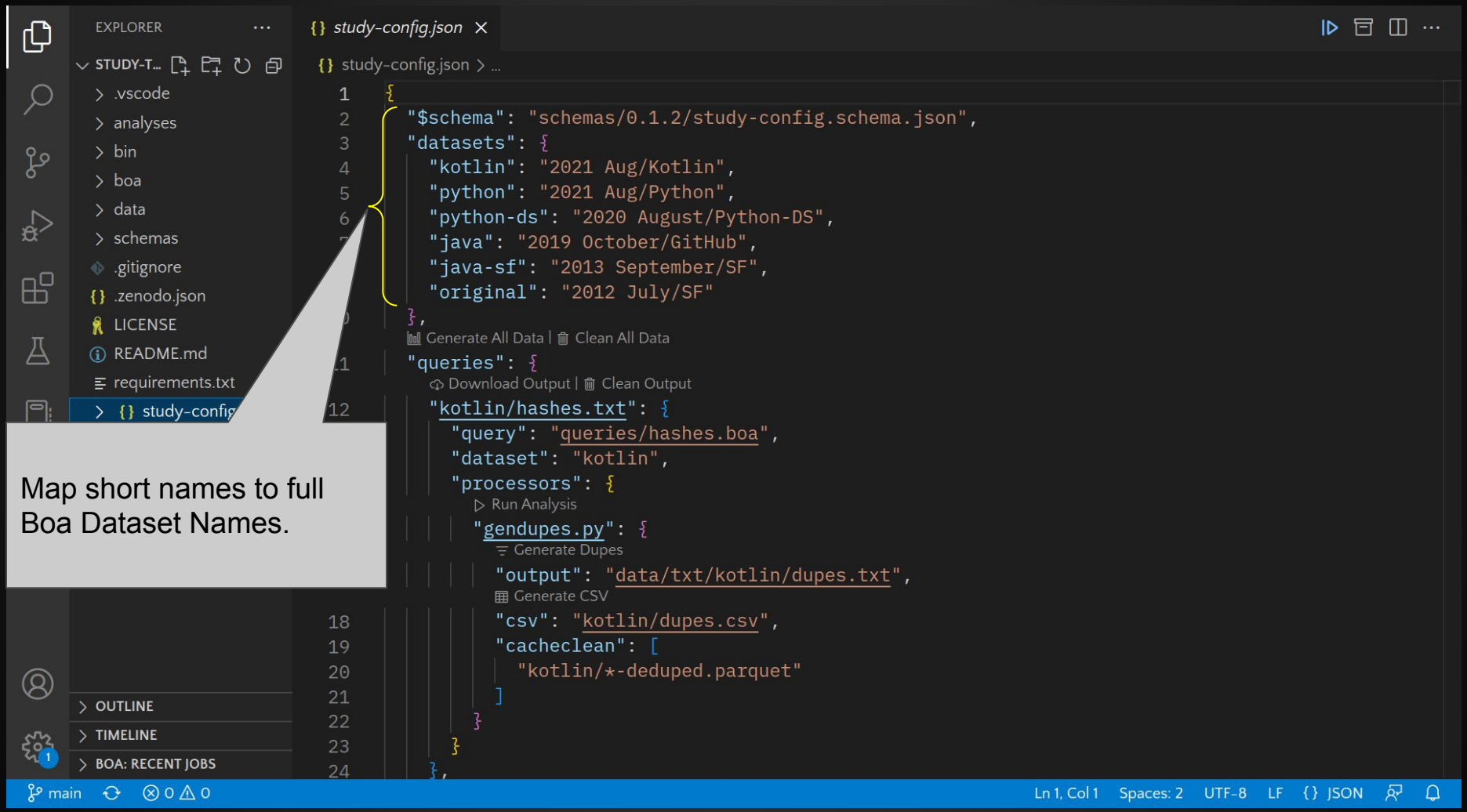
Conversion to CSV possible, as are other post-processing steps.

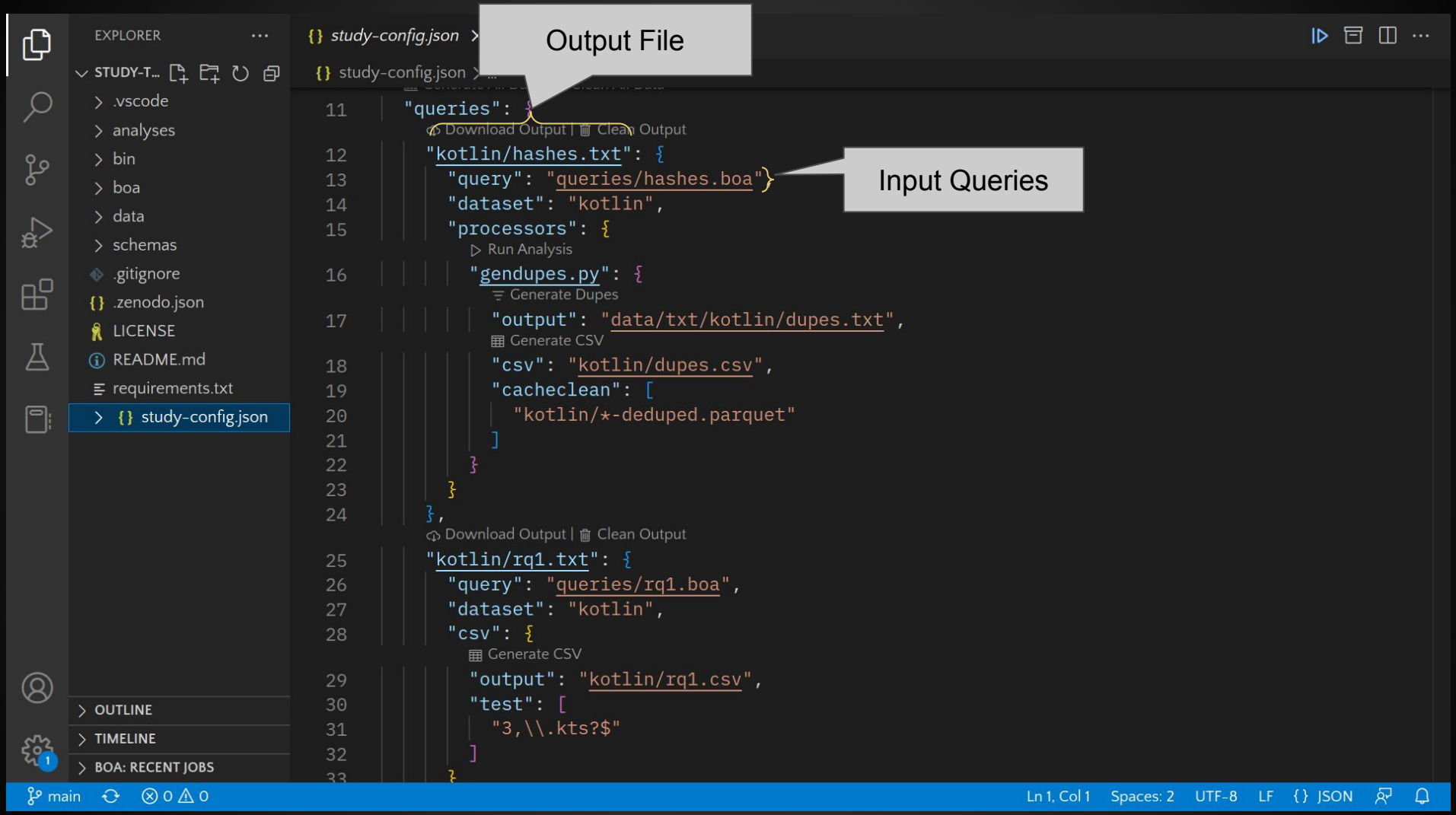
Controlled through `study-config.json`

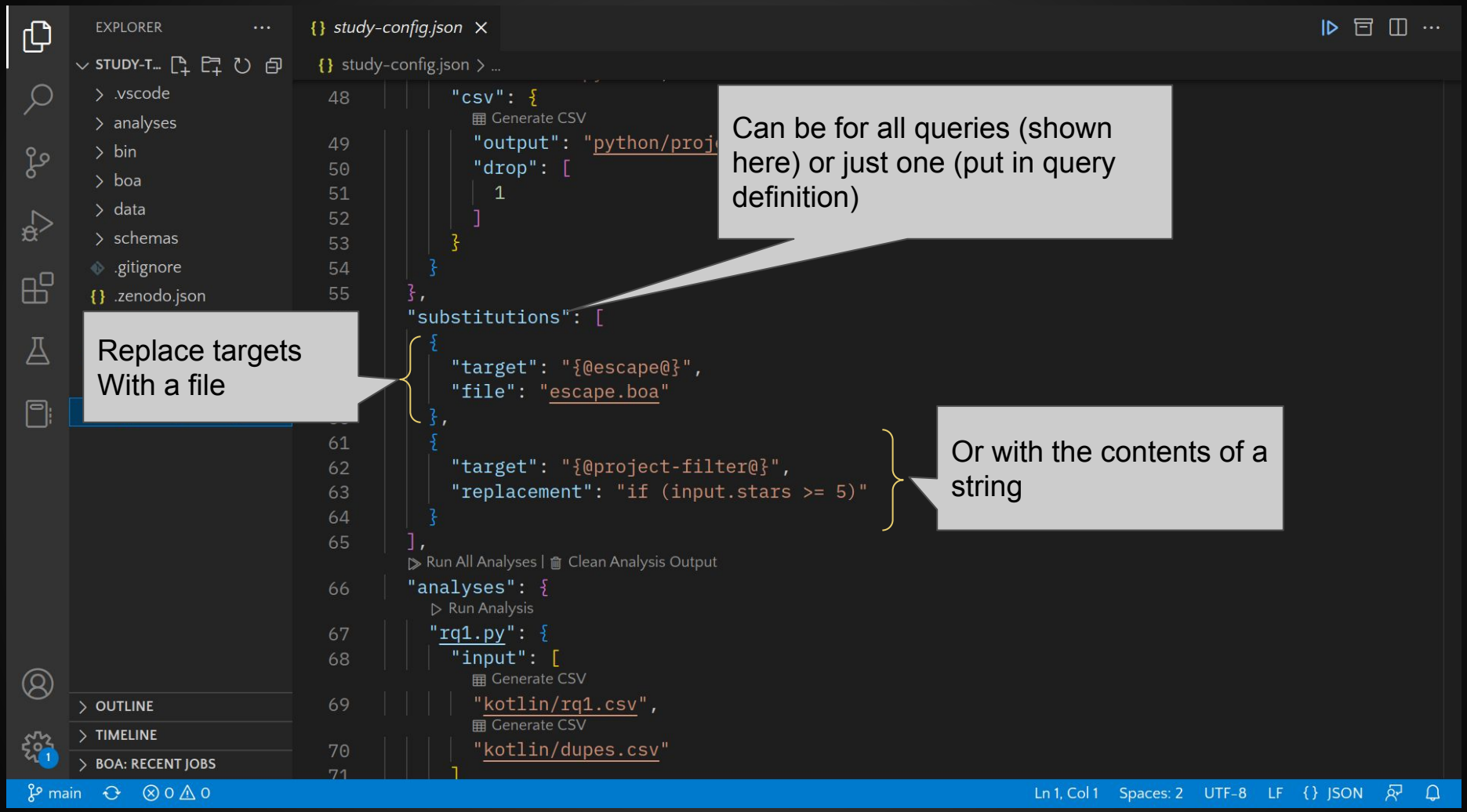
`study-config.json`?

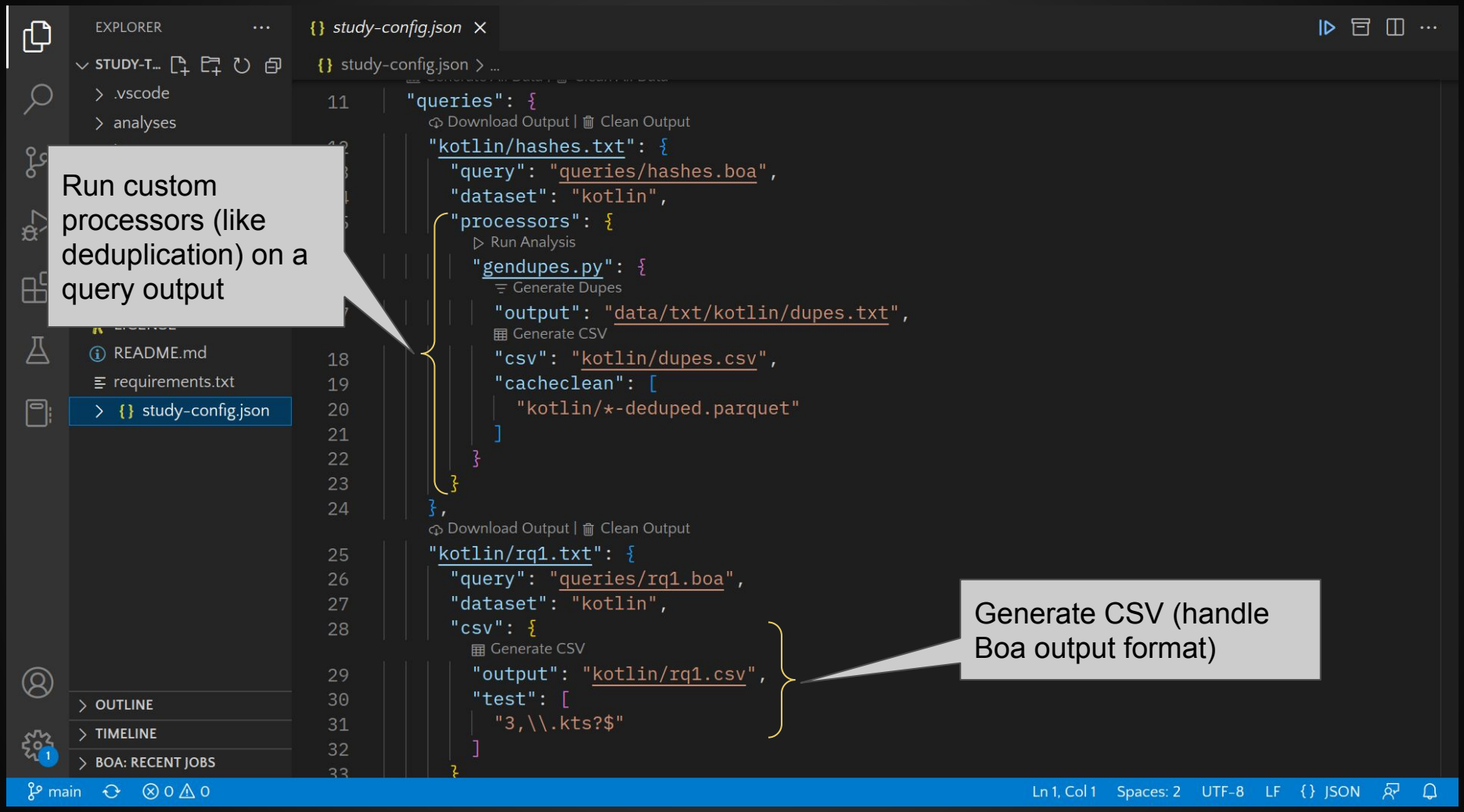
- Every stage/part of the study
- The “core” of the template

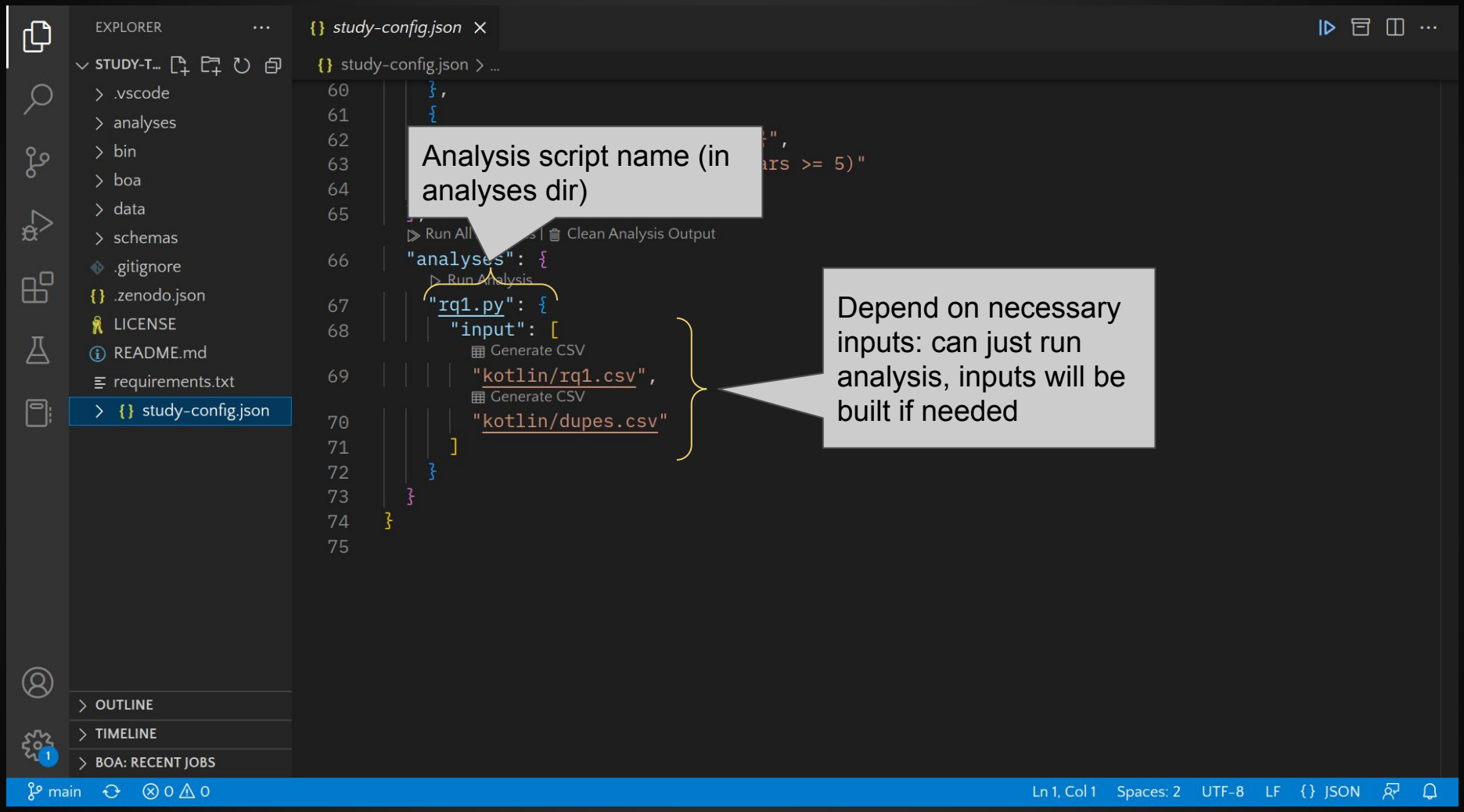
Let’s take a look.


EXPLORER
study-config.json
STUDY-T...
.vscode
analyses
bin
boa
data
schemas
.gitignore
.zenodo.json
LICENSE
README.md
requirements.txt
study-config
OUTLINE
TIMELINE
BOA: RECENT JOBS
{
"$schema": "schemas/0.1.2/study-config.schema.json",
"datasets": {
"kotlin": "2021 Aug/Kotlin",
"python": "2021 Aug/Python",
"python-ds": "2020 August/Python-DS",
"java": "2019 October/GitHub",
"java-sf": "2013 September/SF",
"original": "2012 July/SF"
},
Generate All Data | Clean All Data
"queries": {
Download Output | Clean Output
"kotlin/hashes.txt": {
"query": "queries/hashes.boa",
"dataset": "kotlin",
"processors": {
Run Analysis
"gendupes.py": {
Generate Dupes
"output": "data/txt/kotlin/dupes.txt",
Generate CSV
"csv": "kotlin/dupes.csv",
"cacheclean": [
"kotlin/*-deduped.parquet"
]
}
}
},
Map short names to full Boa Dataset Names.
main
Ln 1, Col 1
Spaces: 2
UTF-8
LF
JSON


Output File
Input Queries
EXPLORER
STUDY-T...
.vscode
analyses
bin
boa
data
schemas
.gitignore
.zenodo.json
LICENSE
README.md
requirements.txt
study-config.json
OUTLINE
TIMELINE
BOA: RECENT JOBS
study-config.json
"queries": {
Download Output | Clean Output
"kotlin/hashes.txt": {
"query": "queries/hashes.boa"
"dataset": "kotlin",
"processors": {
Run Analysis
"gendupes.py": {
Generate Dupes
"output": "data/txt/kotlin/dupes.txt",
Generate CSV
"csv": "kotlin/dupes.csv",
"cacheclean": [
"kotlin/*-deduped.parquet"
]
}
}
},
Download Output | Clean Output
"kotlin/rq1.txt": {
"query": "queries/rq1.boa",
"dataset": "kotlin",
"csv": {
Generate CSV
"output": "kotlin/rq1.csv",
"test": [
"3,\\.kts?$"
]
main
Ln 1, Col 1
Spaces: 2
UTF-8
LF
JSON


EXPLORER
study-config.json
STUDY-T...
.vscode
analyses
bin
boa
data
schemas
.gitignore
.zenodo.json
OUTLINE
TIMELINE
BOA: RECENT JOBS
"csv": {
Generate CSV
"output": "python/proj
"drop": [
1
]
}
}
},
"substitutions": [
{
"target": "{@escape@}",
"file": "escape.boa"
},
{
"target": "{@project-filter@}",
"replacement": "if (input.stars >= 5)"
}
],
Run All Analyses | Clean Analysis Output
"analyses": {
Run Analysis
"rq1.py": {
"input": [
Generate CSV
"kotlin/rq1.csv",
Generate CSV
"kotlin/dupes.csv"
Can be for all queries (shown here) or just one (put in query definition)
Replace targets With a file
Or with the contents of a string
main
Ln 1, Col 1
Spaces: 2
UTF-8
LF
JSON


EXPLORER
study-config.json
STUDY-T...
.vscode
analyses
README.md
requirements.txt
study-config.json
OUTLINE
TIMELINE
BOA: RECENT JOBS
Run custom processors (like deduplication) on a query output
"queries": {
Download Output | Clean Output
"kotlin/hashes.txt": {
"query": "queries/hashes.boa",
"dataset": "kotlin",
"processors": {
Run Analysis
"gendupes.py": {
Generate Dupes
"output": "data/txt/kotlin/dupes.txt",
Generate CSV
"csv": "kotlin/dupes.csv",
"cacheclean": [
"kotlin/*-deduped.parquet"
]
}
}
},
Download Output | Clean Output
"kotlin/rq1.txt": {
"query": "queries/rq1.boa",
"dataset": "kotlin",
"csv": {
Generate CSV
"output": "kotlin/rq1.csv",
"test": [
"3,\\.kts?$"
]
Generate CSV (handle Boa output format)
main
Ln 1, Col 1
Spaces: 2
UTF-8
LF
JSON


EXPLORER
study-config.json
STUDY-T...
.vscode
analyses
bin
boa
data
schemas
.gitignore
.zenodo.json
LICENSE
README.md
requirements.txt
study-config.json
OUTLINE
TIMELINE
BOA: RECENT JOBS
Analysis script name (in analyses dir)
Depend on necessary inputs: can just run analysis, inputs will be built if needed
Run All
Clean Analysis Output
Run Analysis
Generate CSV
Generate CSV
"analyses": {
"rq1.py": {
"input": [
"kotlin/rq1.csv",
"kotlin/dupes.csv"
]
}
}
}
main
Ln 1, Col 1
Spaces: 2
UTF-8
LF
JSON

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5:30 Finished

Hands-on Task 1

Open the file “boa/queries/task1/part1.boa”

This query looks at commit timestamps and finds ones that are suspiciously old (older than the date CVS was released).

Looking for Suspicious Commits

```
    # output a list of timestamps found
P: output collection[projUrl: string][revId: string] of time;
                        # indexed by project URL and commit hash
visit(input, visitor {
    # look at each revision node
    before r: Revision ->
        # is the commit date old?
        if (r.commit_date < T"November 19, 1990, 00:00:00 AM UTC")
            # output what we found
            P[input.project_url][r.id] << r.commit_date;
});
```

DOWNLOAD THE TASK1/PART1.TXT OUTPUT

Why is there no output?

Answer: Because the small dataset has no commits with suspiciously old timestamps!

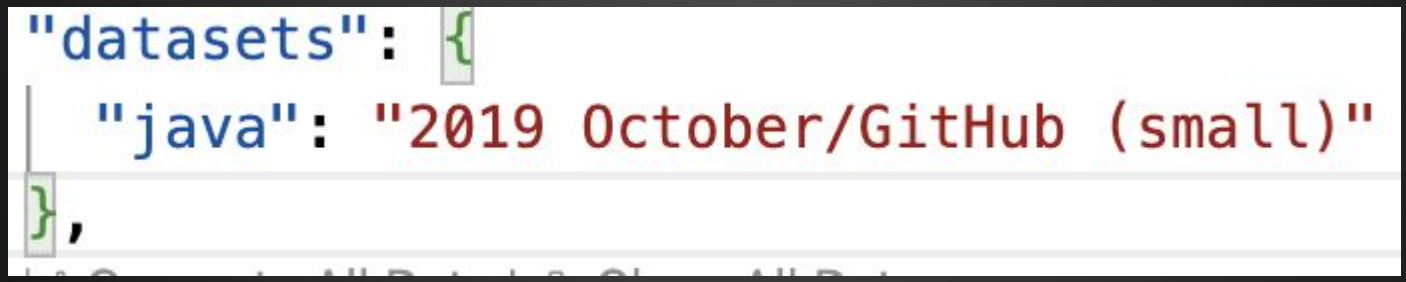
Let's modify the study-config.json file and add a second dataset:

"2019 October/GitHub (medium)"

and then re-run the analysis using that new dataset.

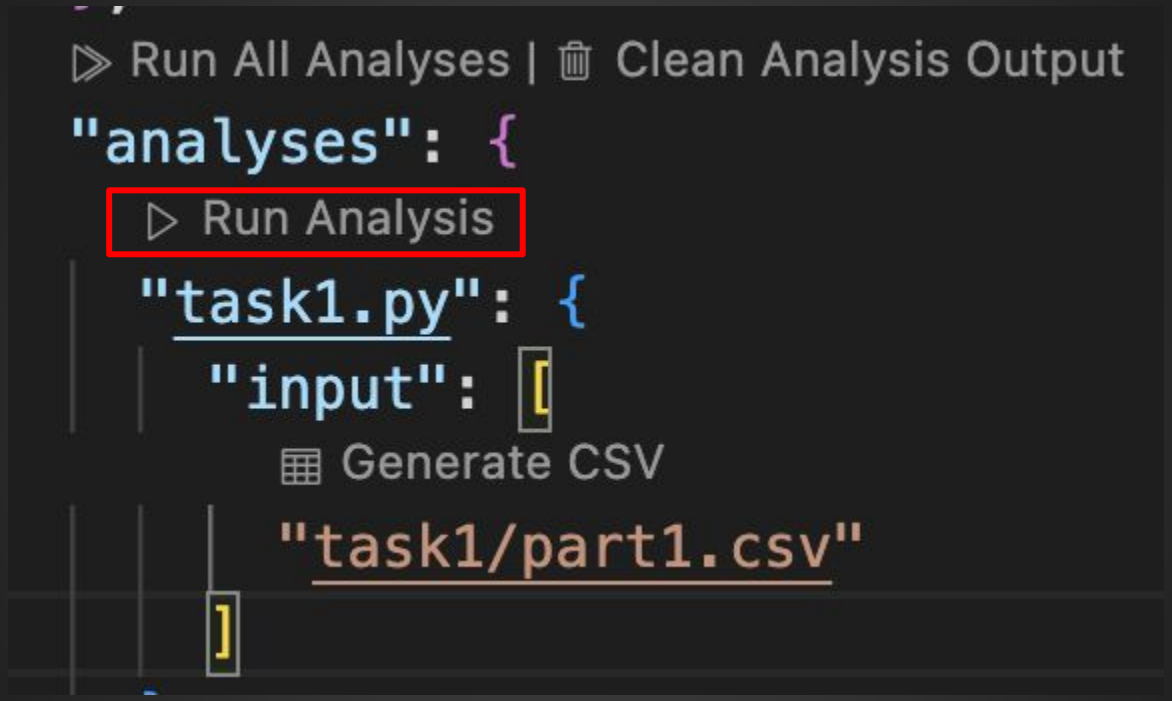
Edit study-config.json

1) Add a new dataset. Datasets can have any name (the key), but must have specific values. The IDE should autocomplete values for you.



2) Modify the output file for Task 1 so it uses the new dataset you specified.

Now that it runs, analyze it!



Look for the generated outputs in tables/ and figures/

Hands-on Task 1, Part 2

Make a copy of the task1/part1.boa file.

Be sure to add the new query to your study-config.json!

Now edit the query so it only looks at commits containing ***at least one source file.***

Hands-on Task 1, Part 2: Hints

1. Hint: is there a domain-specific function to determine if a file is a specific kind?

2. Hint: can you **quantify** if such a file **exists** in a Revision?

Hands-on Task 1, Part 2: Solution

```
P: output collection[projUrl: string][revId: string] of time;

visit(input, visitor {
   before r: Revision ->
       exists (i: int; iskind("SOURCE_", r.files[i].kind))
           if (r.commit_date < T"November 19, 1990, 00:00:00 AM UTC")
               P[input.project_url][r.id] << r.commit_date;
});
```

Task 1 Solution

https://go.unl.edu/fse-task1

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3:30 Break (30 mins)

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4:30 Hands-on Task 3: Analyzing Boa Outputs with Pandas (45 mins)

5:15 Publishing Replication Packages (15 mins) (RD)

5:30 Finished

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5:30 Finished

Hands-on Task 2

Open the file “boa/queries/task2/task2.boa”

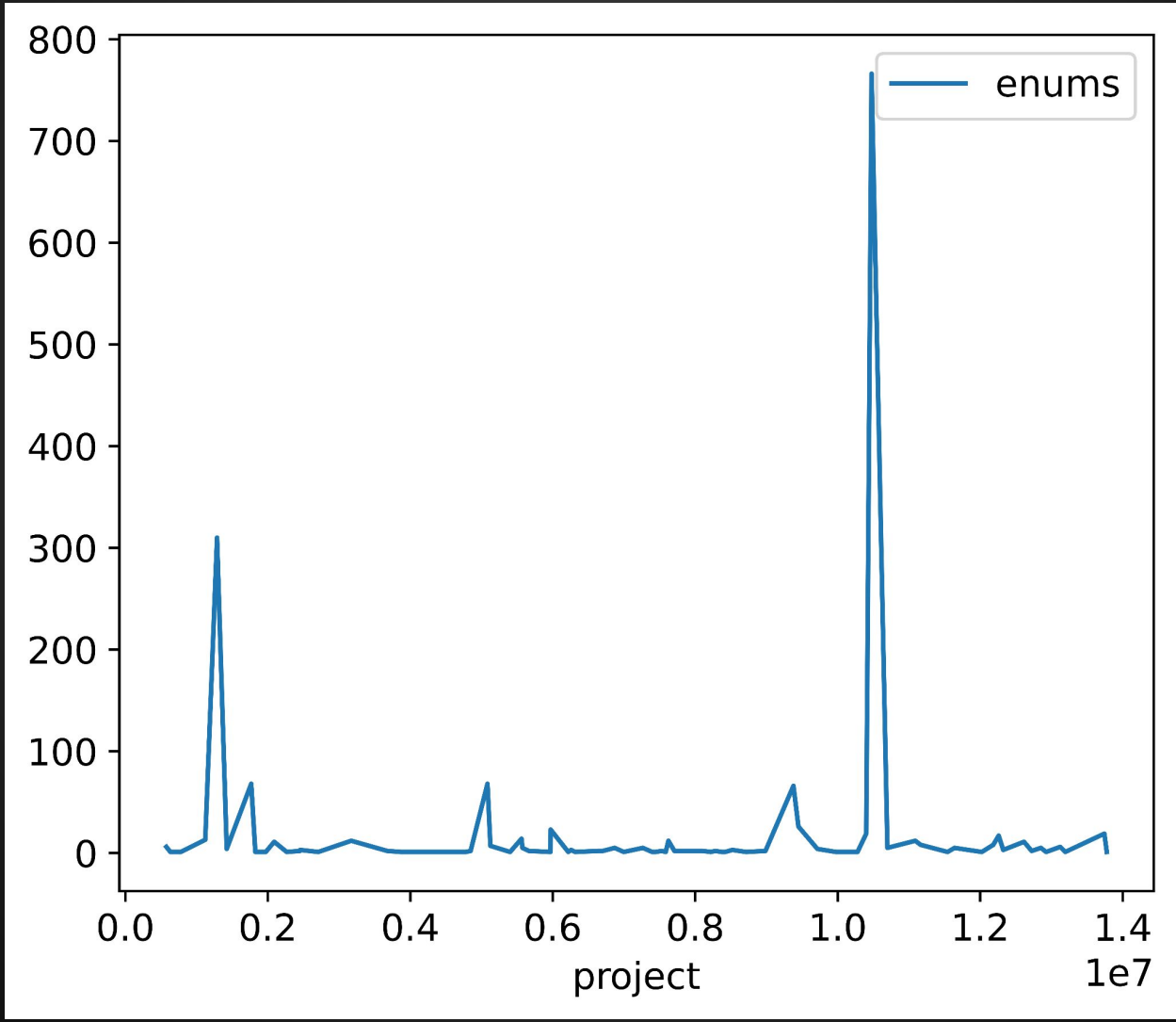
Open the file “analyses/task2.py”

The goal of this research question is to see how often Java projects declare enum types. Here we provide the analysis, but you need to write the query.

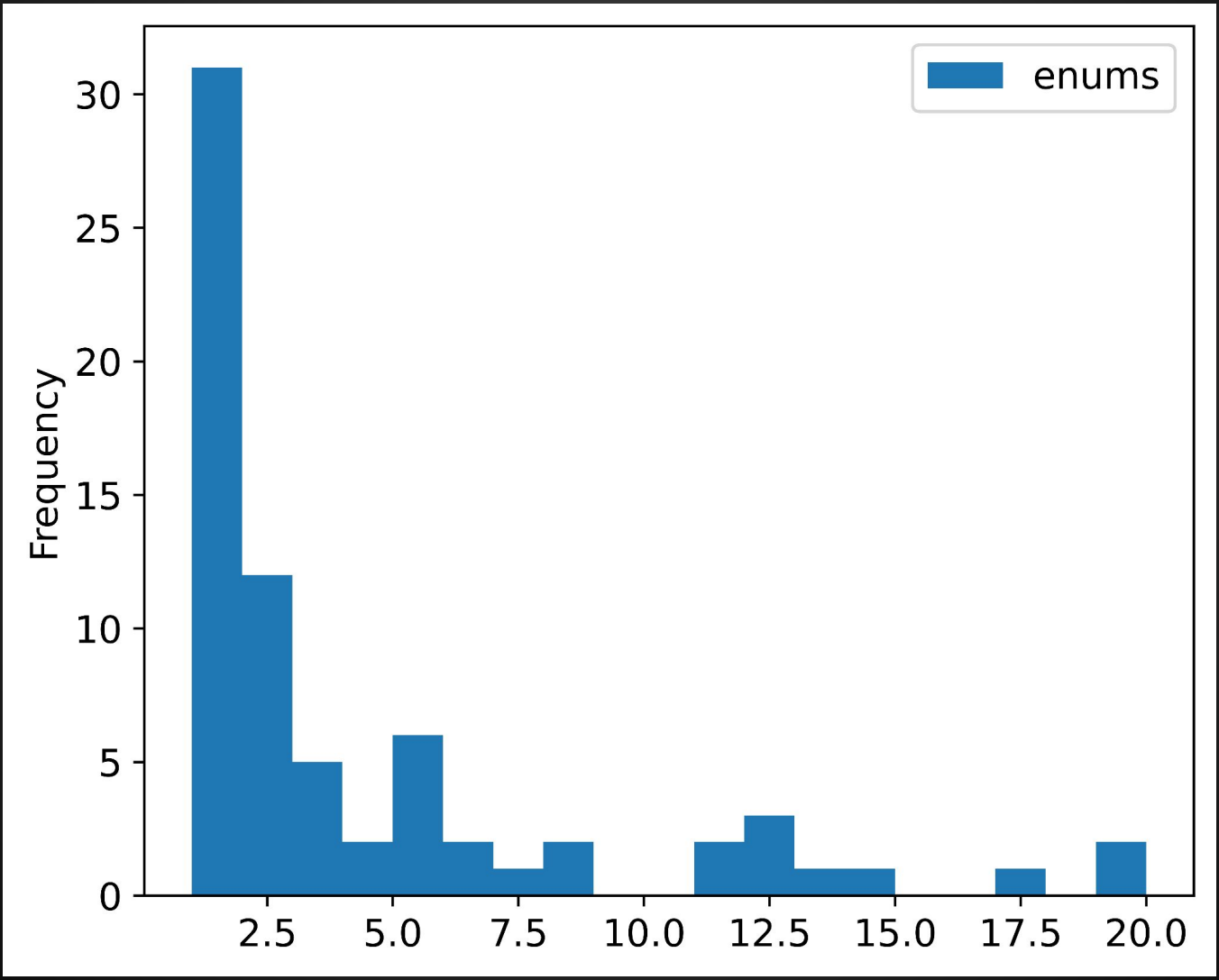
Hands-on Task 2: Expected Output

```
\begin{tabular}{lr}
                  & \textbf{enums} \\
  \textbf{count}  &  78.00 \\
  \textbf{mean}   &  20.64 \\
  \textbf{std}    &  93.07 \\
  \textbf{min}    &   1.00 \\
  \textbf{25\%}   &   1.00 \\
  \textbf{50\%}   &   2.00 \\
  \textbf{75\%}   &   6.75 \\
  \textbf{max}    & 766.00 \\
\end{tabular}
```

Hands-on Task 2: Expected Output



Hands-on Task 2: Expected Output



Hands-on Task 2: TODO 1 Hints

1. Hint: look at the analysis - how does it expect the CSV data to be organized?

2. Hint: define your output variable to match!

Hands-on Task 2: TODO 1 Solution

```
# expected output has 4 columns:
names=['var', 'project', 'file', 'enums']

# first is just the output variable's name
# second is the project (id or name - anything unique)
# third is the file name
# fourth is the number of enums declared in that file

# the last column is always the aggregated value
# so we need 2 indexes:
o: output sum[proj: string][file: string] of int;
```

Hands-on Task 2: TODO 2 Hints

1. Hint: can you get just the last snapshot for each project?
2. Hint: enums are **Declarations**, can you find them?
3. Hint: every time you find an enum, output

Hands-on Task 2: TODO 2 Solution

```
visit(input, visitor {









});
```

Hands-on Task 2: TODO 2 Solution

```
visit(input, visitor {
   before node: CodeRepository -> {
        snapshot := getsnapshot(node);
        foreach (i: int; def(snapshot[i]))
            visit(snapshot[i]);
        stop;
   }



});
```

Hands-on Task 2: TODO 2 Solution

```
visit(input, visitor {
    before node: CodeRepository -> {
        snapshot := getsnapshot(node);
        foreach (i: int; def(snapshot[i]))
            visit(snapshot[i]);
        stop;
    }
    before n: Declaration ->
        if (n.kind == TypeKind.ENUM)
            o[input.id][current(ChangedFile).name] << 1;
});
```

Hands-on Task 2: Analysis won't run

It needs dupes.csv, which isn't generated anywhere.

Hint: Use a processor and the hashes.boa query.

Hands-on Task 2: Analysis Fix

Add this to queries in study-config.json

```
"hashes.txt": {
    "query": "queries/hashes.boa",
    "dataset": "java",
    "processors": {
        "gendupes.py": {
            "output": "data/txt/dupes.txt",
            "csv": "dupes.csv",
            "cacheclean": [
                "*-deduped.parquet"
            ]
        }
    }
}
```

https://go.unl.edu/dedupe

Task 2: Solution

https://go.unl.edu/fse-task2

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5:30 Finished

Hands-on Task 3

Open the file “boa/queries/task3/counts.boa”

This query counts some things in the dataset we are analyzing, like the number of files and projects.

Hands-on Task 3

Open the file “boa/queries/task3/task3.boa”

This query looks at Java features and finds code that could utilize newer language features.

Hands-on Task 3

In this task, we give you a Boa query from an ICSE 2014 paper.

Your task is to provide the Python analysis that takes the query output and generates a LaTeX table similar to the following:

	Assert	Varargs	Binary Literals	Diamond	MultiCatch	Try with Resources	Underscore Literals
Old	89K	612K	56K	3.3M	341K	489K	22.2M
New	291K	1.6M	5K	414K	24K	33K	2.3M
All	380K	2.2M	61K	3.7M	365K	522K	24.5M
Files	1.39%	12.74%	0.11%	12.25%	2.28%	1.85%	20.17%
Projects	18.18%	88.78%	5.9%	59.08%	49.75%	37.27%	88.86%

Figure 15: Potential language feature uses, in old files (before feature release) and new files (after feature release).

Hands-on Task 3

Open the file “analyses/task3.py”

This is the skeleton of the analysis for Task 3.

Read the TODO items and attempt to write Python code for each.

You may want to look at other analyses we provided for insights.

Hands-on Task 3: TODO 1 Hints

load counts.csv into a Pandas DataFrame

1. Hint: maybe you can drop a column?
2. Hint: you can use set_index() to make one of the columns into the dataframe's index.
3. Hint: you can use df[col][row] to select a cell.

Hands-on Task 3: TODO 1 Solution

```
dfcounts = get_df('counts',
                  'task3',
                  drop=['idx'],
                  names=['var', 'idx', 'count']
                 )
dfcounts = dfcounts.set_index('var')

# get the total number of studied projects
total_projs = dfcounts['count']['StudiedProjects']

# get the total number of Java files
total_files = dfcounts['count']['JavaFiles']
```

Hands-on Task 3: TODO 2 Hints

1. load task3.csv into a Pandas DataFrame

2. Hint: do we need to drop a column?

Hands-on Task 3: TODO 2 Solution

```
df = get_df(filename='task3', # reads task3.csv
            subdir='task3', # from the task3 sub-directory
            # so the file is: data/csv/task3/task3.csv

            names=['var', 'kind', 'count']
           )
```

Hands-on Task 3: TODO 3 Hints

1. Hint: create a style for the table

2. Hint: you can use save_table() to generate a LaTeX table in a file

Hands-on Task 3: TODO 3 Solution

```
style = highlight_rows(highlight_cols(get_styler(df4)))


save_table(style,
           'task3.tex',
           colsep='1pt',
           rotate=50,
           rowcolors=True,
           column_format='|c|r|r|r|r|r|r|r|'
          )
```

Hands-on Task 3: Add to study-config.json

Add this analyses in study-config.json

```
"task3.py": {
  "input": [
    "task3/task3.csv",
    "task3/counts.csv"
  ]
}
```

https://go.unl.edu/task3-analysis

Task 3: Solution

https://go.unl.edu/fse-task3

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2:25 Using Boa in VS Code (10 mins) (RD)
2:35 Hands-on Task 0: Boa+VS Code (20 mins) (SF)
2:55 Overview of the Boa Study Template (15 mins) (SF)
3:10 Hands-on Task 1: A Simple Boa Query (20 mins) (RD+SF)

3:30 Break (30 mins)

4:00 Hands-on Task 2: Adding a Second Query (30 mins) (RD+SF)
4:30 Hands-on Task 3: Analyzing Boa Outputs with Pandas (45 mins)
5:15 Publishing Replication Packages (15 mins) (RD)
5:30 Finished

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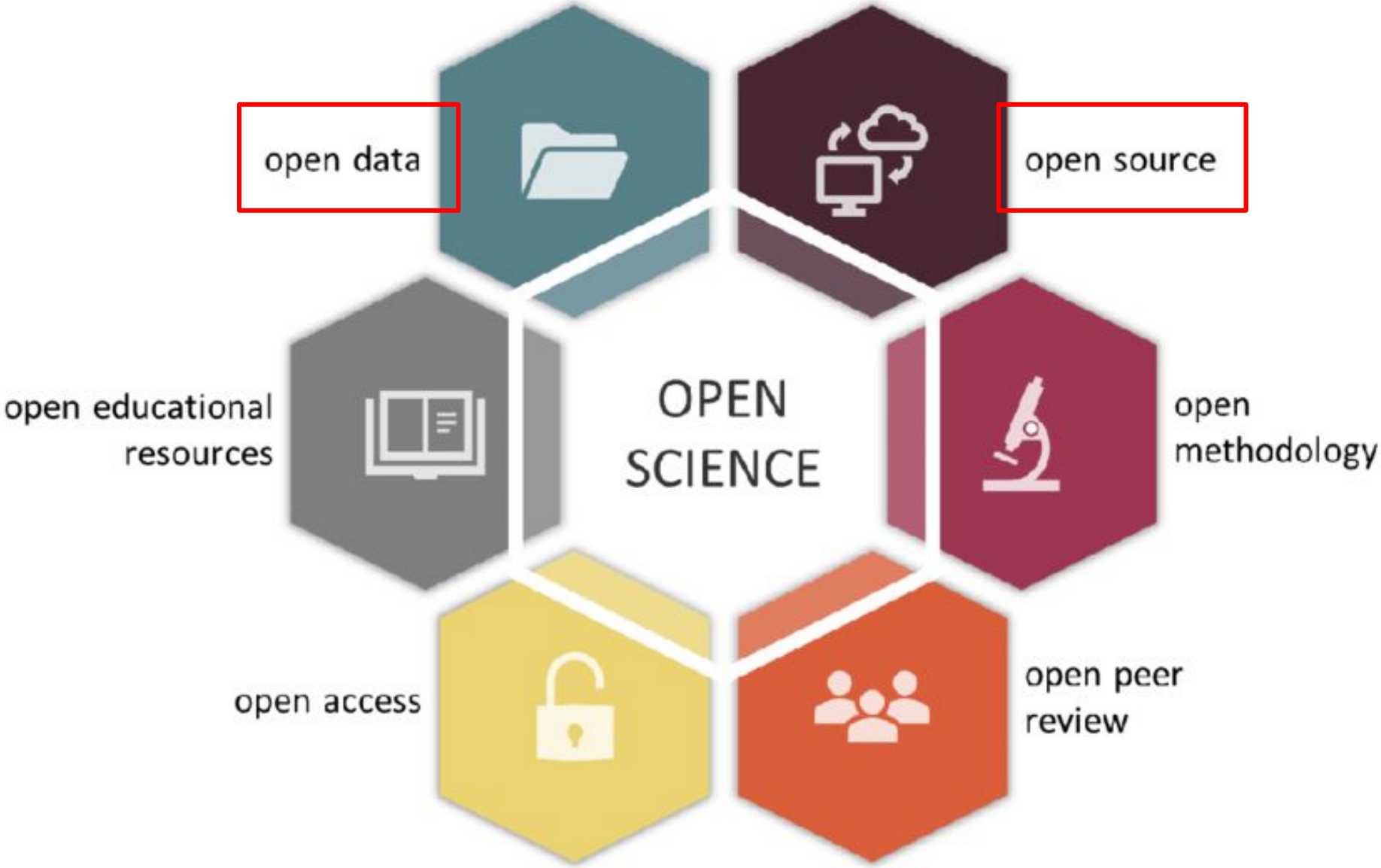
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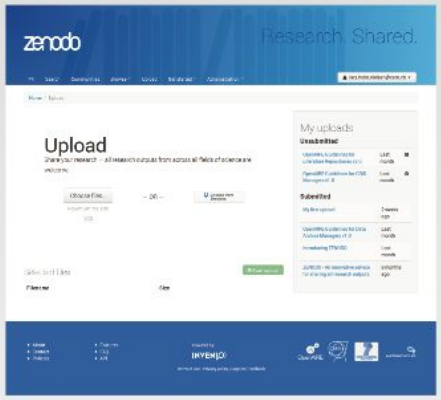

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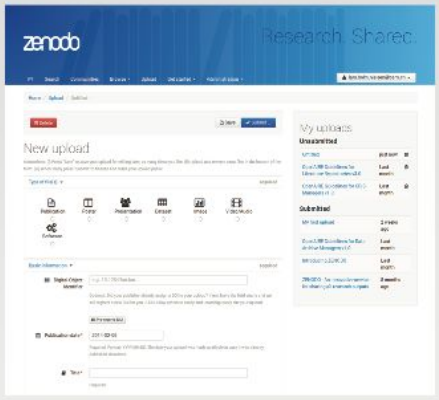

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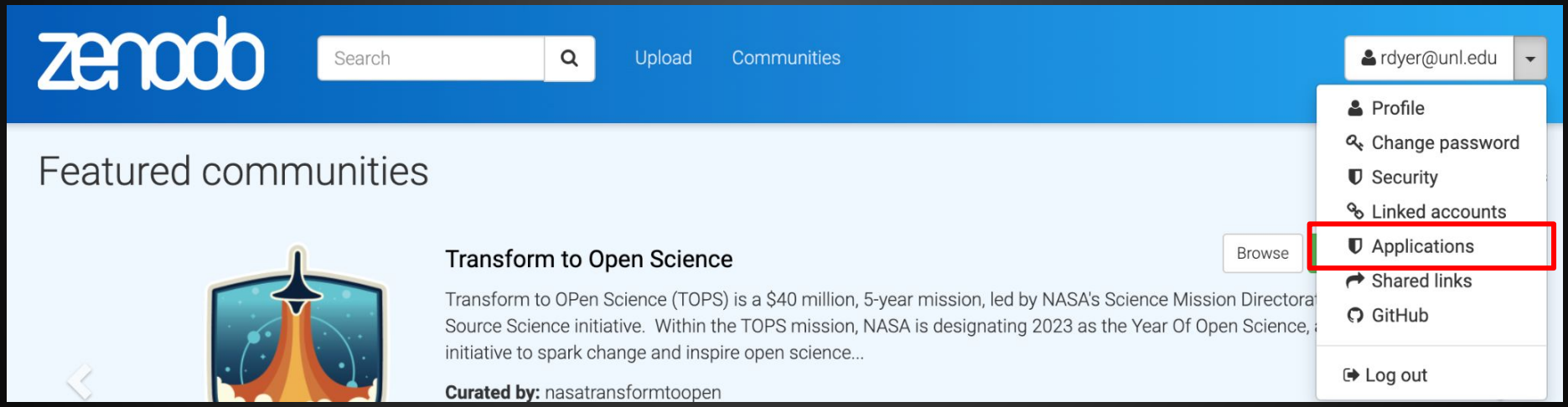
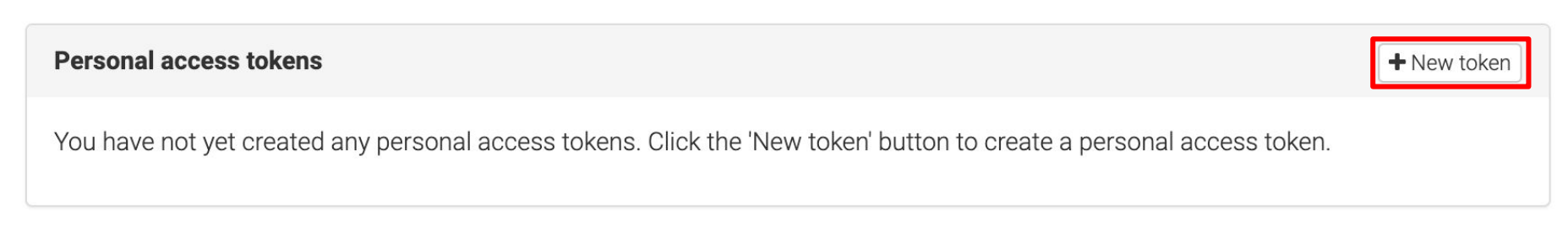
1) Go to: https://sandbox.zenodo.org/

2) Make a user (you can't use OAuth logins - make an actual user!)

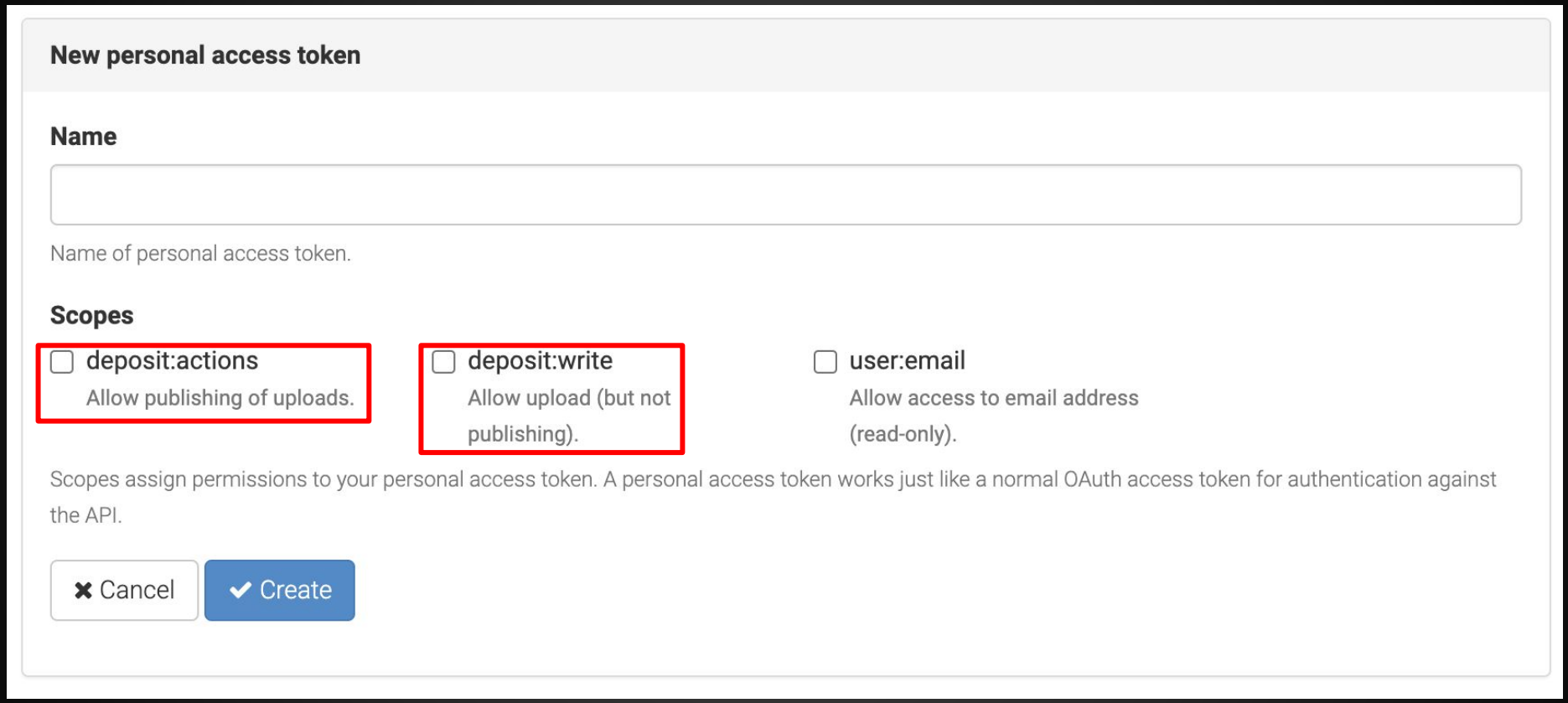
3) Go to your user's "Applications" settings



4) Create a “New token”



5) Give it a name
6) Select first two scopes



Copy the token for later - you can't access it again!

Environment Setup

Edit the “.env” file to put your token:

```
ZENODO_API_TOKEN='<paste here>'
ZENODO_API_ENDPOINT='https://sandbox.zenodo.org'
```

Edit the JSON

Edit the “.zenodo.json” file.

Fill in/change anything you see to match your particular paper.

Upload to Zenodo

Now you can upload to Zenodo!

Run: make package and then make zenodo

This will generate the ZIP files, create a new deposit, and upload the ZIPs. If you run it again, it will update the existing record's metadata and re-upload any files that changed.

The record is not published yet!

After Publication

Once your paper is accepted, you need to un-blind your record.

1) Re-edit the .zenodo.json file to update the author information
2) Re-run “make zenodo”
3) Update your paper to reference the DOI (if you have not already)

Boa

http://boa.cs.iastate.edu/