南京大學
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How do Developers Fix Cross-project Correlated Bugs?

A case study on the GitHub scientific Python ecosystem

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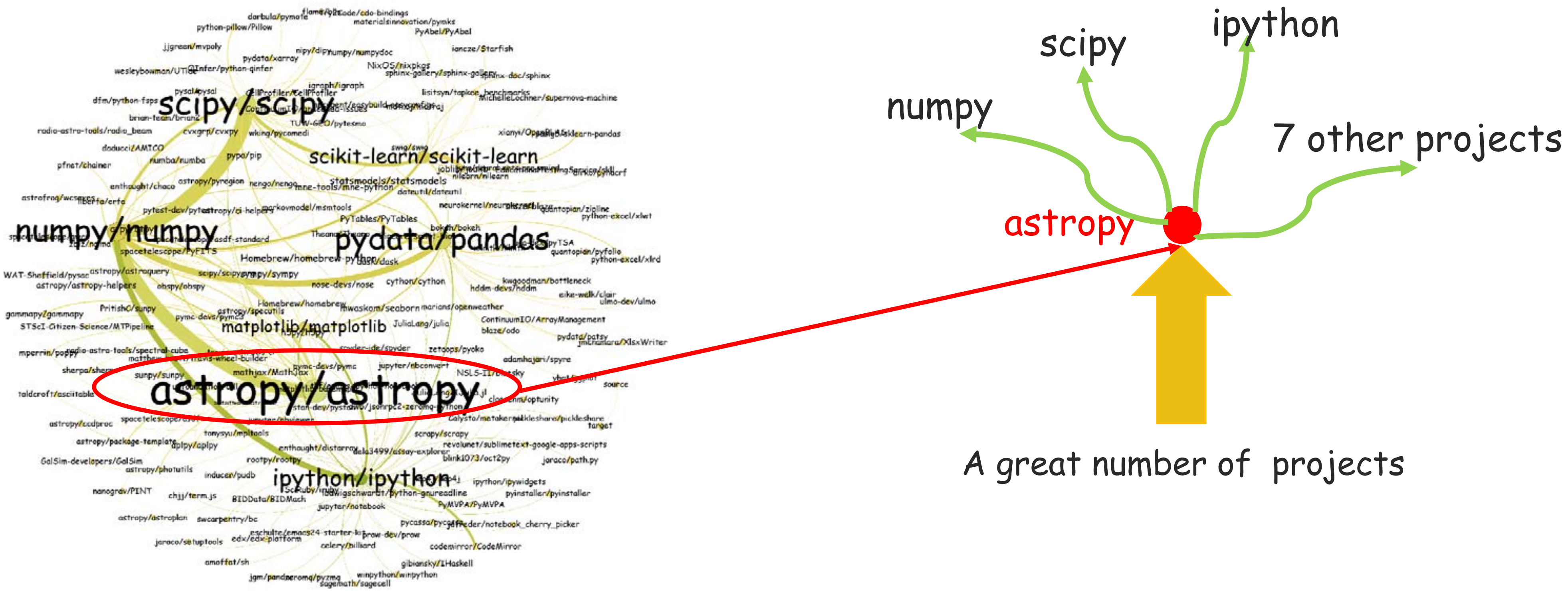
Contents

- Motivation
- Objective
- Study Design
- Study Results
- Discussions
- Conclusion

Background—*GitHub Ecosystems*

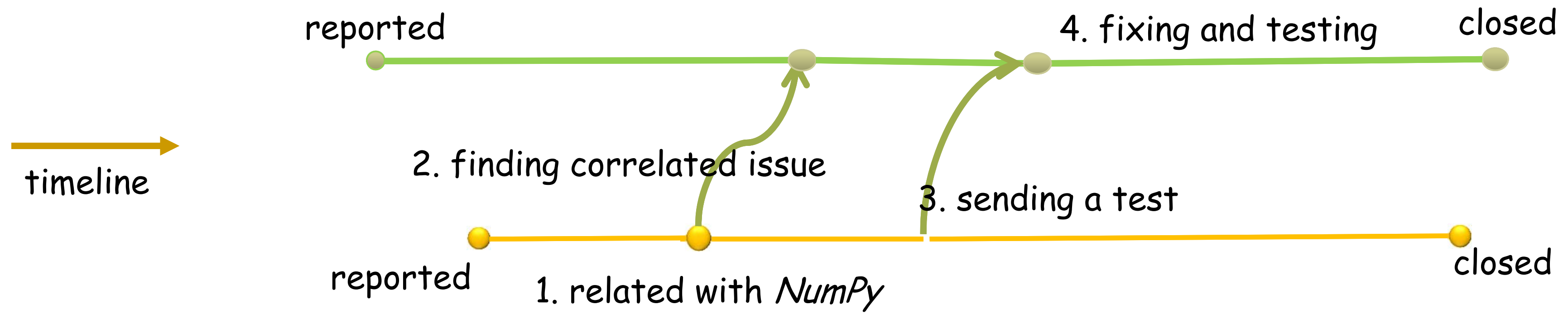
- Dependency between projects



Motivation—*Cross-project correlated bugs*

Upstream project: numpy

numpy/numpy#6467



reported

4. fixing and testing

closed

timeline

2. finding correlated issue

3. sending a test

reported

1. related with *NumPy*

closed

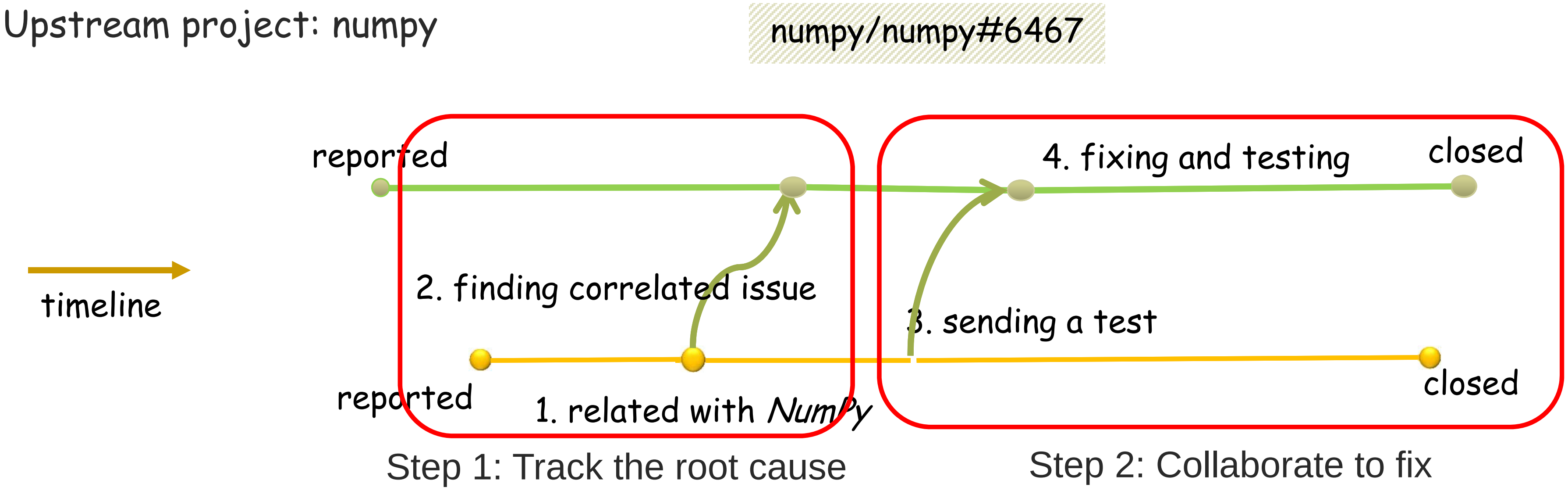
Downstream project: astropy

astropy/astropy#4259

An average of 17.28% of bugs are cross-project ones.

Motivation—*Cross-project correlated bugs*

Upstream project: numpy



Step 1: Track the root cause

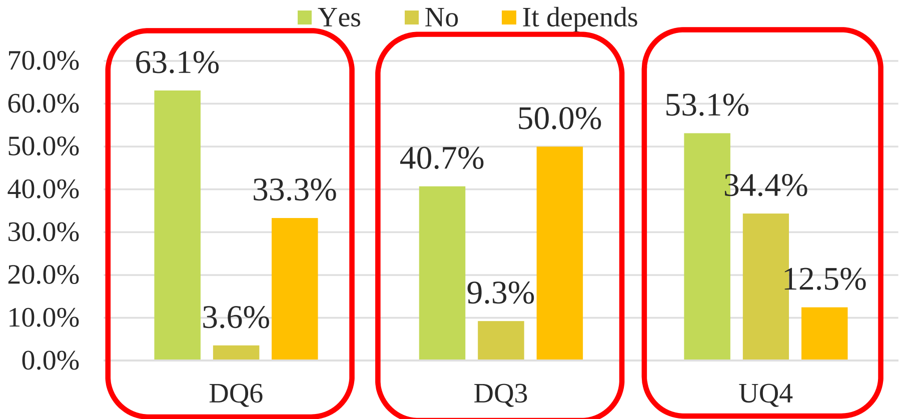
Step 2: Collaborate to fix

Downstream project: astropy

astropy/astropy#4259

Motivation—*Cross-project bugs*

- **Survey results**



- Compared with within-project bugs,
  - DQ6. more difficult to deal with ?
  - DQ3. have more severe impact ?
  - UQ4. pay more attention ?

DQ: for downstream developers UQ: for upstream developers

- **Statistical comparison**
  - Cross-project bugs vs. within-project bugs
  - Based on the data collected from bug reports

Results:

- Requiring more time to fix
- More comments in bug reports
- More participants during fixing

- More severe impact
- More difficult to fix
- Attracting more attention

Part 1

Objective

To investigate how software practitioners fix cross-project correlated bugs

- **Focusing on two aspects:**
  1. cross-project root cause tracking
     - as the bug carries over from one project to another, it becomes harder to trace the bug back to its root
  2. coordination in bug fixing
     - while waiting for an upstream fix, the downstream developers need to coordinate their project with the upstream one in order to minimize any undesirable impact of the cross-project bugs

Study design—*Studied Projects*

- GitHub Scientific Python ecosystem
  - Seven seed projects

SciPy library
Fundamental library for scientific computing

IP[y]:
IPython

IPython
Enhanced Interactive Console

pandas
Data structures & analysis

NumPy
Base N-dimensional array package

Matplotlib
Comprehensive 2D Plotting

scikits learn
machine learning in Python

astropy
A Community Python Library for Astronomy

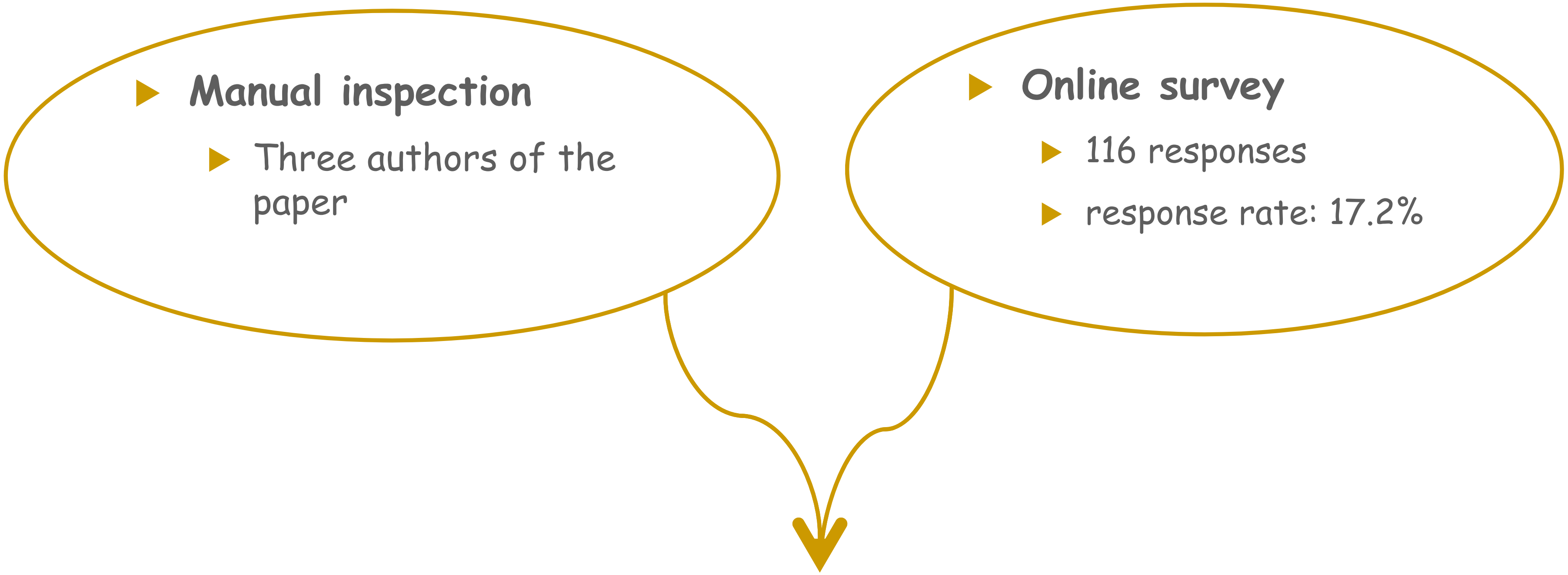
- totally 271 pairs of cross-project correlated bugs
- involving 204 projects

Study design—*Research Questions*

- Research questions

1. **How long** does it take to find the root cause of cross-project correlated bugs, that is, to link the downstream bug to the criminal upstream bug?
2. **What factors** are important to track the root cause of cross-project correlated bugs?
3. How do downstream developers **coordinate with upstream projects** to deal with cross-project correlated bugs after identifying the root cause?

Study design—*Research Methods*



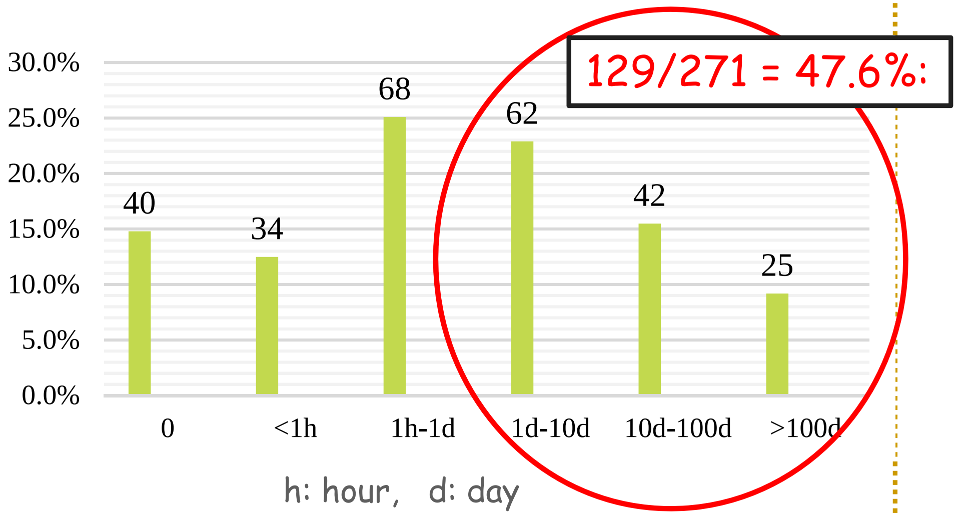
- Manual inspection
  - Three authors of the paper

- Online survey
  - 116 responses
  - response rate: 17.2%

Summarizing the findings

Results-*RQ1:Difficulty of Finding the Root Cause*

- **Manual inspection**
  - *How long to find the root cause?*

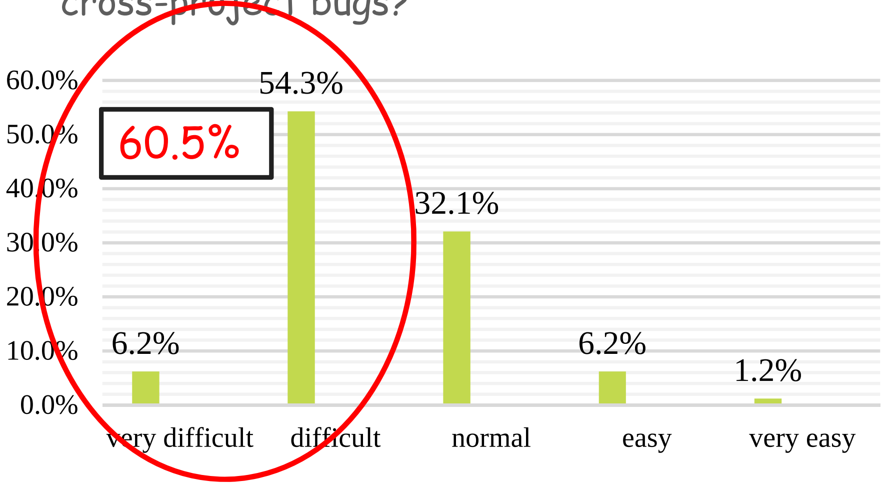


h: hour, d: day

- The root causes of nearly half of the cross-project bugs are identified in a relatively long time (one day to more than 100 days).

Results-*RQ1:Difficulty of Finding the Root Cause*

- **Survey results**
  - DQ2: is it difficult to find the root causes for cross-project bugs?



- 60.5% of the downstream developers thought it difficult or very difficult to find the root cause.

Results-*RQ2:Factors for Tracking the Root Cause*

- Manual inspection

Stack traces

the sequences of calls to the failure

Communication

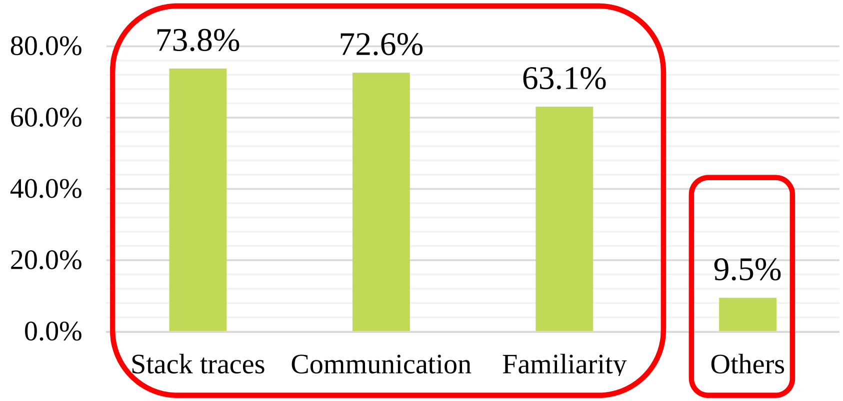
between upstream and downstream developers

Familiarity

expertise in the buggy component

Results-*RQ2:Factors for Tracking the Root Cause*

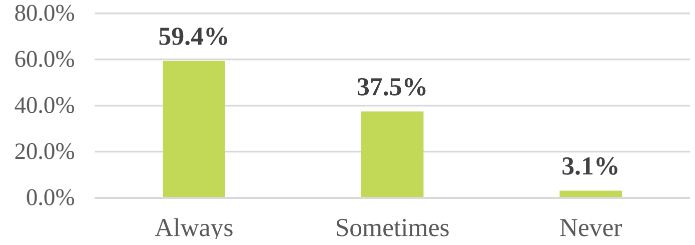
- Survey results
  - DQ4: what factors may act as positive roles to find the root-causes of cross-project bugs?



  - Others: test cases, documentation, stack overflow, …

Results-*RQ2:Factors for Tracking the Root Cause*

- Communication

	Downstream	Upstream
Attitude	*"One is rarely facile with the upstream project's internals, so communication is essential"*	UQ3. As an upstream developer, do you care about the opinions from the downstream projects or communicate with the downstream developers? 
Focus	Responsiveness: early and friendly responses	Content: concrete description of the bug and the requirements of the downstream project

Results-*RQ3:Practices of Downstream Developers*

- Manual inspection

Working around the bug locally (60)

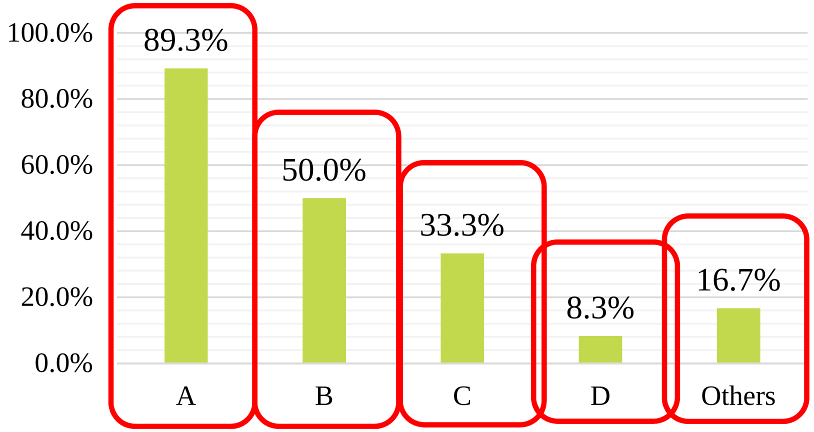
Workaround: a temporary solution injected in the downstream code locally

Restricting the dependent upstream versions (8)

Doing nothing bug waiting for the upstream fix (49)

Results-*RQ3:Practices of Downstream Developers*

- Survey results
  - DQ7. What do downstream developers usually do with a cross-project bug?



A. Proposing a workaround

B. Restricting the upstream versions

C. Doing nothing but waiting

D. Using a different upstream project

Others: Actively help the upstream project by proposing/pushing solutions

"Whatever is easiest in their specific circumstances, above are good examples! but probably work around the issue."

Results-*RQ3:Practices of Downstream Developers*

- **Workaround**
  - Problems:
    - version-dependent codes
    - ➔adding maintenance burden
  - Implications:
    - tools to support synthesis and maintenance of workarounds

A bug in *numpy* 1.6 affected *astropy*.

- Affected code in astropy:

```
format_ufunc  =  np.vectorize(do_format,  otypes=['U'])
result = format_ufunc(values)
```

- Workaround:

```
if numpy_version < 1.7:
    # work around it
     new code
else:
```

Discussions—*Dilemmas in collaboration*

- Cross-project testing

  → to prevent cross-project bugs

  - **Downstream**
    - it would be helpful if the testing suites for downstream projects are run before releasing an upstream version.
  - **Upstream**
    - impossible to get the complete list of downstream projects
    - different ways for downstream projects to run their tests
    - time consuming

to develop tools for effective cross-project testing

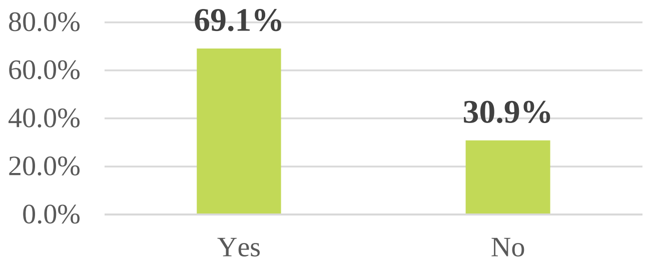
Discussions—*Dilemmas in collaboration*

- Notification of bug fixes

  → to deprecate outdated workarounds

  - **Downstream**
    - helpful
  - **Upstream**
    - an extra burden

DQ8. Is it necessary for the affected downstream projects to be notified?



to improve the notification scheme of GitHub so that it can send automatic massages

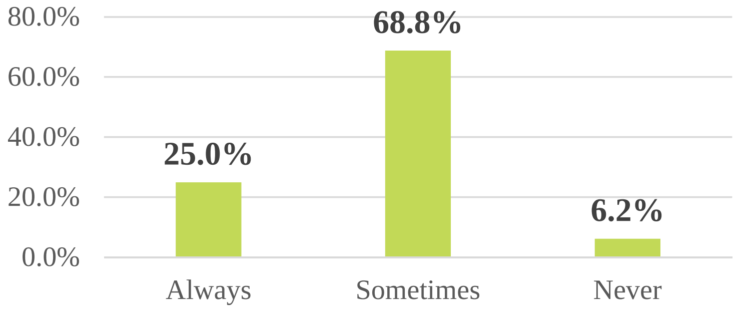
Discussions—*Dilemmas in collaboration*

Releasing the bug fix version

Problem: *“release cycles of downstream and upstream projects are out of sync”*

- **Downstream**
  - hoping for a quick release
- **Upstream**
  - preferring to give a bit of time for reflection

UQ8. When scheduling a bug-fix release, will you consider the requirements of the important downstream projects?



“The reformation should help best of both-ends.”

Related Work

- ## Practices in fixing bugs

T. Zimmermann, N. Nagappan, P. J. Guo, and B. Murphy, "Characterizing and predicting which bugs get reopened“

G. Canfora, L. Cerulo, M. Cimitile, and M. Di Penta, "Social interactions around cross-system bug fixings: the case of FreeBSD and OpenBSD“

S. Breu, R. Premraj, J. Sillito, and T. Zimmermann, "Information needs in bug reports: improving cooperation between developers and users"

- ## Collaboration on GitHub

L. Dabbish, C. Stuart, J. Tsay, and J. Herbsleb, "Social coding in GitHub: transparency and collaboration in an open software repository"

A. Lima, L. Rossi, and M. Musolesi, "Coding together at scale: GitHub as a collaborative social network"

- ## Evolution of software ecosystems

J. Bosch and P. M. Bosch-Sijtsema, "Softwares product lines, global development and ecosystems: collaboration in software engineering“

A. Decan, T. Mens, M. Claes, and P. Grosjean, "On the development and distribution of R packages: an empirical analysis of the R ecosystem"

Conclusion and Future Work

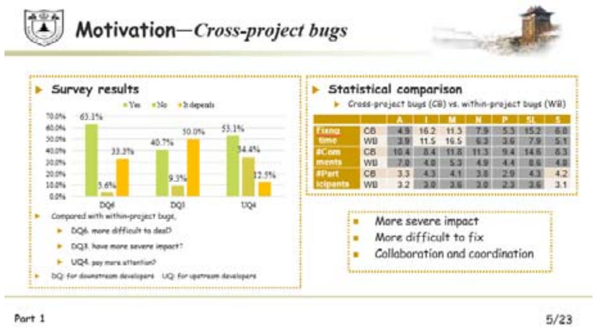
- How do developers fix cross-project bugs?
  - More difficult to repair and more severe
  - Beneficial factors for finding the root cause

    Stack traces, communication, and familiarity
  - Common practices for downstream developers

    The workaround
- Future work:
  - Workarounds
  - Tool support

Thank you !

Q & A



Motivation—*Cross-project bugs*

- Survey results

- Compared with within-project bugs,
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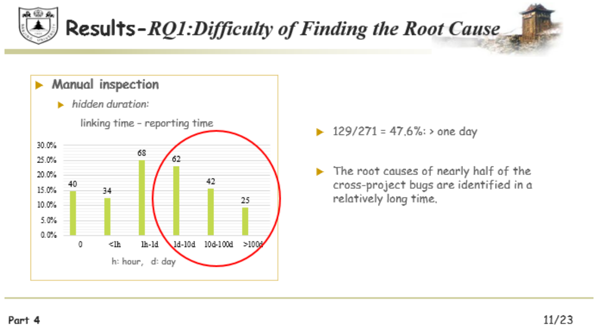
  - UQ4. pay more attention?
- DQ: for downstream developers UQ: for upstream developers

- Statistical comparison
  - Cross-project bugs (CB) vs. within-project bugs (WB)

		A	I	M	N	P	SL	S
Fixing time	CB	4.9	16.2	11.3	7.9	5.3	15.2	6.0
	WB	3.9	11.5	16.5	6.3	3.6	7.9	5.1
#Comments	CB	10.4	8.4	11.8	11.3	9.4	14.6	8.3
	WB	7.0	4.0	5.3	4.9	4.4	8.6	4.0
#Participants	CB	3.3	4.3	4.1	3.8	2.9	4.3	4.2
	WB	3.2	3.0	3.6	3.0	2.3	3.6	3.1

- More severe impact
- More difficult to fix
- Collaboration and coordination

Part 1 5/23



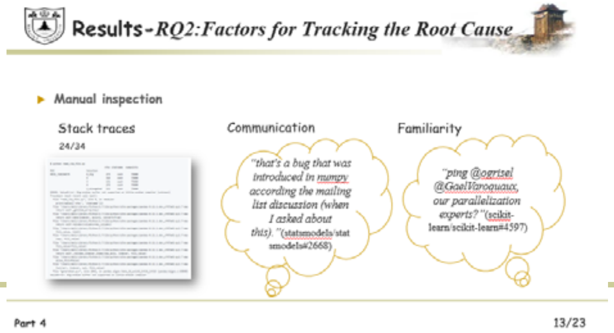
Results-*RQ1:Difficulty of Finding the Root Cause*

- Manual inspection
  - *hidden duration:*

    linking time - reporting time

- 129/271 = 47.6%: > one day
- The root causes of nearly half of the cross-project bugs are identified in a relatively long time.

Part 4 11/23



Results-*RQ2:Factors for Tracking the Root Cause*

- Manual inspection

Stack traces

24/34

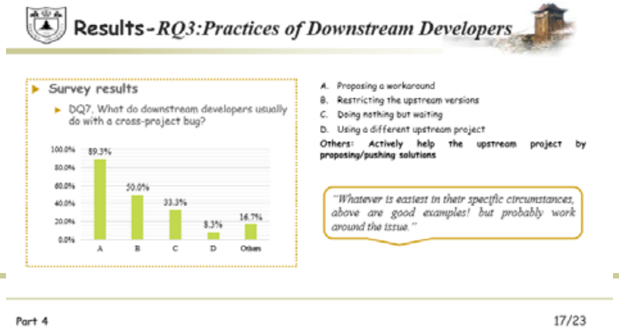
Communication

"that's a bug that was introduced in numpy according the mailing list discussion (when I asked about this)."(statsmodels/statsmodels#2668)

Familiarity

"ping @ogrisel @GaelVaroquaux, our parallelization experts?"(scikit-learn/scikit-learn#4597)

Part 4 13/23



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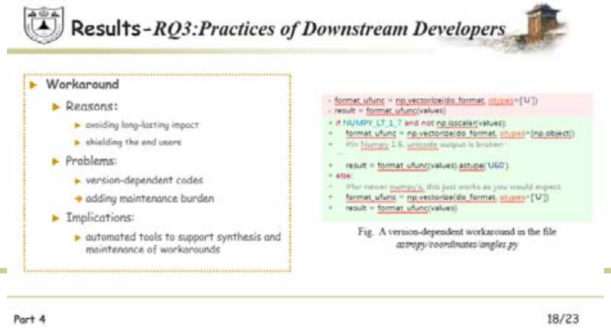
Part 4 17/23



Results-*RQ3:Practices of Downstream Developers*

- Workaround
  - Reasons:
    - avoiding long-lasting impact
    - shielding the end users
  - Problems:
    - version-dependent codes
    - → adding maintenance burden
  - Implications:
    - automated tools to support synthesis and maintenance of workarounds

```
- format_ufunc = np.vectorize(do_format, otypes=['U'])
- result = format_ufunc(values)
+ if NUMPY_LT_1_7 and not np.isscalar(values):
+     format_ufunc = np.vectorize(do_format, otypes=[np.object])
+     #In Numpy 1.6, unicode output is broken
+
+     result = format_ufunc(values).astype('U60')
+ else:
+     #for newer numpy's, this just works as you would expect
+     format_ufunc = np.vectorize(do_format, otypes=['U'])
+     result = format_ufunc(values)
```

Fig. A version-dependent workaround in the file *astropy/coordinates/angles.py*

Part 4 18/23