Faster Feedback through
Concept-based Test Prioritization

Toni Mattis, Robert Hirschfeld
Research School for Service-Oriented Systems Engineering
Hasso Plattner Institute, University of Potsdam, Germany

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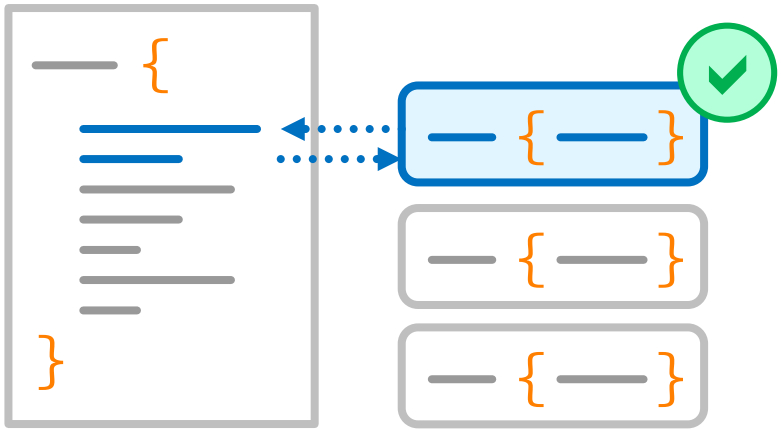
Testing in Software Engineering



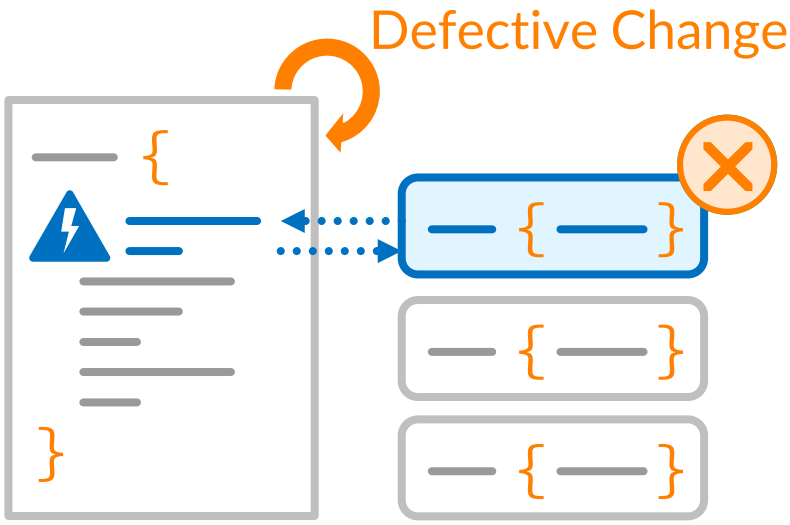
Code (Production)

Tests

Unit Test

1. Runs a small part of the code with example input
2. Checks if output is as expected

Testing in Software Engineering



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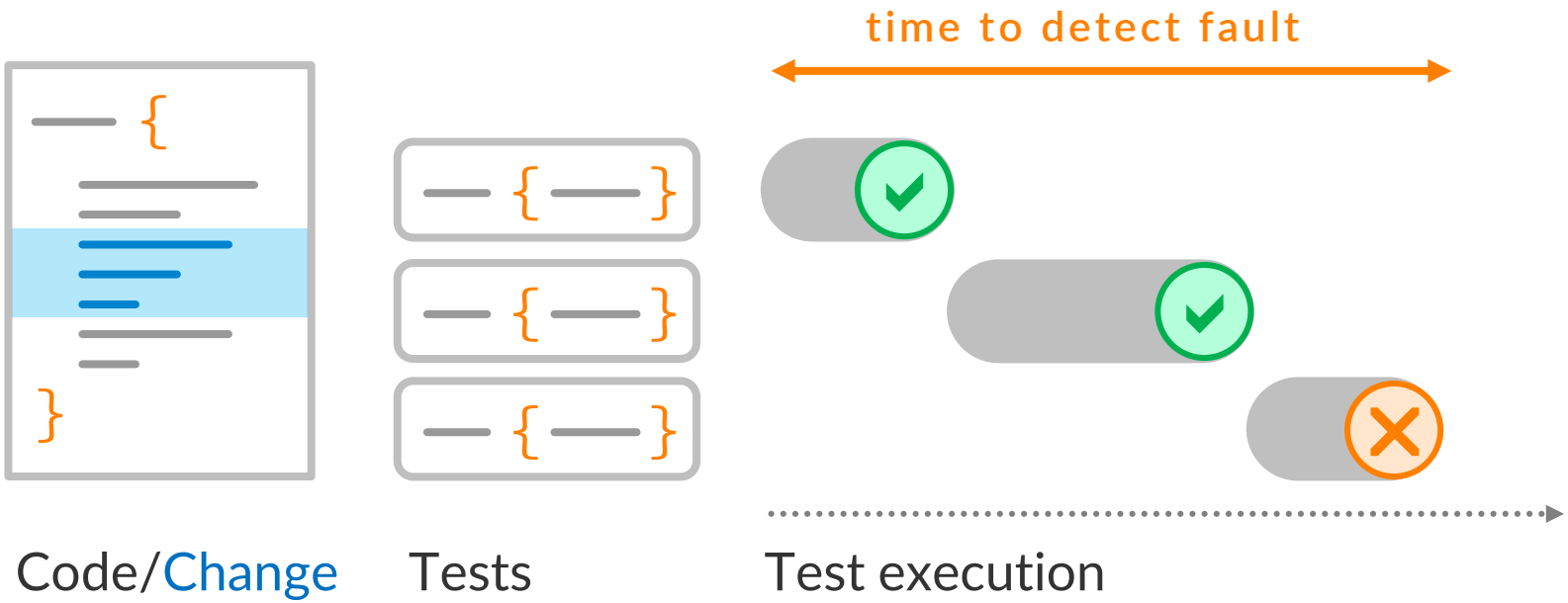
Goal: Immediate Feedback



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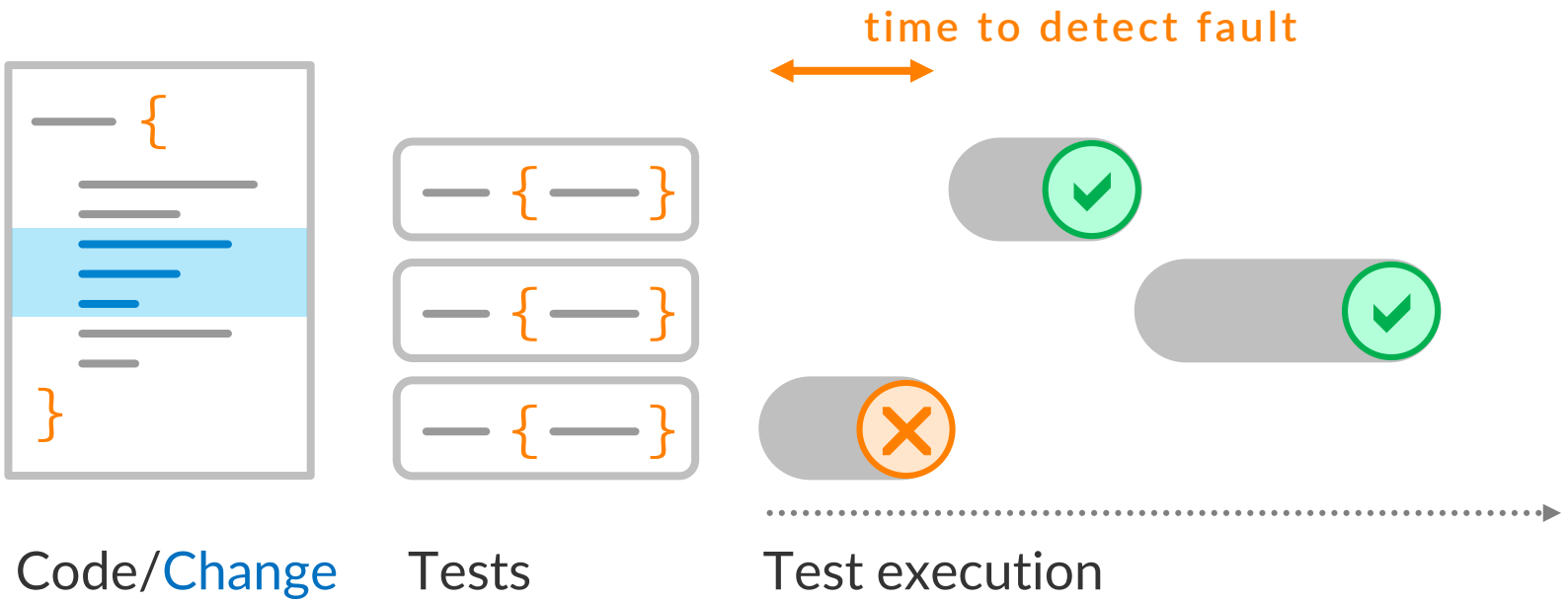
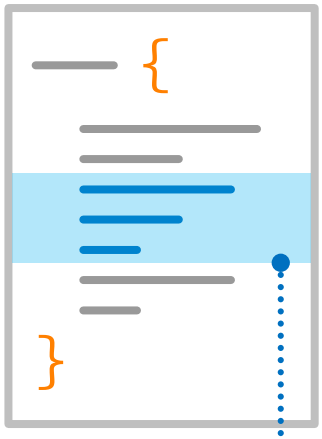
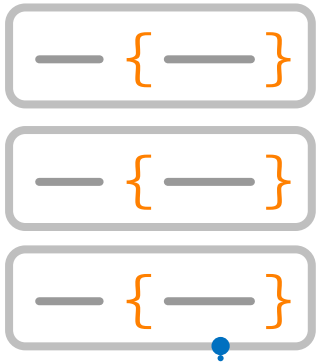


Lexical Test Prioritization





```
-  return …
+  if session.user.is_admin:
+    return …
```

```
assert get(…).status == 403
with login(admin_user):
  assert get(…) == …
```

Lexical similarity

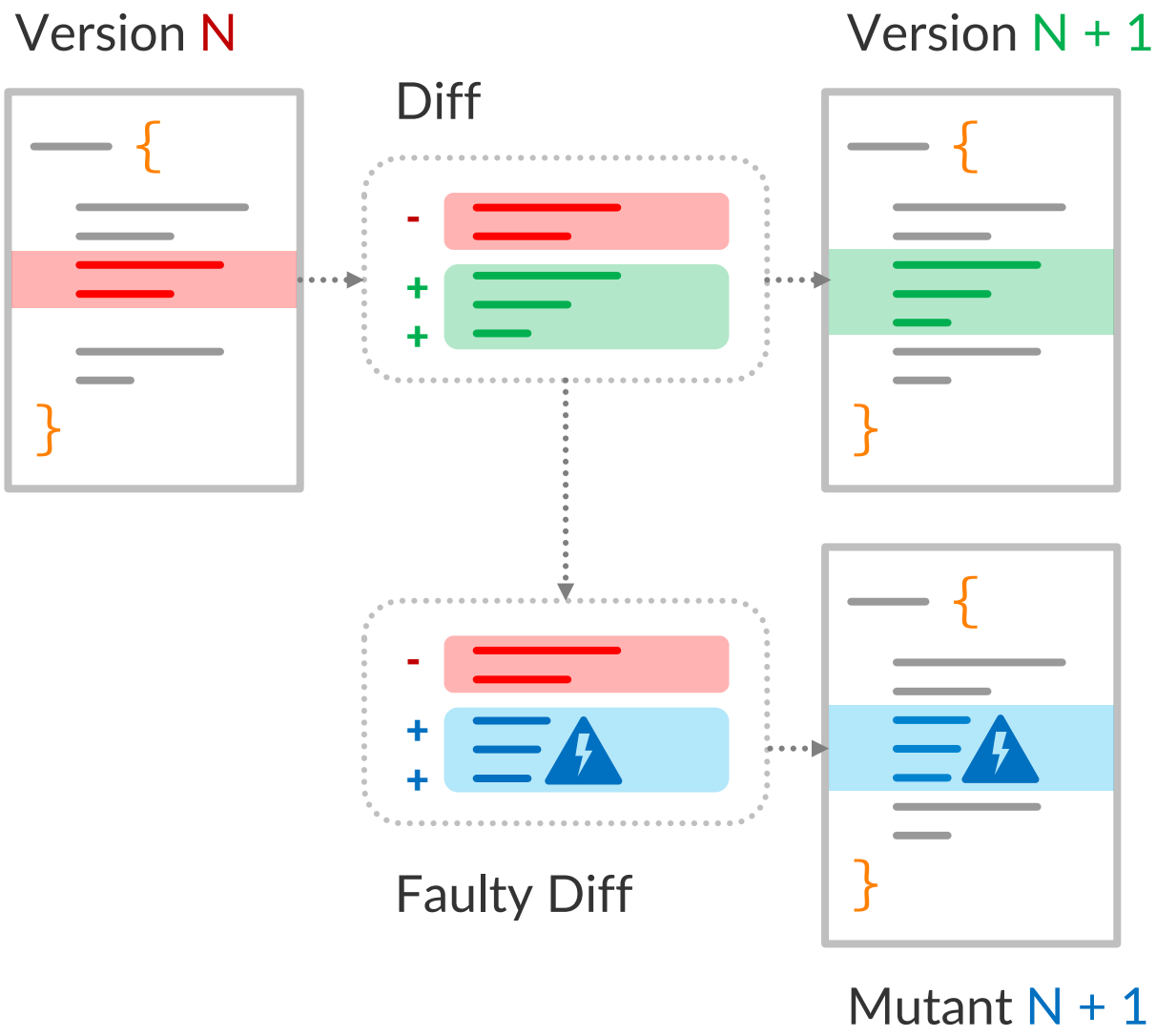
Hypothesis

Test cases that **share vocabulary** with the most recent **change** are more likely to fail

Approach

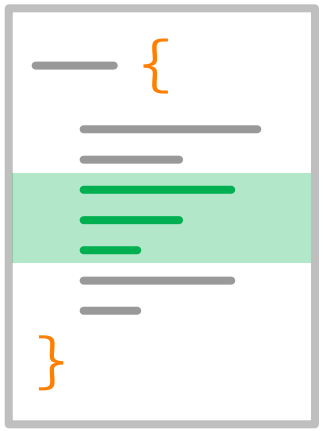
1. Seed faulty changes
2. Run tests
3. Re-order tests based on lexical similarity
4. Check how much earlier failures occur

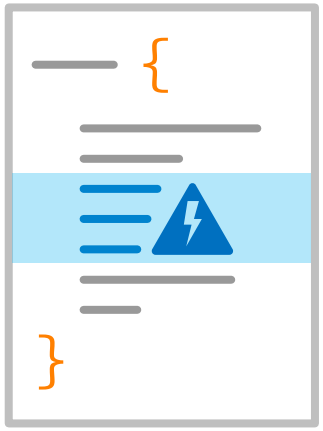
Fault Seeding



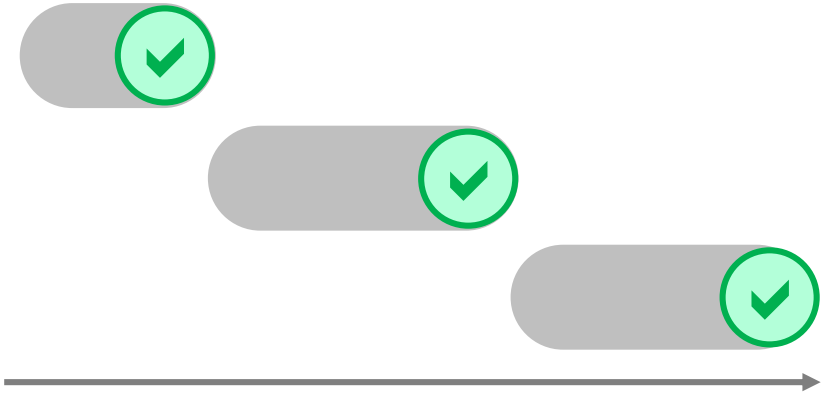
Fault Seeding

Version N + 1

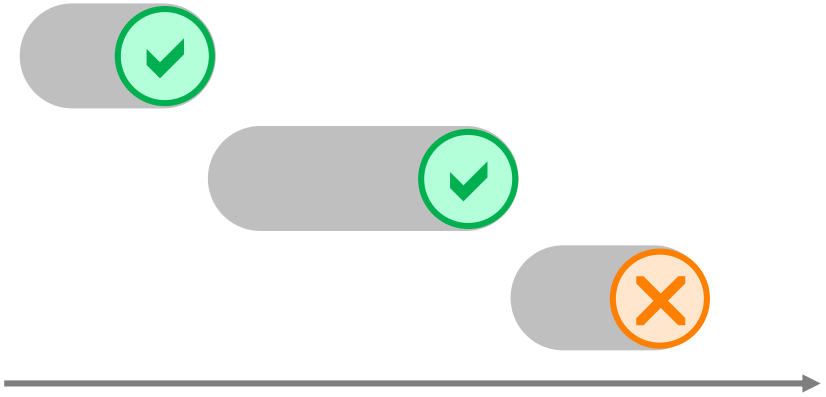




Mutant N + 1



Control Run



Sampling Run

Fault Seeding

Negate condition

```
if session.user.is_admin:
    …
```

```
if not session.user.is_admin:
    …
```

Swap operator

```
average = total / count
```

```
average = total * count
```

Change number

```
response.status = 404
```

```
response.status = 405
```

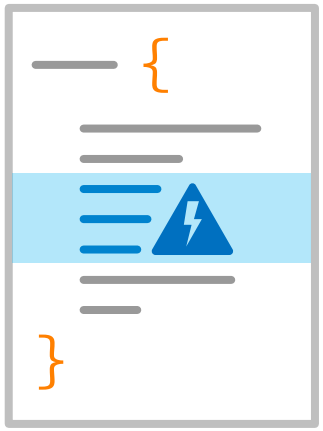
Drop call

```
user_profile.save()
return redirect(…)
```

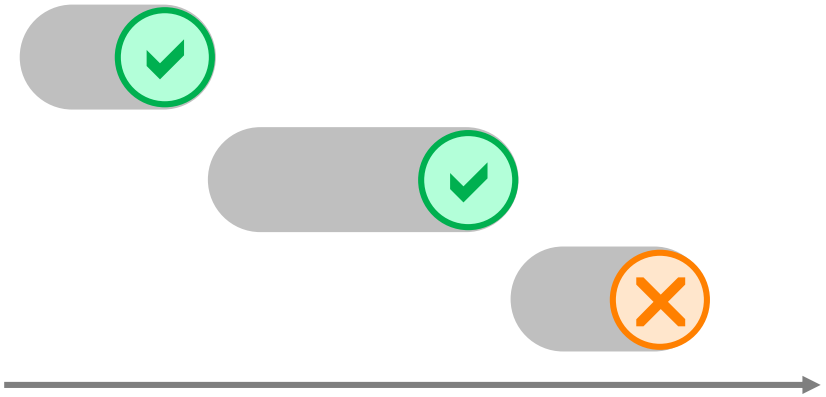
```

return redirect(…)
```

Feature Extraction



Mutant



Sampling Run

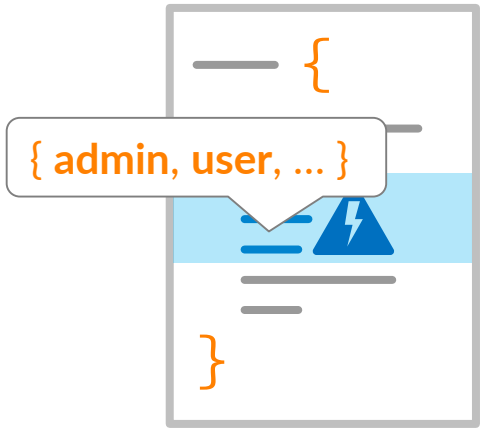
```
if not session.user.is_admin:
  return …
```

{ admin, user, session … }

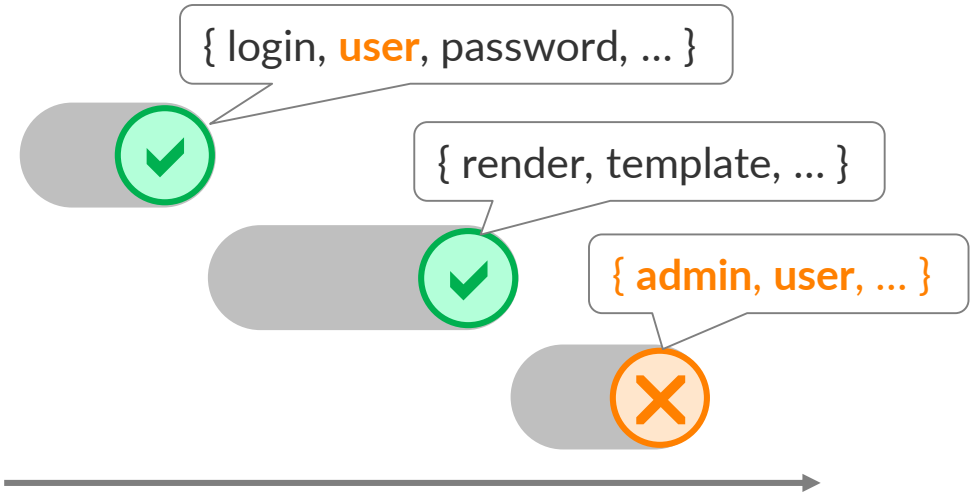
```
assert get(…).status == 403
with login(admin_user):
  assert get(…) == …
```

{ admin, user, status, login, … }

Prioritization

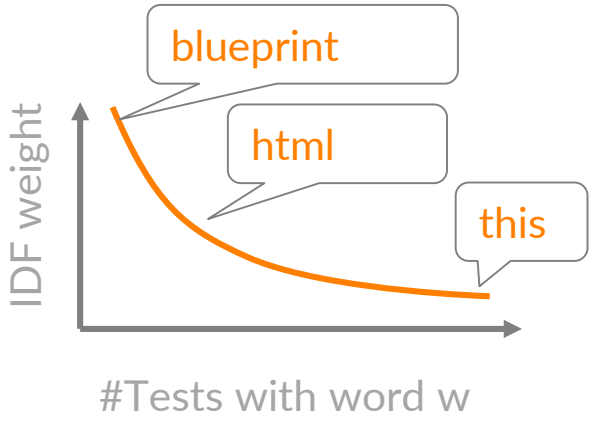


Mutant

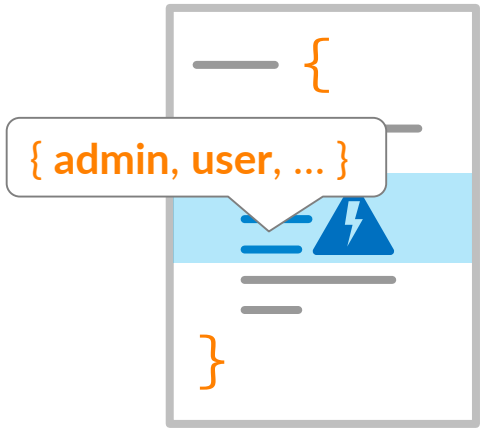


Sampling Run

TF-IDF:



Prioritization



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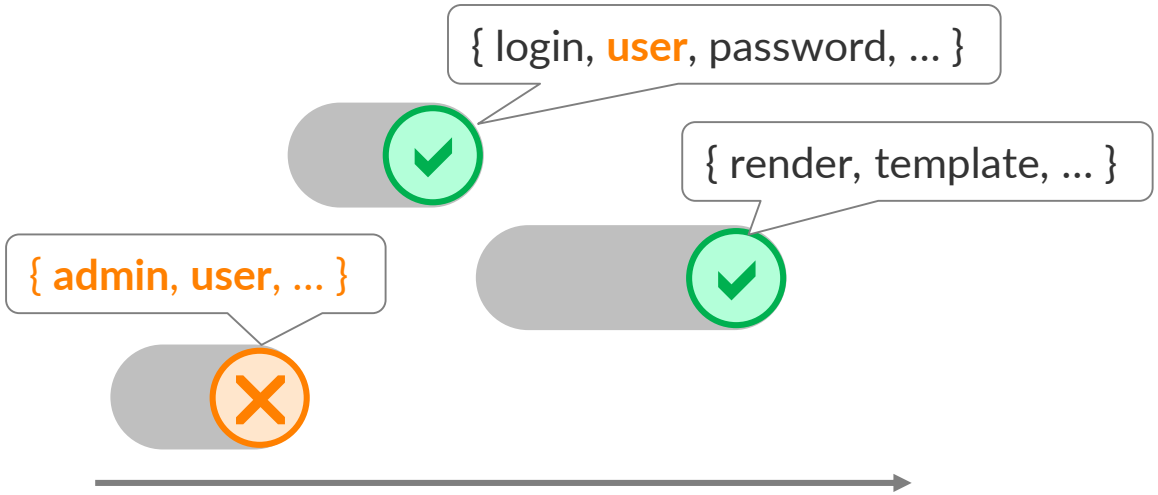
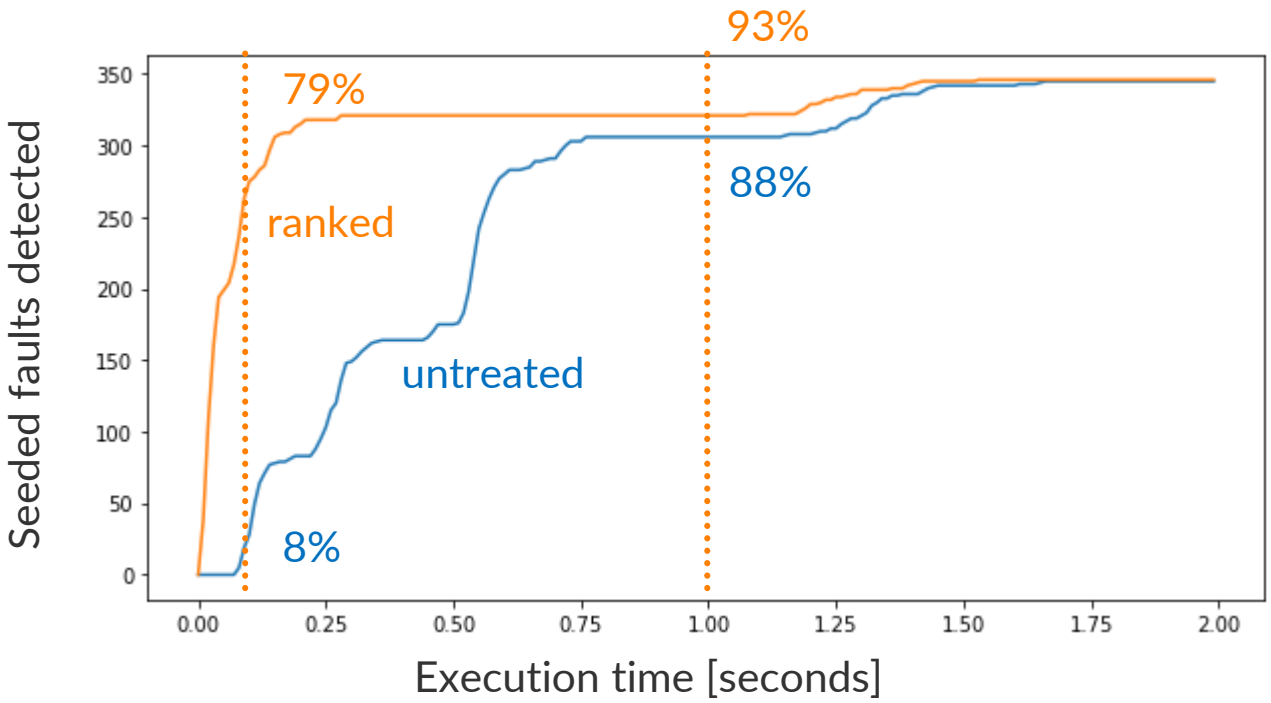


Sorted sampling run results

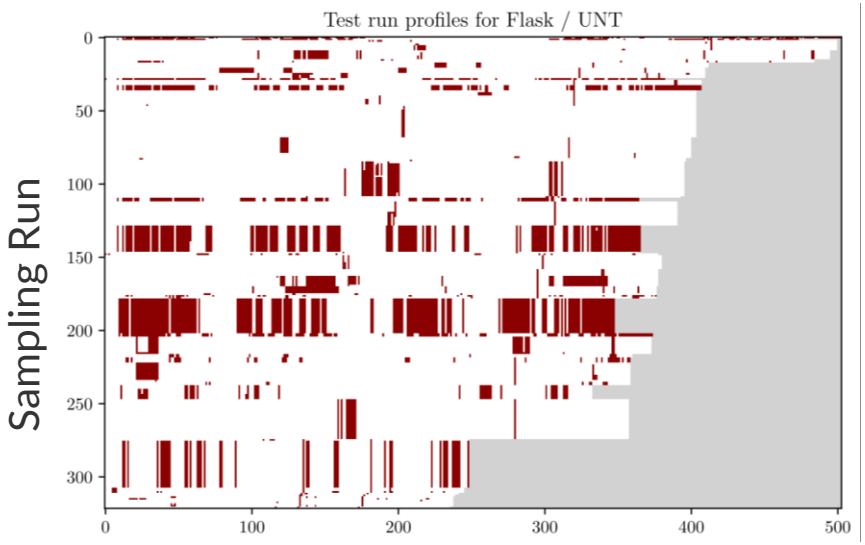
Case Study: Flask

Python web framework, 74 diffs, 413 seeded faults

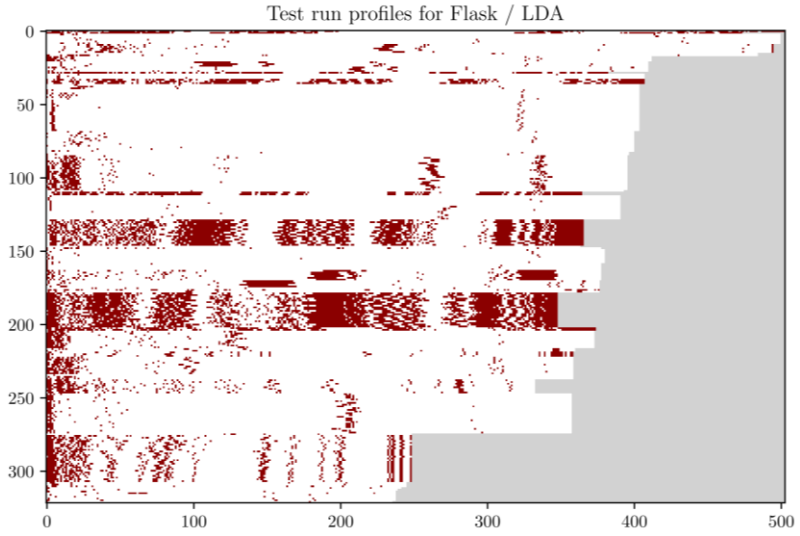


Case Study: Flask

Python web framework, 74 commits, 413 seeded faults



Test Executions (untreated)

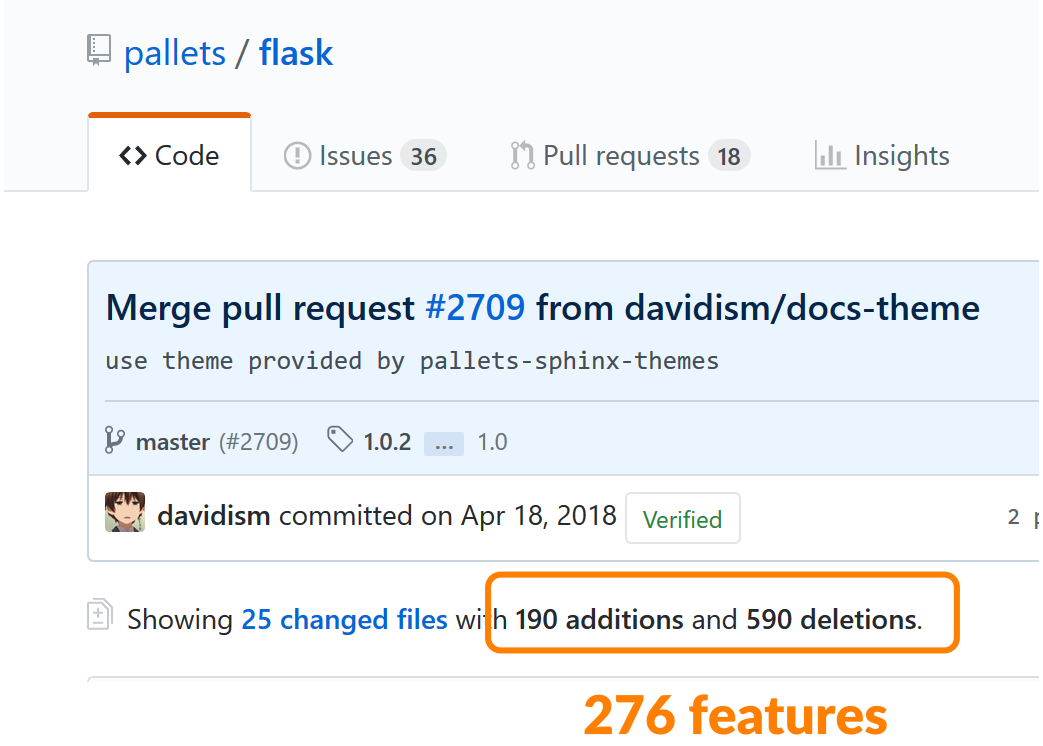


Test Executions (ranked)

Case Study: Flask

Limitation: **Pull Requests**

» Largest type of “change”



Case Study: Flask

Limitations:

- Pull Requests
- Distinguishing names (“NoAppException”) split into generic words (“no”, “app”, “exception”)

GitHub, Inc. (US) | https://github.com/pallets/flask/commit/5fba092c22bee738ad2818d587d75ae17

2 flask/cli.py

```
@@ -243,7 +243,7 @@ def locate_app(script_info, module_name, app_name, raise_if_not_
                )
            elif raise_if_not_found:
                raise NoAppException(
-                   'Could not import "{name}".'.format(name=module_name)
+                   'Could not import "{name}".'.format(name=module_name)
                )
            else:
                return
```

of 276…

‘no’, ‘app’, ‘exception’,

```
def test_locate_app_raises(test_apps, iname, aname):
    info = ScriptInfo()

    with pytest.raises(NoAppException):
        locate_app(info, iname, aname)
```

Exploiting Topicality

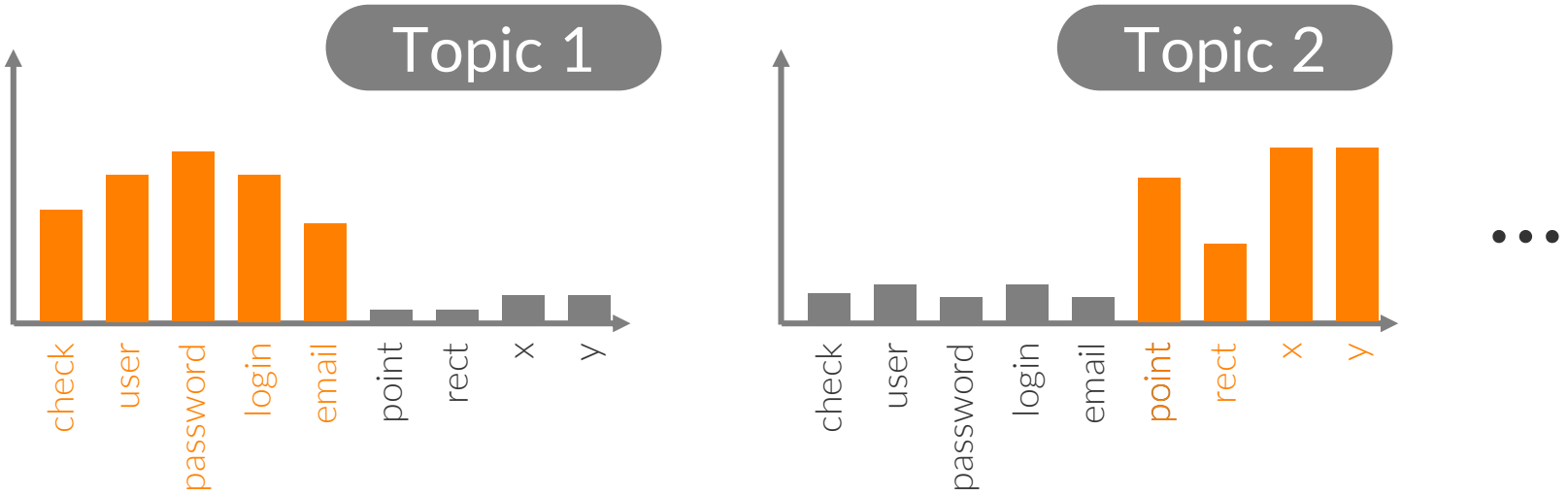
Changed identifiers:

user, **password**, check

Test to prioritize:

login, email, **password**

Topic/Concept Model



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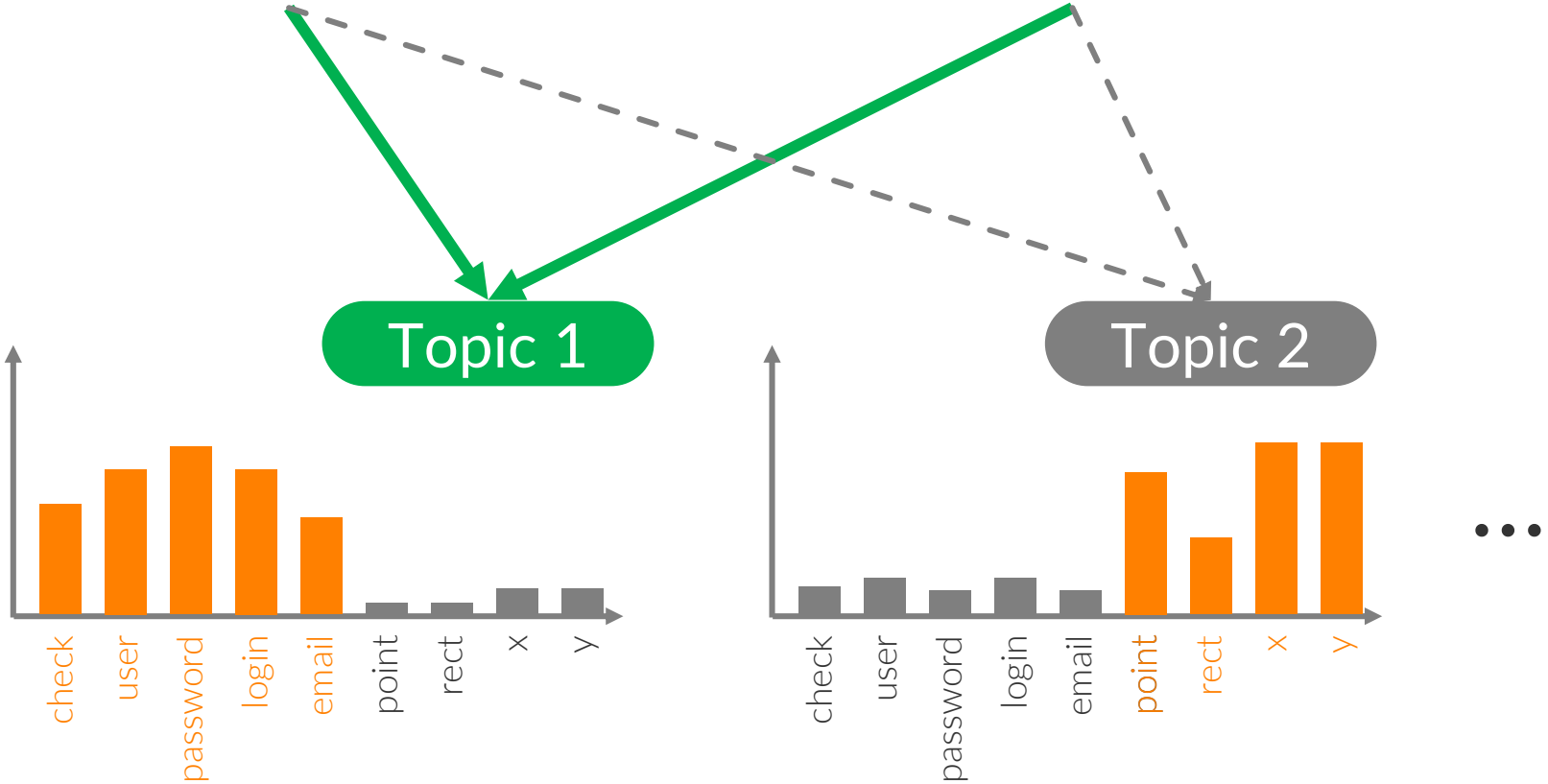
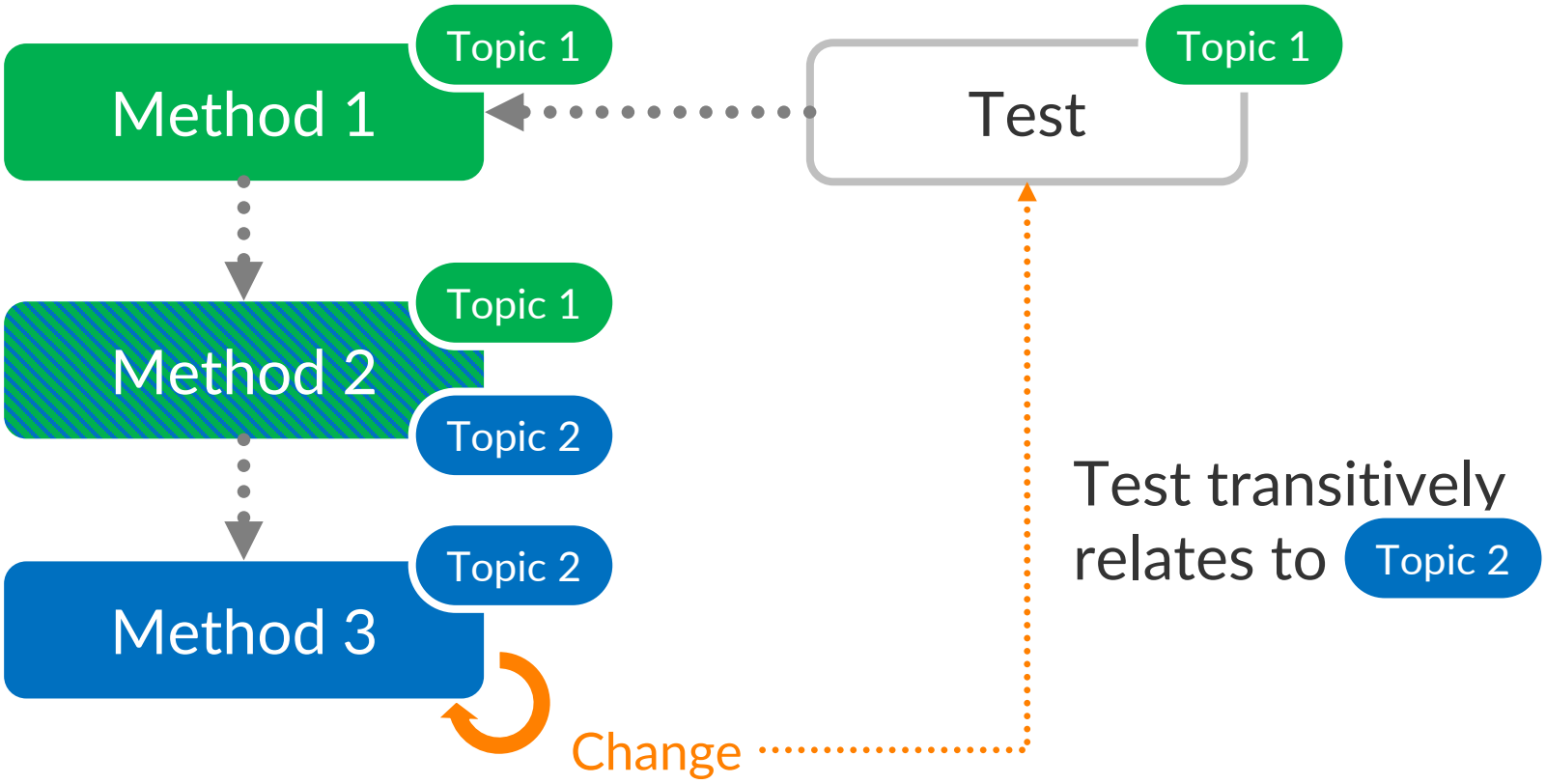


Approximating the Call Graph



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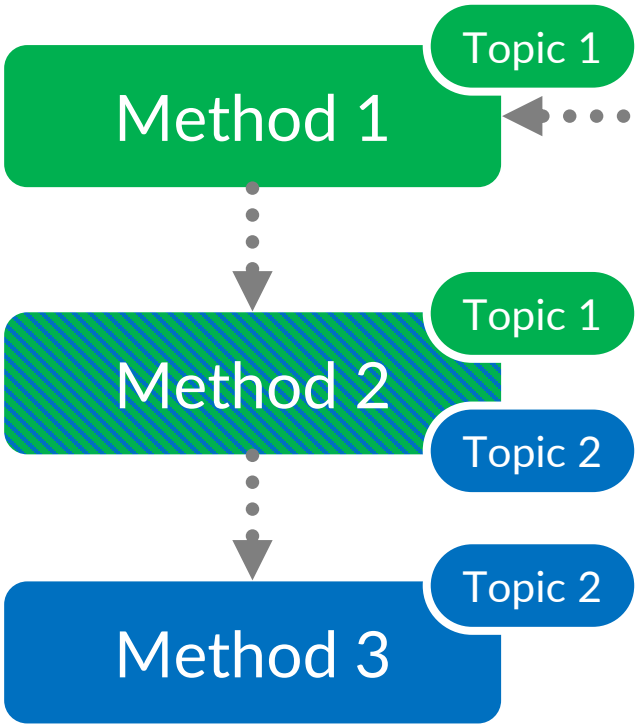
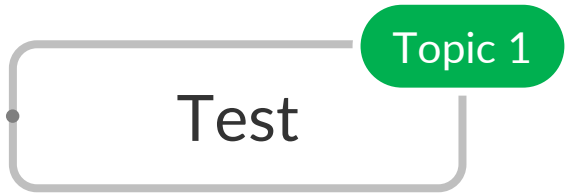
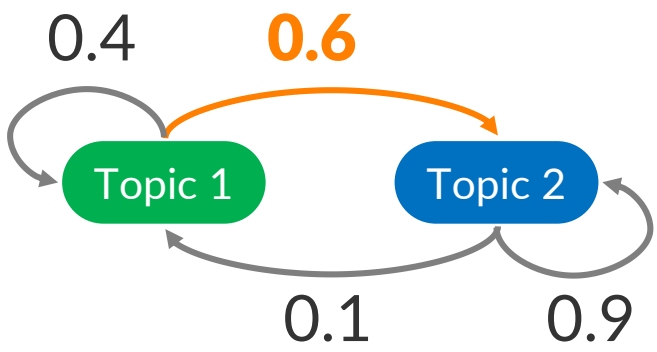




Markov Chain



Live Testing Tools

AutoTDD runs a selected set of tests whenever another selected set of code locations is changed

GitHub, Inc. (US) | https://github.com/hpi-swa-teaching/AutoTDD

AutoTDD with Travis-CI Support

build passing

Installation

1. Make sure you have metacello-work installed.
2. Load the project with:

```
Metacello new
```

Conclusion

- **Change-based fault seeding** is an effective method to generate many failures distributed like actual changes
- **Lexical information** can be exploited to quickly guess which tests may fail
- There is more potential in exploring **topicality** and **Markov properties** of the vocabulary