

OPENVALUE



FEAR THE MUTANTS. LOVE THE MUTANTS.

Max Kahan

 **@max_does_tech**

Paco van Beckhoven


 **@DevPaco**



V VONAGE

OPENVALUE

ENTER... OUR PROTAGONIST

A photograph of a penguin, likely a Gentoo penguin, standing in a snowy environment. The penguin has a white body, a black head and neck, and a distinctive white patch around its eye. Its wings are slightly out, and its orange beak is visible. The background is a soft-focus snowfield.

Henry



WHO'S HEARD OF...



...TESTING?



...CODE COVERAGE?



...MUTATION TESTING?



MAINTENANCE



DOCUMENTATION



**“Always code as if the guy who ends up
maintaining your code will be a violent
psychopath who knows where you live”
— John F. Woods**





THE PROBLEM

Projects evolve, grow

Tests evolve, sometimes missed when refactoring

Test code often not monitored

CODE COVERAGE

“How much of the source code of a program is executed when a test suite is run”



EXAMPLE


```
public Result submit(Proposal proposal, int openProposals, Instant deadline){  
    if (openProposals >= 3 || Instant.now().isAfter(deadline)) {  
        notificationService.notifySubmitFailed(proposal.getUserId());  
        return new Failure("Not allowed to submit");  
    }  
  
    // Doing the actual submit  
    return new Success();  
}
```


METHOD COVERAGE

```
public Result submit(Proposal proposal, int openProposals, Instant deadline) {  
    if (openProposals >= 3 || Instant.now().isAfter(deadline)) {  
        notificationService.notifySubmitFailed(proposal.getUserId());  
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METHOD COVERAGE

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    }  
  
    // Doing the actual submit  
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}
```

TESTS:

```
testX: submit(proposal, 0, Instant.now().plusSeconds(999));
```


STATEMENT COVERAGE

```
public Result submit(Proposal proposal, int openProposals, Instant deadline) {  
    if (openProposals >= 3 || Instant.now().isAfter(deadline)) {  
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        return new Failure("Not allowed to submit");  
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```

TESTS:

```
testX: submit(proposal, 0, Instant.now().plusSeconds(999));  
testY: submit(proposal, 5, Instant.now().plusSeconds(999));
```


CONDITION COVERAGE

```
public Result submit(Proposal proposal, int openProposals, Instant deadline) {  
    if (openProposals >= 3 || Instant.now().isAfter(deadline)) {  
        notificationService.notifySubmitFailed(proposal.getUserId());  
        return new Failure("Not allowed to submit");  
    }  
  
    // Doing the actual submit  
    return new Success();  
}
```

TESTS:

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testX: submit(proposal, 0, Instant.now().plusSeconds(999));  
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CONDITION COVERAGE

```
public Result submit(Proposal proposal, int openProposals, Instant deadline) {  
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        return new Failure("Not allowed to submit");  
    }  
  
    // Doing the actual submit  
    return new Success();  
}
```

TESTS:

```
testX: submit(proposal, 0, Instant.now().plusSeconds(999));  
testY: submit(proposal, 5, Instant.now().plusSeconds(999));  
testZ: submit(proposal, 0, Instant.now().minusSeconds(999));
```


THE GOOD

Helps you write more/better tests

Easy/cheap to measure

Shows what you didn't test

Shows that what you did test, didn't crash

THE NOT-SO-GOOD

Can be misleading

Doesn't guarantee test quality



THE NOT-SO-GOOD

Can be misleading

Doesn't guarantee test quality



```
@Test
public void shouldReturnSuccessOnValidSubmit() {
    proposalService.submit(randomProposal(), 0, tomorrow());
}
```


GOODHART'S LAW

**“When a metric becomes
a target, it ceases to be a
good metric.”**

How do we know...

...if our tests are high quality?

How can we understand...
...what our tests are really doing?

How do we know...

...if our tests are trustworthy?

**“Who watches the
watchers?”**

- Juvenal, 100 AD, after a 4th glass of wine



MUTATION TESTING

Introduce faults in code

Run your test suite

If tests fail, good!

Otherwise, bad!

A way to evaluate test quality

A photograph of a Gentoo penguin standing in a snowy environment. The penguin has a white body, a black head and neck, and a distinctive white patch around its eye. Its wings are slightly out, and its orange beak and feet are visible. The background is a soft-focus snowfield.

Henry



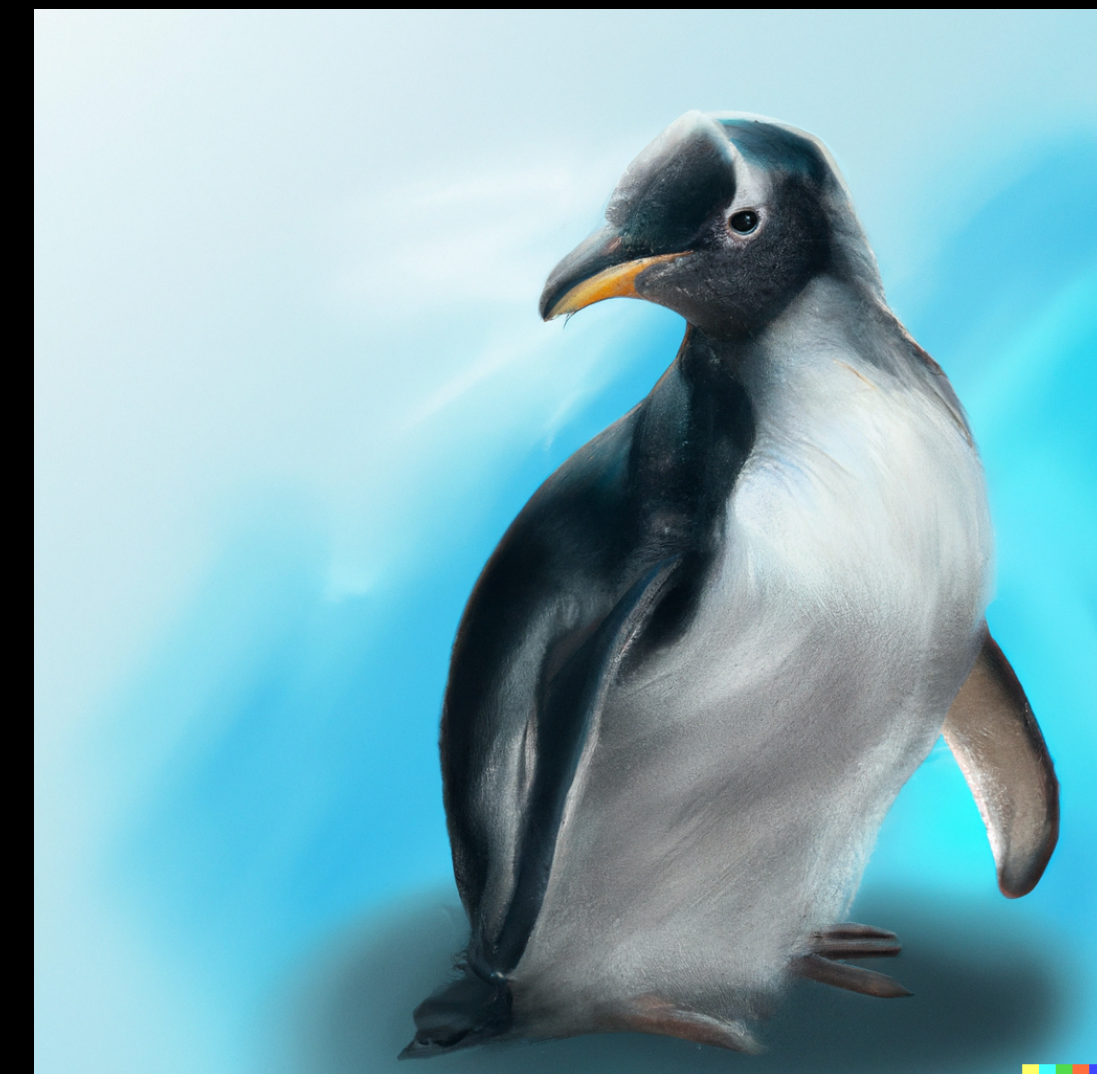




STEP 1: GENERATING MUTANTS



Production code



The mutant
Altered version of the
production code

CONDITIONAL LOGIC MUTATORS



```
boolean isAllowedToApplyForDriversLicense(int age) {  
    return age >= 17;  
}
```



```
boolean isAllowedToApplyForDriversLicense(int age) {  
    return age < 17;  
}
```


CONDITIONAL LOGIC MUTATORS



```
boolean isAllowedToApplyForDriversLicense(int age) {  
    return age >= 17;  
}
```

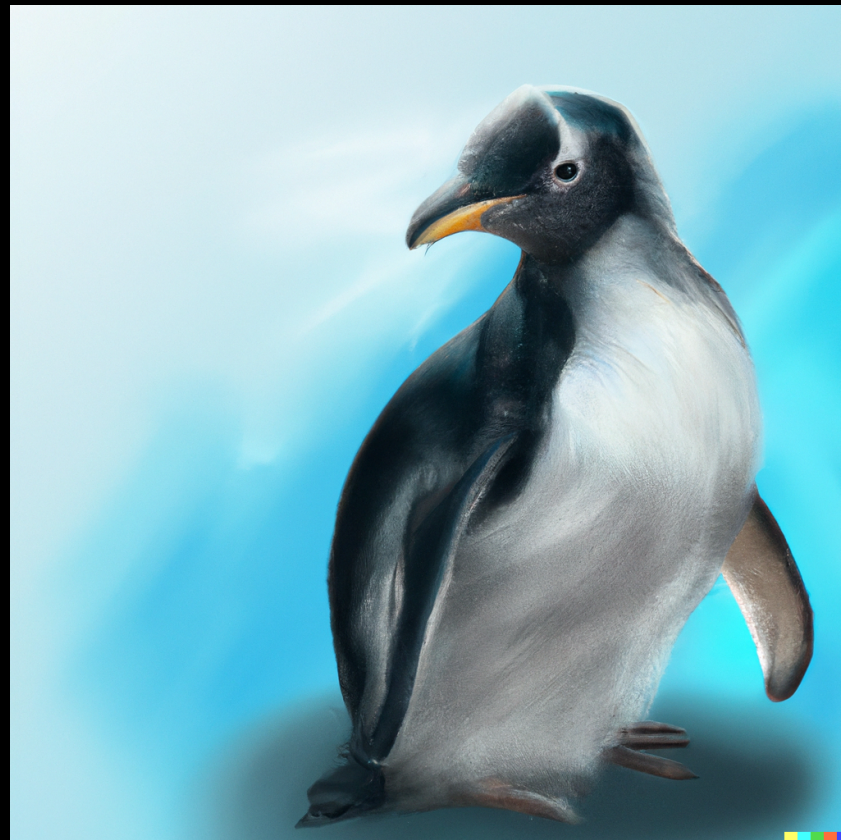


```
return age < 17; // negate conditional  
return age > 17; // change conditional boundaries  
return true;    // true returns  
return false;   // false returns
```

REMOVING STATEMENT

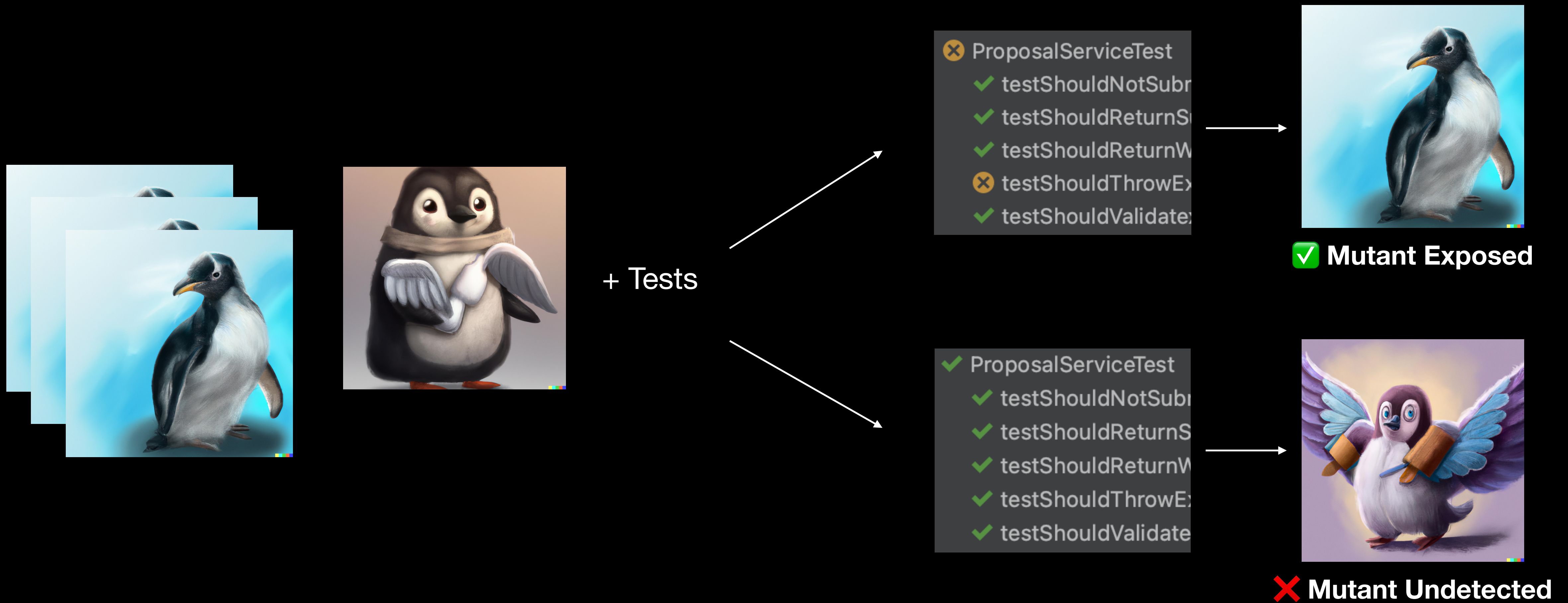


```
Metadata addTimeStamp(Metadata metaData, Instant timestamp) {  
    metaData.setPublished(timestamp);  
    return metaData;  
}
```



```
Metadata addTimeStamp(Metadata metaData, Instant timestamp) {  
    return metaData;  
}
```


STEP 2: MUTATION ANALYSIS





MUTATION TESTING FRAMEWORKS

boxed / mutmut

Public

Watch 10

Fork 66

Star 694

<> Code

Issues 51

Pull requests 5

Actions

Projects

Security

Insights

master

Go to file

Add file

<> Code

About

Anders Hovmöller Release on Dec 11, 2022 456

.github/workflows

Delete lint stages from CI workflow

last year

docs

Fixed broken link. Fixed github issue #22

4 years ago

mutmut

Release

last month

tests

Fix thread synchronization issue, add test

last month

.gitignore

Much faster dunder whitelist code. This m...

3 years ago

Mutation testing system

mutmut.readthedocs.io

python testing mutation-testing

Readme

BSD-3-Clause license

694 stars

10 watching

sixty-north / cosmic-ray

Public

Watch 17

Fork 51

Star 516

<> Code

Issues 38

Pull requests 6

Actions

Projects

Wiki

Security

Insights

master

Go to file

Add file

<> Code

About

ThunderKey Feature - Verify that the module pat... 3 weeks ago 1,028

.github/workflows

Pipeline work.

last month

docs

Feature - Allow module-path configuratio...

last month

src/cosmic_ray

Feature - Verify that the module paths exi...

3 weeks ago

tests

Feature - Verify that the module paths exi...

3 weeks ago

Mutation testing for Python

python testing mutation-testing

Readme

MIT license

516 stars

17 watching



master

Go to file

Add file

<> Code

Anders Hovmöller Release ...

✓ on Dec 11, 2022 456

github/workflows	Delete lint stages from CI workflow	last year
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Mutation testing system

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python

testing

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10 watching

Vonage / vonage-python-sdkPublic

Edit Pins

Watch21

Fork102

Star155

<> Code

Issues1

Pull requests

Actions

Projects

Wiki

Security

Insights

...

main

Go to file

Add file

<> Code

About

maxkahan

Bump version: 3.2.1 → 3.2.2

...

✓ 3 days ago

🕒 473

📁 .github	Create mutation test github action (#232)	last month
📁 src/vonage	Bump version: 3.2.1 → 3.2.2	3 days ago
📁 tests	Fix ncco error (#238)	4 days ago
📄 .bumpversion.cfg	Bump version: 3.2.1 → 3.2.2	3 days ago
📄 .editorconfig	Test Python 3.7 on Travis CI (#76)	4 years ago

Vonage Server SDK for Python.
API support for SMS, Voice, Text-to-Speech, Numbers, Verify (2FA) and more.

developer.vonage.com

python

text-to-speech

video

phone

messaging

sms

voice

nexmo

two-factor authentication

<https://github.com/Vonage/vonage-python-sdk>


```
pip install mutmut
```

```
mutmut run
```



```
○ (venv-mutant) mkahan@V0NFVFH93FXQ05N vonage-python-sdk % mutmut run
```

– Mutation testing starting –



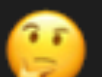


These are the steps:

1. A full test suite run will be made to make sure we can run the tests successfully and we know how long it takes (to detect infinite loops for example)
2. Mutants will be generated and checked

Results are stored in `.mutmut-cache`.

Print found mutants with ``mutmut results``.

Legend for output:

- | | |
|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
|  Killed mutants. | The goal is for everything to end up in this bucket. |
|  Timeout. | Test suite took 10 times as long as the baseline so were killed. |
|  Suspicious. | Tests took a long time, but not long enough to be fatal. |
|  Survived. | This means your tests need to be expanded. |
|  Skipped. | Skipped. |

mutmut cache is out of date, clearing it...

1. Running tests without mutations

:: Running...Done

2. Checking mutants

:: 682/682 🎉 512 ⌚ 0 🤔 0 😞 170 🚫 0

Let's look at some mutants!


```
class Messages:
    valid_message_channels = {'sms', 'mms', 'whatsapp', 'messenger', 'viber_service'}
```

```
class Messages:
    valid_message_channels = {'XXsmsXX', 'mms', 'whatsapp', 'messenger', 'viber_service'}
```

```
@validator('amount')
def round_amount(cls, v):
    return round(v, 2)
```

```
def round_amount(cls, v):
    return round(v, 2)
```

```
mutmut show  
mutmut html
```


mutmut show

Survived 🙄 (170)

----- src/vonage/_internal.py (4) -----

17-20

----- src/vonage/account.py (12) -----

492-493, 505-507, 510-512, 518-520, 522

----- src/vonage/application.py (10) -----

284-286, 291-293, 299-301, 303

mutmut show 1

```
--- src/vonage/short_codes.py
+++ src/vonage/short_codes.py
@@ -1,5 +1,5 @@
 class ShortCodes:
-     auth_type = 'params'
+     auth_type = 'XXparamsXX'
     defaults = {'auth_type': auth_type, 'body_is_json': False}

     def __init__(self, client):
```


mutmut html

Mutation testing report

Killed 512 out of 682 mutants

File	Total	Killed	% killed	Survived
src/vonage/numbers.py	18	18	100.00	0
src/vonage/sms.py	16	11	68.75	5
src/vonage/redact.py	21	10	47.62	11
src/vonage/client.py	212	159	75.00	53
src/vonage/messages.py	100	69	69.00	31
src/vonage/_internal.py	5	1	20.00	4
src/vonage/application.py	20	10	50.00	10
src/vonage/account.py	38	26	68.42	12
src/vonage/number_insight.py	22	21	95.45	1
src/vonage/ussd.py	10	10	100.00	0
src/vonage/voice.py	20	11	55.00	9
src/vonage/verify.py	24	24	100.00	0
src/vonage/short_codes.py	16	16	100.00	0
src/vonage/ncco_builder/pay_prompts.py	27	23	85.19	4
src/vonage/ncco_builder/input_types.py	2	2	100.00	0
src/vonage/ncco_builder/ncco.py	98	78	79.59	20
src/vonage/ncco_builder/connect_endpoints.py	33	23	69.70	10

Mutant 58

```
--- src/vonage/client.py
+++ src/vonage/client.py
@@ -35,7 +35,7 @@
     except ImportError:
         JSONDecodeError = ValueError
```

```
-logger = logging.getLogger("vonage")
+logger = logging.getLogger("XXvonageXX")
```


Mutant 62

```
--- src/vonage/client.py
+++ src/vonage/client.py
@@ -82,7 +82,7 @@
         timeout=None,
         pool_connections=10,
         pool_maxsize=10,
-        max_retries=3,
+        max_retries=4,
     ) :
```

Mutant 112

```
--- src/vonage/client.py
+++ src/vonage/client.py
@@ -122,7 +122,7 @@
         self.sms = Sms(self)
         self.usd = Usd(self)
         self.verify = Verify(self)
-        self.voice = Voice(self)
+        self.voice = None

         self.timeout = timeout
         self.session = Session()
```


PYTHON DEV?

Mutmut

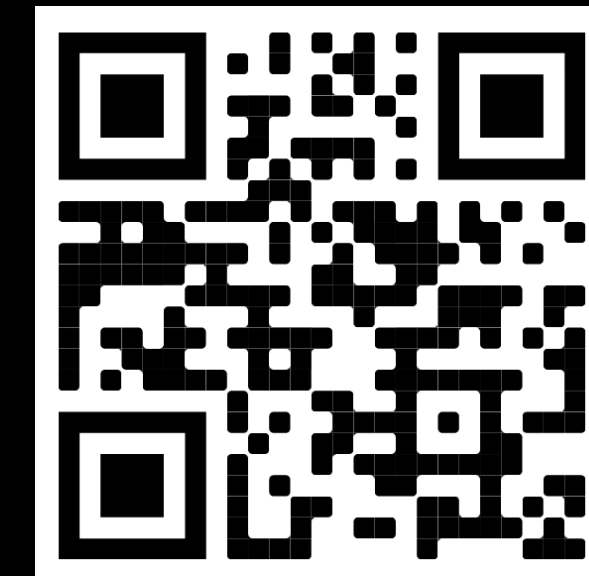
Python mutation testing



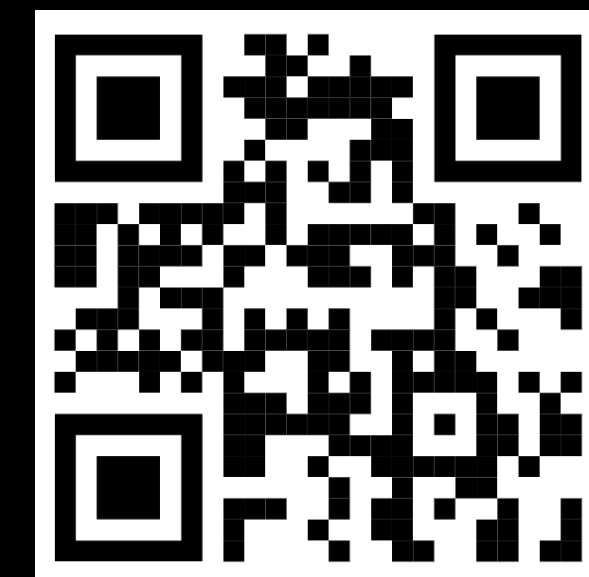
MORE FRAMEWORKS, MORE LANGUAGES



Pitest
Mutation testing for Java



Stryker
Supports JavaScript, C#, Scala



**CODE WITH GOOD COVERAGE
AND BAD MUTATION SCORE**

Pit Test Coverage Report

Package Summary

nl.openvalue.proposal

Number of Classes	Line Coverage	Mutation Coverage	Test Strength
3	86% <div><div>18/21</div></div>	31% <div><div>4/13</div></div>	33% <div><div>4/12</div></div>

Breakdown by Class

Name	Line Coverage	Mutation Coverage	Test Strength
NotificationService.java	0% <div><div>0/3</div></div>	0% <div><div>0/1</div></div>	0% <div><div>0/0</div></div>
ProposalService.java	100% <div><div>9/9</div></div>	67% <div><div>4/6</div></div>	67% <div><div>4/6</div></div>
ProposalService2.java	100% <div><div>9/9</div></div>	0% <div><div>0/6</div></div>	0% <div><div>0/6</div></div>

Report generated by [PIT](#) 1.9.4

mutmut cache is out of date, clearing it...

1. Running tests without mutations

:: Running...Done

2. Checking mutants

:: 682/682  512  0  0  170  0

$$512/682 \approx 75\%$$

Is this good?

100% doesn't make sense



GETTING STARTED

Start locally & start small

Tweak for performance:

- Exclude tests
- Exclude code



RUNNING OFF YOUR MACHINE

WHY?

Takes time

Use cloud resources

Specify platforms and versions



EXAMPLE

Edit Pins

Watch 21

Fork 102

Star 155

Code

Issues 1

Pull requests

Actions

Projects

Wiki

Security

Insights

...

Actions

New workflow

All workflows

Build

Lint

Mutation Test

Management

Caches

Mutation Test

mutation-test.yml

Filter workflow runs

...

33 workflow runs

Event

Status

Branch

Actor

This workflow has a workflow_dispatch event trigger.

Run workflow

✓ Mutation Test

Mutation Test #34: Manually run by maxkahan

15 hours ago ...
14m 51s

✓ Mutation Test

last month ...

event trigger.

Run workflow ▼

Use workflow from

Branch: main ▼

Run workflow

✓ **Mutation Test #34**

Re-run all jobs



🏠 Summary

Jobs

✓ run mutation test (...)

Run details

🕒 Usage

📄 Workflow file

Manually triggered 16 hours ago

maxkahan de12078

Status

Success

Total duration

14m 51s

Artifacts

1

mutation-test.yml

on: workflow_dispatch

Matrix: run mutation test

✓ **1 job completed**

Show all jobs



Artifacts

Produced during runtime

Name	Size
------	------



mutation-test-report

79 KB





DOING THIS YOURSELF

GitHub Actions

```
1  name: Mutation Test
2  on: workflow_dispatch
3
4
5
6
7
8
9
10
11
12
13
14
```



```
15     steps:
16     - uses: actions/checkout@v3
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
```

OTHER CI CONCERNS

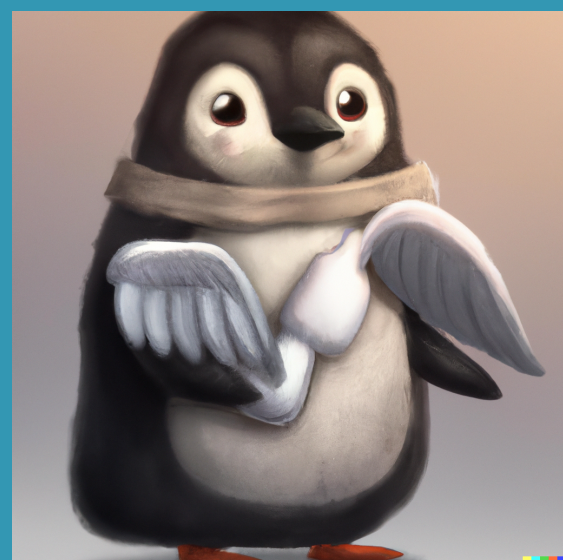
Manual vs. Automatic triggering?

Multiple versions

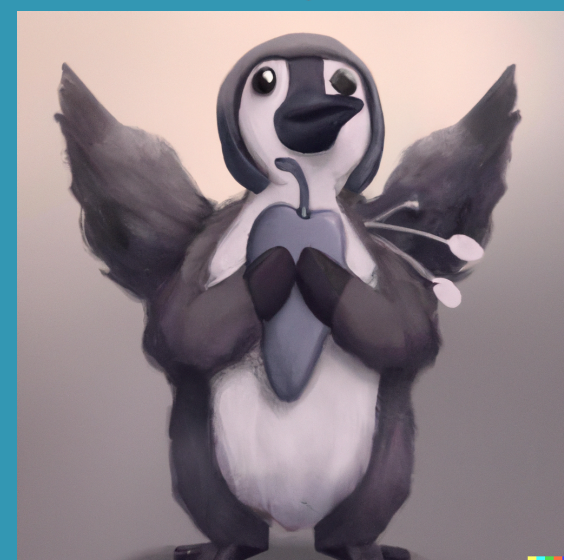
Should we run on push/PR?



**SHOULD I USE
MUTATION TESTING?**



YES



NO



Are there lives at stake?
Are you building software for a rocket?
Is it a self driving car?

Are you using code coverage?
What is the cost of fixing a bug?

SUMMARY

Mutation testing tests your tests

Helps beat Goodhart's Law

Start small

Run in a CI system for async reports

Mutants are valuable and wonderful

Don't fear them, love them!

