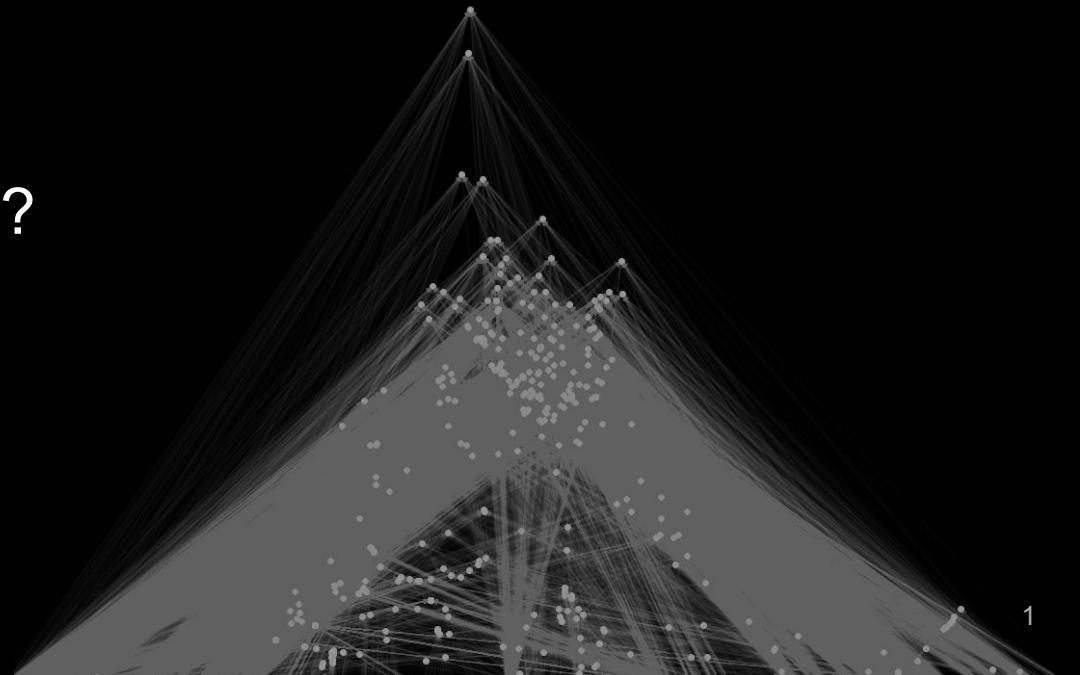


# How does Software break?

Code Repository Mining Seminar SS20  
Software Architecture Chair

Dominik Meier  
July 14th, 2020



The screenshot shows a PyCharm interface with two code files open in split panes, facilitating a side-by-side comparison.

**Left File:** CRM - reordering\_evaluation.py

```
File Edit View Navigate Code Refactor Run Tools VCS Window Help
CRM - mutester > reordering_evaluation.py
Project Test Execution Test AppContext Main... Test Reordering Evaluation
CRM /studium/8_Semester/CRM
github
.github_checkpoints
.pytest_cache
.azure-devops-python-samples
mutester
__init__.py
main.py
data_analysis.py
data_crawler.py
data_crawler.pybak
execution.py
mutant.py
reordering_evaluation.py
semantic_mutant_analysis.py
Mutester.egg-info
paper
repos
submodules
tests
data
__init__.py
integration_tests.py
test_execution.py
test_mutant.py
test_reordering_evaluation.py
test_semantic_mutant_analysis.py
.gitignore
.gitmodules
.gitmutt-cache
20200618-170401_dataframe.pkl
20200618-171810_dataframe.pkl
20200618-171920_dataframe.pkl
20200618-172936_dataframe.pkl
20200618-173037_dataframe.pkl
20200618-173422_dataframe.pkl
20200618-175337_dataframe.pkl
20200621-215850_dataframe.pkl
20200621-220847_dataframe.pkl
20200621-221912_dataframe.pkl
20200621-222027_dataframe.pkl
20200621-222311_dataframe.pkl
23
import pytest
import pandas
from mutester.reordering_evaluation import ReorderingEvaluation
28
@pytest.fixture()
def dataframe():
    data = {'test_id': [1, 2, 3, 4, 5], 'outcome': [True, False, True, False, True]}
    pd = pandas.DataFrame(data)
    return pd
10
@pytest.fixture()
def linear_ordering():
    return [1, 2, 3, 4, 5]
7
6
@pytest.fixture()
5
def reverse_ordering():
4
    return [5, 4, 3, 2, 1]
3
2
1
24
def good_ordering():
    return [2, 4, 5, 1, 3]
1
2
def test_linear_ordering(linear_ordering, dataframe):
3
    r = ReorderingEvaluation(linear_ordering, dataframe)
4
    assert r.first_failing_duration() == 3
5
    assert r.last_test_failing_duration() == 15
6
    assert round(r.APFD(), 6) == round(0.3666666666666666, 6)
8
def test_reverse_ordering(reverse_ordering, dataframe):
9
    r = ReorderingEvaluation(reverse_ordering, dataframe)
10
    assert r.first_failing_duration() == 5
11
    assert r.last_test_failing_duration() == 14
good_ordering()
```

**Right File:** pytest for test\_reordering\_evaluation.test\_good\_ordering

```
File Edit View Navigate Code Refactor Run Tools VCS Window Help
pytest for test_reordering_evaluation.test_good_ordering > builtins.py
reordering_evaluation.py
23
from typing import List
22
from pandas import DataFrame
21
28
class ReorderingEvaluation:
19
    def __init__(self, ordering: List[int], dataframe: DataFrame):
18
        self.ordering = ordering
16
        self.dataframe = dataframe
14
# TODO: assert that ordering and dataframe are kind of legit
assert len(self.ordering) == self.dataframe.shape[0], "Dataframe has"
13
12
def first_failing_duration(self):
11
    summed_duration = 0
10
    for test_id in self.ordering:
9
        rows = self.dataframe.loc[self.dataframe['test_id'] == test_id]
8
        assert rows.shape[0] == 1, "The provided dataframe contains more"
7
6
        summed_duration += rows['duration'].iloc[0]
5
        if rows['outcome'].iloc[0] == False:
4
            return summed_duration
3
2
1
24
def last_test_failing_duration(self):
1
    summed_duration = 0
2
    temporary_duration = 0
3
    for test_id in self.ordering:
4
        rows = self.dataframe.loc[self.dataframe['test_id'] == test_id]
5
        assert rows.shape[0] == 1, "The provided dataframe contains more"
6
7
        if rows['outcome'].iloc[0] == True:
8
            temporary_duration += rows['duration'].iloc[0]
9
        if rows['outcome'].iloc[0] == False:
10
            summed_duration += temporary_duration + rows['duration'].iloc[0]
11
            temporary_duration = 0
ReorderingEvaluation.last_test_failing_duration()
```



## Pipelines

[Recent](#) [All](#) [Runs](#)

### All pipeline runs

#### Description

#### Stages

##### Merge pull request #3620 from pallets/requirements

#20200523.3 on Tests master 51c87e6



May 23  
 1m 0s

##### use pip-compile to pin dev requirements

#20200523.2 on Tests 3620 e47837b



May 23  
 1m 3s

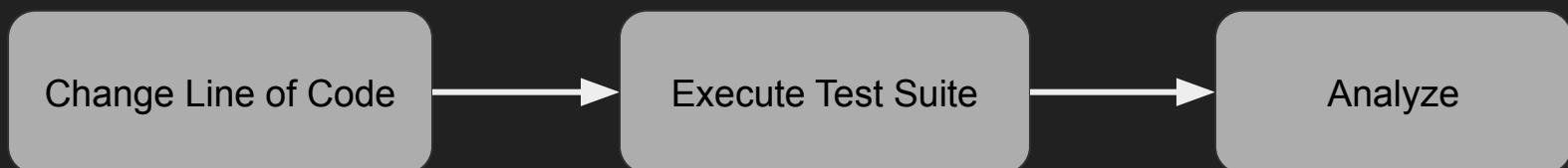
##### add EditorConfig

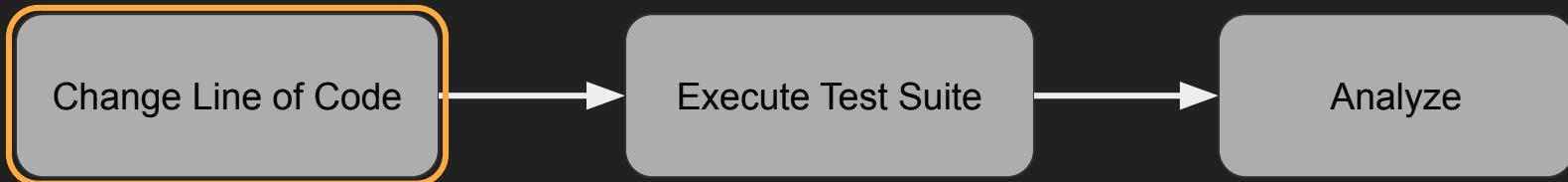
#20200523.1 on Tests master 295e1e7



May 23  
 1m 7s

# Recap: Mutation Testing



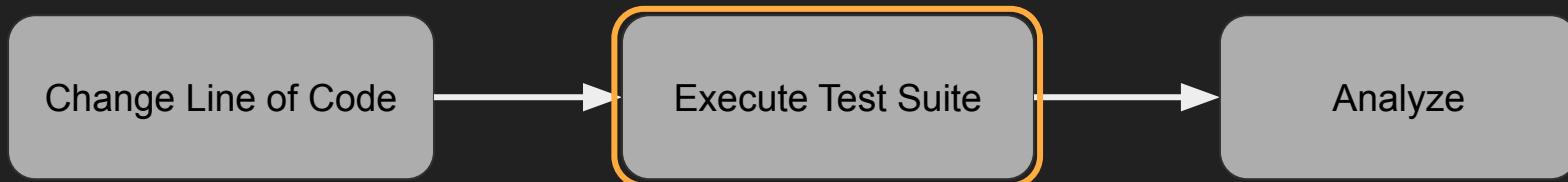


```
@property
def max_cookie_size(self):
    """Read-only view of the :data:`MAX_COOKIE_SIZE` config key.

    See :attr:`werkzeug.wrappers.BaseResponse.max_cookie_size` in
    Werkzeug's docs.
    """
    if current_app:
        return current_app.config["XXMAX_COOKIE_SIZEXX"]

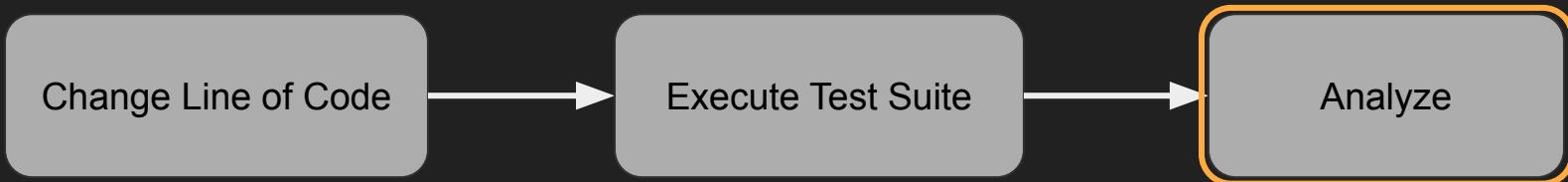
    # return Werkzeug's default when not in an app context
    return super().max_cookie_size
```

```
if current_app:
-     return current_app.config["MAX_COOKIE_SIZE"]
+     return current_app.config["XXMAX_COOKIE_SIZEXX"]
```

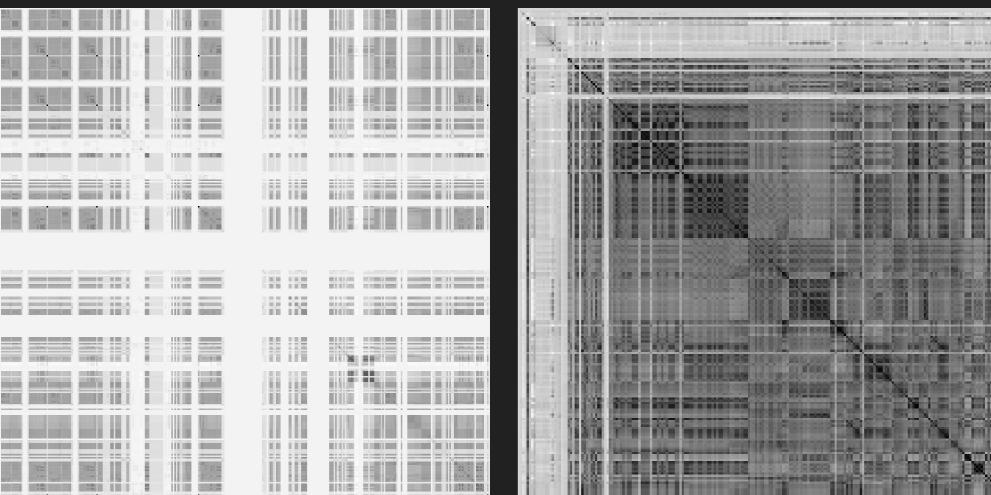
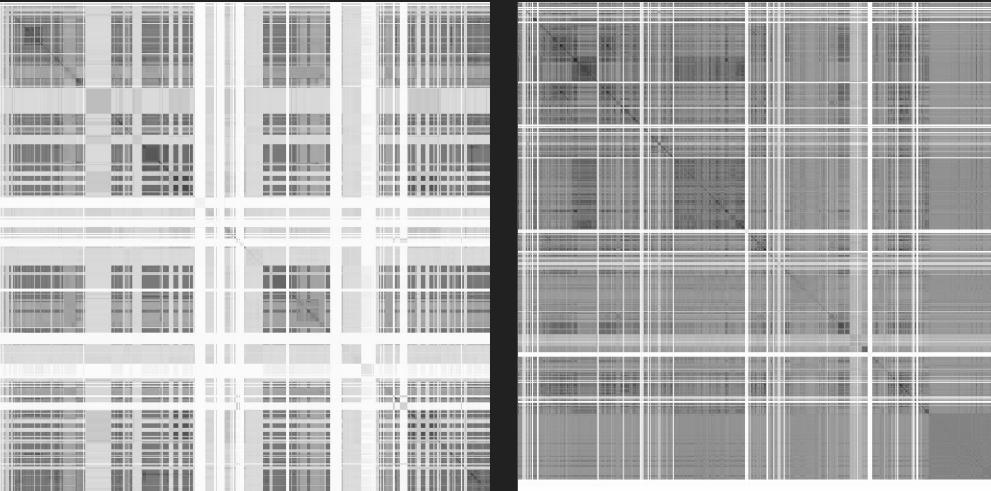


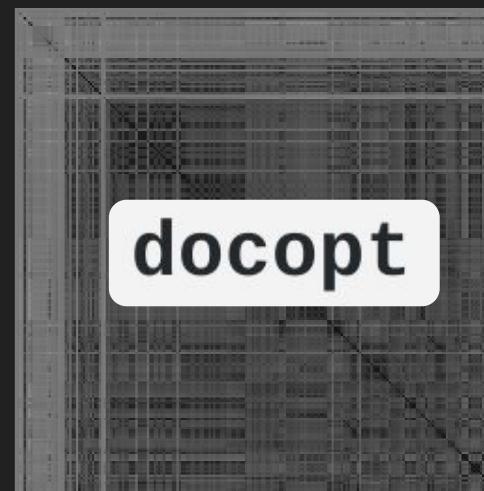
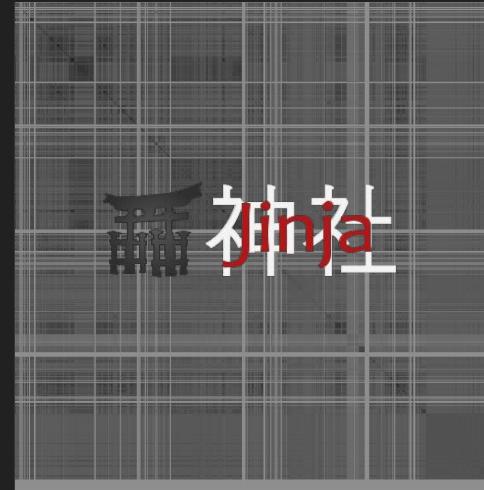
```
===== short test summary info =====
FAILED tests/test_basic.py::test_session - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_basic.py::test_session_using_server_name - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_basic.py::test_session_using_server_name_and_port - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_basic.py::test_session_using_server_name_port_and_path - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_basic.py::test_session_using_application_root - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_basic.py::test_session_using_session_settings - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_basic.py::test_session_using_samesite_attribute - KeyError: 'XXMAX_COOKIE_SIZEEXX'
|FAILED tests/test_basic.py::test_session_localhost_warning - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_basic.py::test_session_ip_warning - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_basic.py::test_session_expiration - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_basic.py::test_session_stored_last - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_basic.py::test_session_special_types - KeyError: 'XXMAX_COOKIE_SIZEEXX'
|FAILED tests/test_basic.py::test_session_cookie_setting - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_basic.py::test_session_vary_cookie - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_basic.py::test_extended_flashing - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_basic.py::test_max_cookie_size - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_helpers.py::TestStreaming::test_stream_keeps_session - KeyError: 'XXMAX_COOKIE_SIZEEXX'
|FAILED tests/test_reqctx.py::test_session_dynamic_cookie_name - AssertionError: assert b'<!DOCTYPE H...cation.</p>\n' ...
FAILED tests/test_templating.py::test_standard_context - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_testing.py::test_redirect_keep_session - KeyError: 'XXMAX_COOKIE_SIZEEXX'
FAILED tests/test_testing.py::test_session_transactions - KeyError: 'XXMAX_COOKIE_SIZEEXX'
ERROR tests/test_helpers.py::TestStreaming::test_stream_keeps_session - AssertionError: assert [<RequestCont...f flask...
===== 21 failed, 431 passed, 13 skipped, 3 xpassed, 1 error in 5.55s =====
```

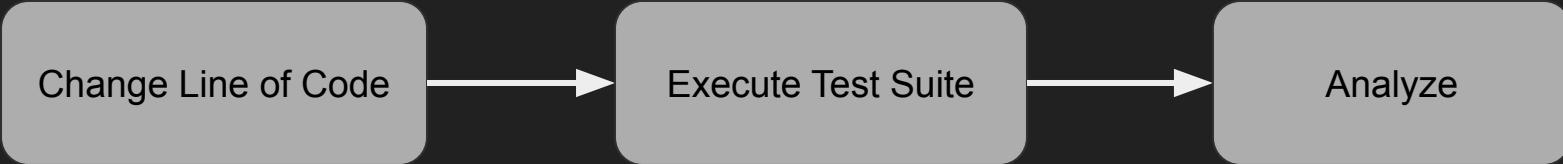
PID	USER	PRI	NI	VIRT	RES	SHR	S	CPU%	MEM%	TIME+	Command
42642	dmeier	20	0	4700M	143M	24744	S	105.	0.0	3:00.10	python mutester repos/flask/ repos/flask/env/ 1 2094 --filename flask_full_threaded_with_method_names -j 20 -v
48904	dmeier	20	0	142M	53964	9196	R	100.	0.0	0:58.00	/tmp/tmpqzulmpa/venv/bin/python /tmp/tmpqzulmpa/venv/bin/pytest -N --timeout=70 --json=report.json
51207	dmeier	20	0	137M	49408	8848	R	99.7	0.0	0:09.67	/tmp/tmp19op5chq/venv/bin/python /tmp/tmp19op5chq/venv/bin/pytest -N --timeout=30 --json=report.json
51624	dmeier	20	0	130M	41968	8836	R	99.7	0.0	0:03.50	/tmp/tmpa8swk_ug/venv/bin/python /tmp/tmpa8swk_ug/venv/bin/pytest -N --timeout=70 --json=report.json
51698	dmeier	20	0	126M	39848	9236	R	99.7	0.0	0:02.30	/tmp/tmpasyokit5/venv/bin/python /tmp/tmpasyokit5/venv/bin/pytest -N --timeout=70 --json=report.json
51706	dmeier	20	0	123M	36372	8568	R	99.7	0.0	0:02.21	/tmp/tmp02hhbsu/venv/bin/python /tmp/tmp02hhbsu/venv/bin/pytest -N --timeout=70 --json=report.json
51729	dmeier	20	0	123M	36112	8776	R	99.7	0.0	0:01.82	/tmp/tmpc07208od/venv/bin/python /tmp/tmpc07208od/venv/bin/pytest -N --timeout=70 --json=report.json
51060	dmeier	20	0	221M	49664	9352	R	99.0	0.0	0:11.67	/tmp/tmpy9dqvb1g/venv/bin/python /tmp/tmpy9dqvb1g/venv/bin/pytest -N --timeout=30 --json=report.json
50617	dmeier	20	0	229M	56244	10280	R	99.0	0.0	0:19.89	/tmp/tmp_abq2rnu/venv/bin/python /tmp/tmp_abq2rnu/venv/bin/pytest -N --timeout=30 --json=report.json
47260	dmeier	20	0	213M	42684	9104	R	99.0	0.0	1:34.17	/tmp/tmp2k_9l6y_/venv/bin/python /tmp/tmp2k_9l6y_/venv/bin/pytest -N --timeout=30 --json=report.json
51740	dmeier	20	0	122M	36168	8836	R	99.0	0.0	0:01.68	/tmp/tmpkfipmdcq/venv/bin/python /tmp/tmpkfipmdcq/venv/bin/pytest -N --timeout=70 --json=report.json
51482	dmeier	20	0	225M	51736	16208	R	81.5	0.0	0:05.11	/tmp/tmp5wid0772/venv/bin/python /tmp/tmp5wid0772/venv/bin/pytest -N --timeout=30 --json=report.json
49376	dmeier	20	0	3469M	82276	24612	S	74.0	0.0	0:17.79	python mutester repos/jinja/ repos/flask/env/ 1 4959 -j 10 -v
50184	dmeier	20	0	3469M	82276	24612	S	19.4	0.0	0:01.24	python mutester repos/jinja/ repos/flask/env/ 1 4959 -j 10 -v
50190	dmeier	20	0	3469M	82276	24612	S	19.4	0.0	0:01.12	python mutester repos/jinja/ repos/flask/env/ 1 4959 -j 10 -v
50181	dmeier	20	0	3469M	82276	24612	S	13.8	0.0	0:00.61	python mutester repos/jinja/ repos/flask/env/ 1 4959 -j 10 -v
42791	dmeier	20	0	4700M	143M	24744	D	11.3	0.0	0:05.40	python mutester repos/flask/ repos/flask/env/ 1 2094 --filename flask_full_threaded_with_method_names -j 20 -v
42796	dmeier	20	0	4700M	143M	24744	D	10.7	0.0	0:07.20	python mutester repos/flask/ repos/flask/env/ 1 2094 --filename flask_full_threaded_with_method_names -j 20 -v
51702	dmeier	20	0	4700M	143M	24744	D	10.7	0.0	0:00.17	python mutester repos/flask/ repos/flask/env/ 1 2094 --filename flask_full_threaded_with_method_names -j 20 -v
42786	dmeier	20	0	4700M	143M	24744	D	10.0	0.0	0:07.16	python mutester repos/flask/ repos/flask/env/ 1 2094 --filename flask_full_threaded_with_method_names -j 20 -v
51688	dmeier	20	0	4700M	143M	24744	R	8.8	0.0	0:00.15	python mutester repos/flask/ repos/flask/env/ 1 2094 --filename flask_full_threaded_with_method_names -j 20 -v
42771	dmeier	20	0	4700M	143M	24744	D	7.5	0.0	0:08.04	python mutester repos/flask/ repos/flask/env/ 1 2094 --filename flask_full_threaded_with_method_names -j 20 -v
42767	dmeier	20	0	4700M	143M	24744	D	6.9	0.0	0:07.82	python mutester repos/flask/ repos/flask/env/ 1 2094 --filename flask_full_threaded_with_method_names -j 20 -v
50182	dmeier	20	0	3469M	82276	24612	S	6.3	0.0	0:01.18	python mutester repos/jinja/ repos/flask/env/ 1 4959 -j 10 -v



mutant_id	current_line	line_number_changed	modified_file_path	previous_line	outcome	test_id	full_name	name	filepath	duration
0	1665.0	exc_info = None\n	335.0	src/flask/cli.py	True	0.0	tests/test_appctx.py::test_basic_url_generation	test_basic_url_generation	tests/test_appctx.py	0.060797
1	1665.0	exc_info = None\n	335.0	src/flask/cli.py	True	1.0	tests/test_appctx.py::test_url_generation_requ...	test_url_generation_requires_server_name	tests/test_appctx.py	0.003388
2	1665.0	exc_info = None\n	335.0	src/flask/cli.py	True	2.0	tests/test_appctx.py::test_url_generation_with...	test_url_generation_without_context_fails	tests/test_appctx.py	0.000921
3	1665.0	exc_info = None\n	335.0	src/flask/cli.py	True	3.0	tests/test_appctx.py::test_request_context_mea...	test_request_context_means_app_context	tests/test_appctx.py	0.003365
4	1665.0	exc_info = None\n	335.0	src/flask/cli.py	True	4.0	tests/test_appctx.py::test_app_context_provide...	test_app_context_provides_current_app	tests/test_appctx.py	0.002728
...	...	...	...	...	...	...	...	...	...	...
958036	1040.0	if self.session_interface.is_null_sess...	2171.0	src/flask/app.py	True	463.0	tests/test_views.py::test_explicit_head	test_explicit_head	tests/test_views.py	0.004476
958037	1040.0	if self.session_interface.is_null_sess...	2171.0	src/flask/app.py	True	464.0	tests/test_views.py::test_endpoint_override	test_endpoint_override	tests/test_views.py	0.005103
958038	1040.0	if self.session_interface.is_null_sess...	2171.0	src/flask/app.py	True	465.0	tests/test_views.py::test_methods_var_inheritance	test_methods_var_inheritance	tests/test_views.py	0.004000
958039	1040.0	if self.session_interface.is_null_sess...	2171.0	src/flask/app.py	True	466.0	tests/test_views.py::test_multiple_inheritance	test_multiple_inheritance	tests/test_views.py	0.004184
958040	1040.0	if self.session_interface.is_null_sess...	2171.0	src/flask/app.py	True	467.0	tests/test_views.py::test_remove_method_from_p...	test_remove_method_from_parent	tests/test_views.py	0.018770







```
-     self.instance_path = instance_path
+     self.instance_path = None

-         if index is None:
+         if index is not None:

if current_app:
    return current_app.config["MAX_COOKIE_SIZE"]
    return current_app.config["XXMAX_COOKIE_SIZEXX"]
```

**mutmut - python mutation tester**

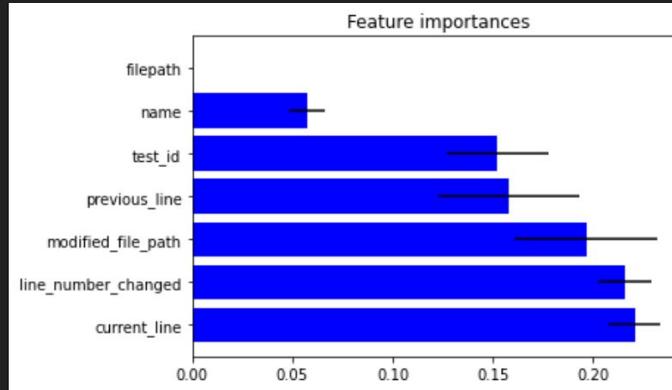


4 Projects  
~ 5.000.000 Test Executions  
~ 9.000 Mutations

# Can we predict failing tests?

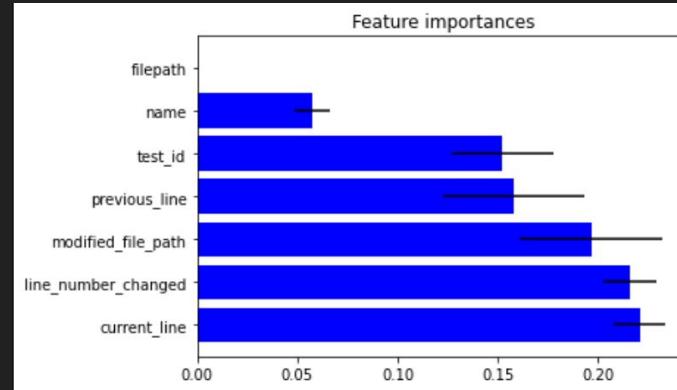
Yes!

```
True      599141  
False     42716  
Name: outcome, dtype: int64  
True      273971  
False     42168  
Name: outcome, dtype: int64  
precision    recall   f1-score  
  
    False      0.60      0.25      0.36  
    True       0.89      0.97      0.93  
  
accuracy          0.88  
macro avg       0.75      0.61      0.64  
weighted avg     0.85      0.88      0.86
```

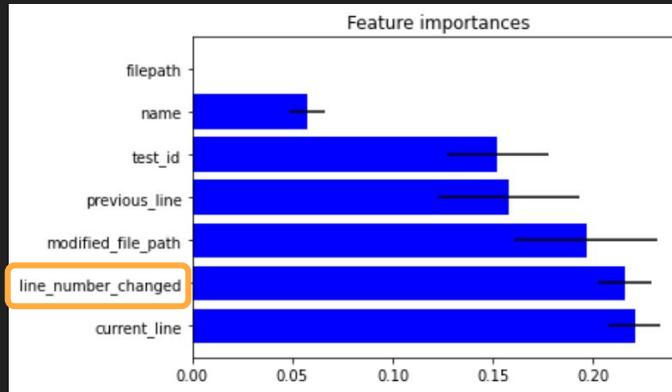


only 9%  
failures

True	599141		
False	42716		
Name: outcome, dtype: int64			
True	273971		
False	42168		
Name: outcome, dtype: int64			
	precision	recall	f1-score
False	0.60	0.25	0.36
True	0.89	0.97	0.93
accuracy			0.88
macro avg	0.75	0.61	0.64
weighted avg	0.85	0.88	0.86



```
True      599141  
False     42716  
Name: outcome, dtype: int64  
True      273971  
False     42168  
Name: outcome, dtype: int64  
precision    recall   f1-score  
  
    False      0.60      0.25      0.36  
    True       0.89      0.97      0.93  
  
accuracy          0.88  
macro avg       0.75      0.61      0.64  
weighted avg     0.85      0.88      0.86
```



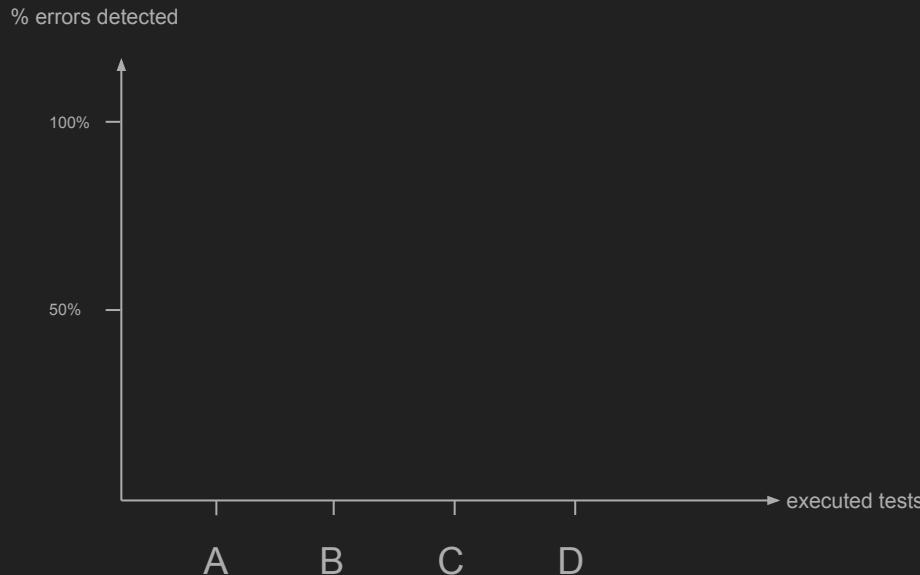
# Test Case Reordering Metrics in a nutshell

Test	Outcome
A	✓
B	✗
C	✓
D	✗

# Test Case Reordering Metrics in a nutshell

Test	Outcome
A	✓
B	✗
C	✓
D	✗

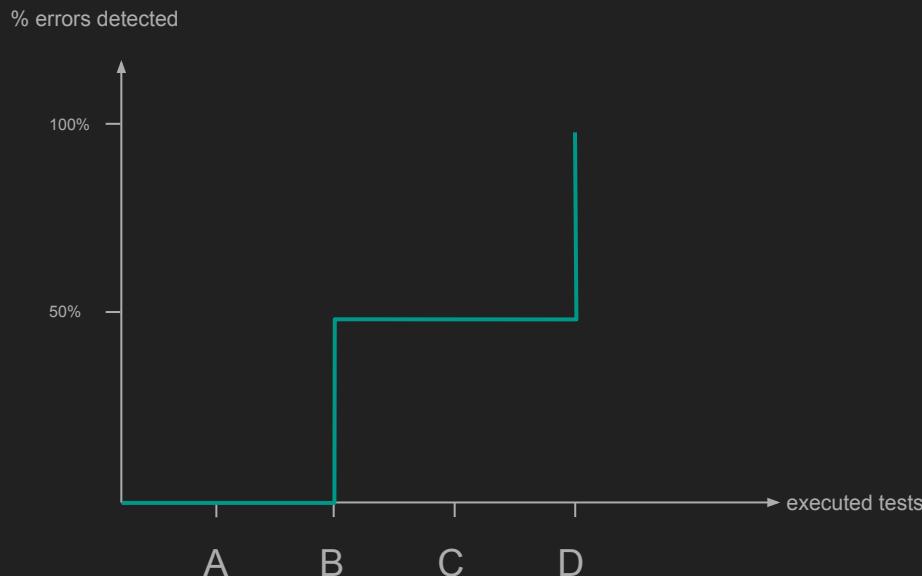
Naive Ordering:



# Test Case Reordering Metrics in a nutshell

Test	Outcome
A	✓
B	✗
C	✓
D	✗

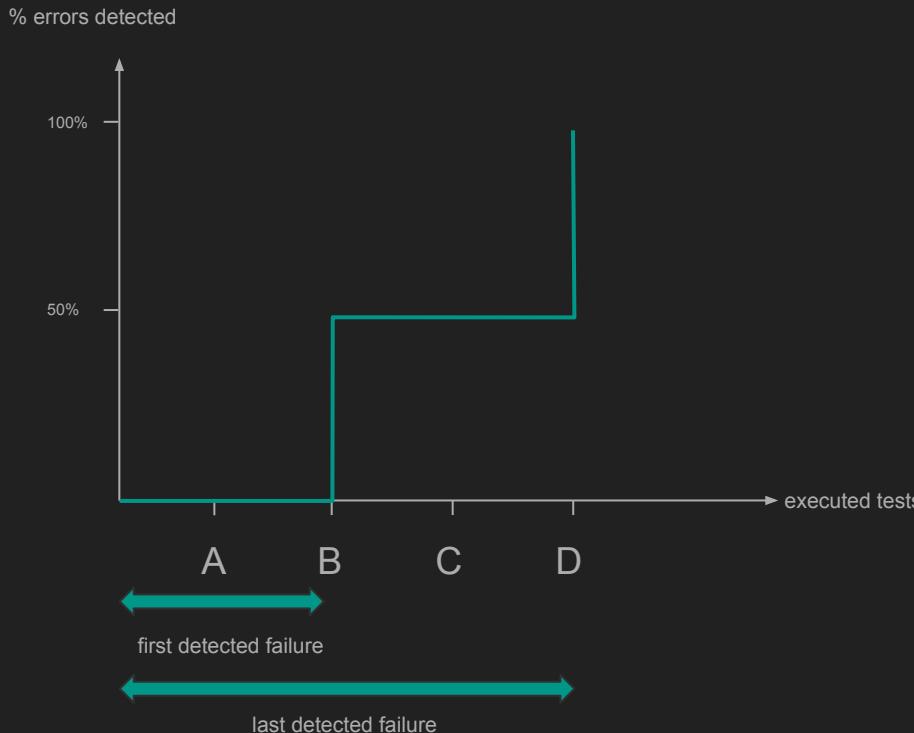
Naive Ordering:



# Test Case Reordering Metrics in a nutshell

Test	Outcome
A	✓
B	✗
C	✓
D	✗

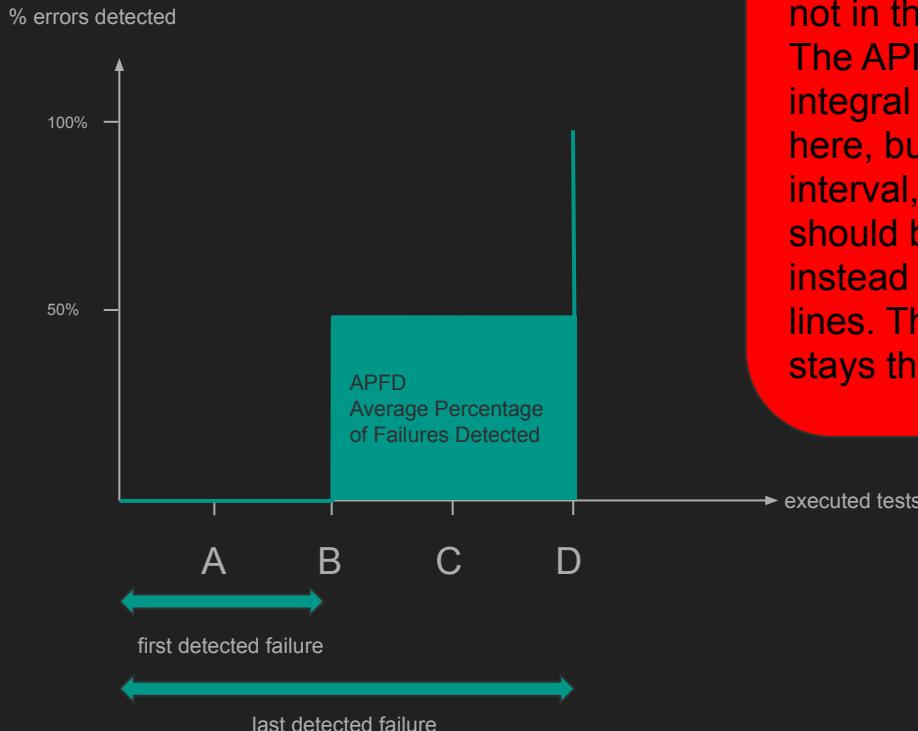
Naive Ordering:



# Test Case Reordering Metrics in a nutshell

Test	Outcome
A	✓
B	✗
C	✓
D	✗

Naive Ordering:

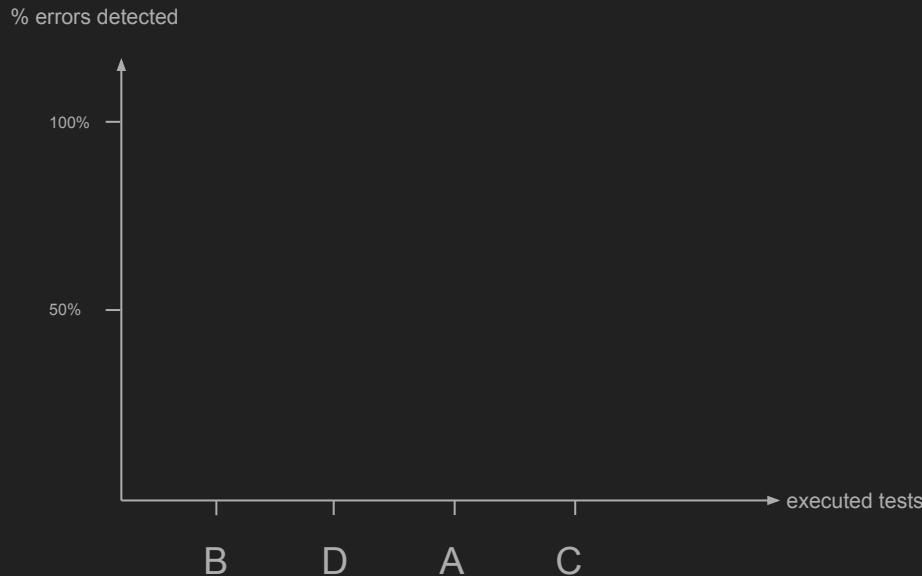


Correction (this box was not in the original slides):  
The APFD is not the integral that is shown here, but the trapez interval, which is why it should be diagonal lines instead of horizontal lines. The intuition behind stays the same.

# Test Case Reordering Metrics in a nutshell

Test	Outcome
A	✓
B	✗
C	✓
D	✗

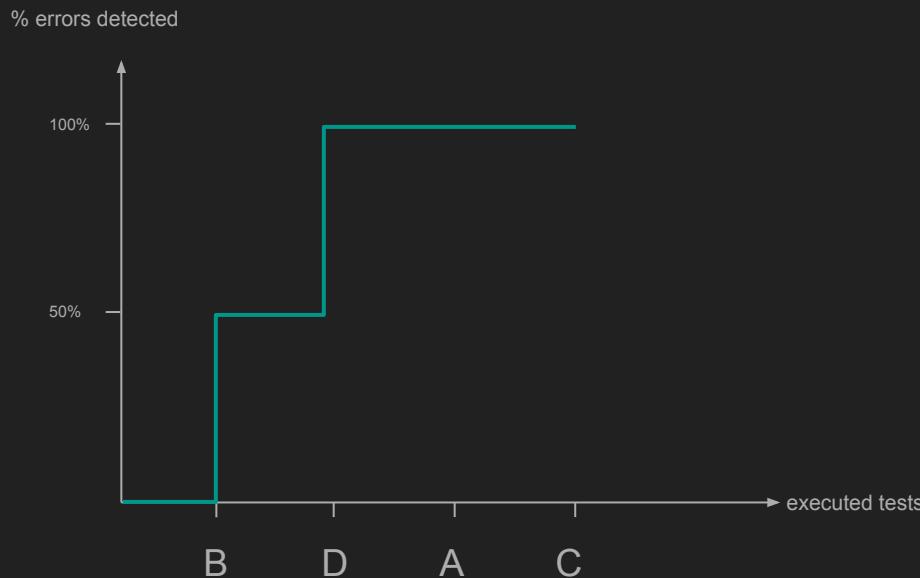
Perfect Ordering:



# Test Case Reordering Metrics in a nutshell

Test	Outcome
A	✓
B	✗
C	✓
D	✗

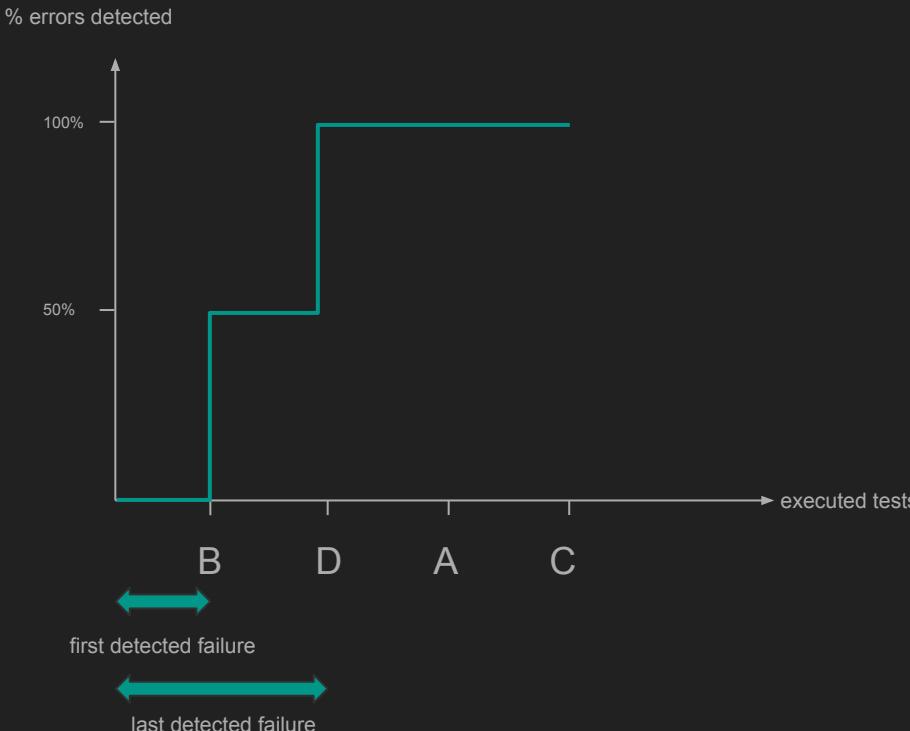
Perfect Ordering:



# Test Case Reordering Metrics in a nutshell

Test	Outcome
A	✓
B	✗
C	✓
D	✗

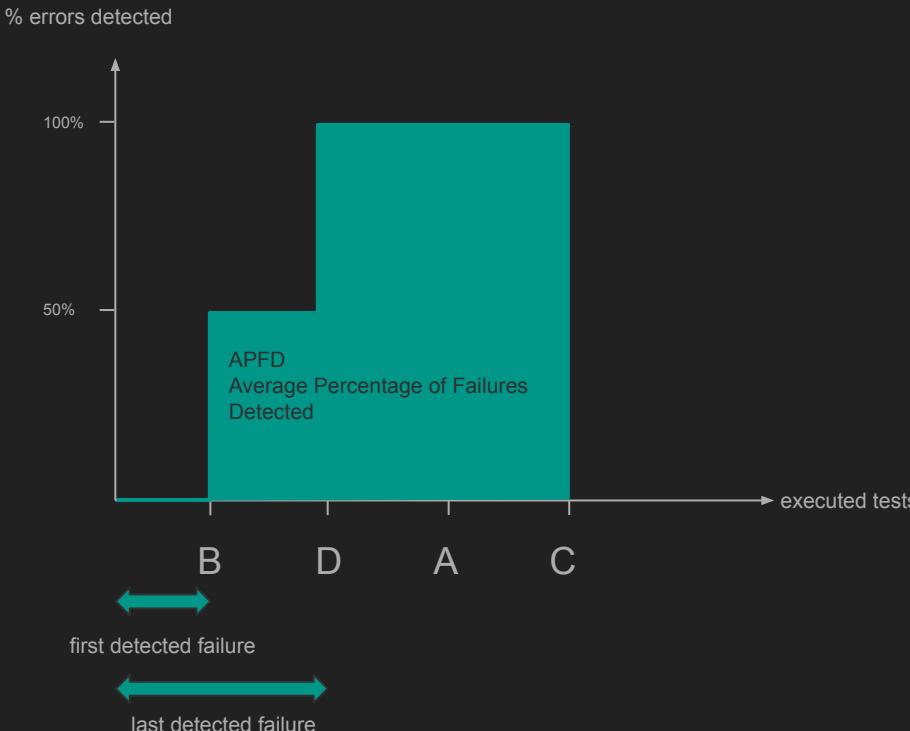
Perfect Ordering:



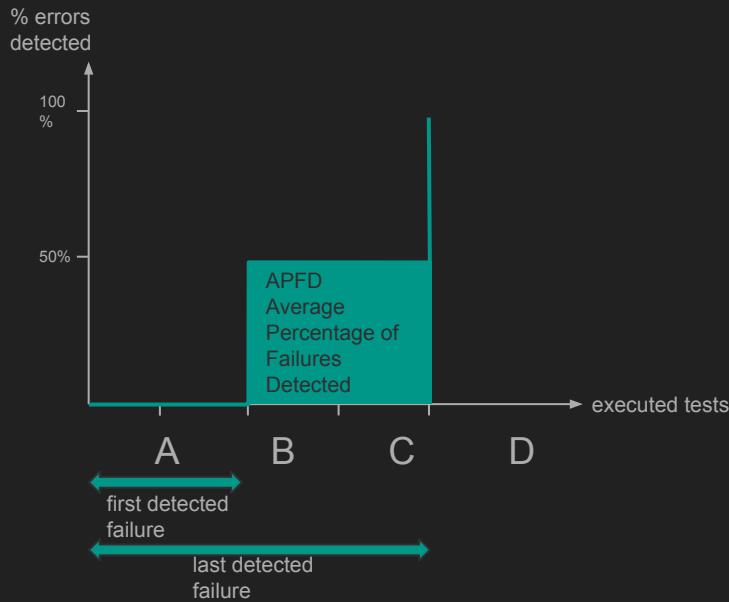
# Test Case Reordering Metrics in a nutshell

Test	Outcome
A	✓
B	✗
C	✓
D	✗

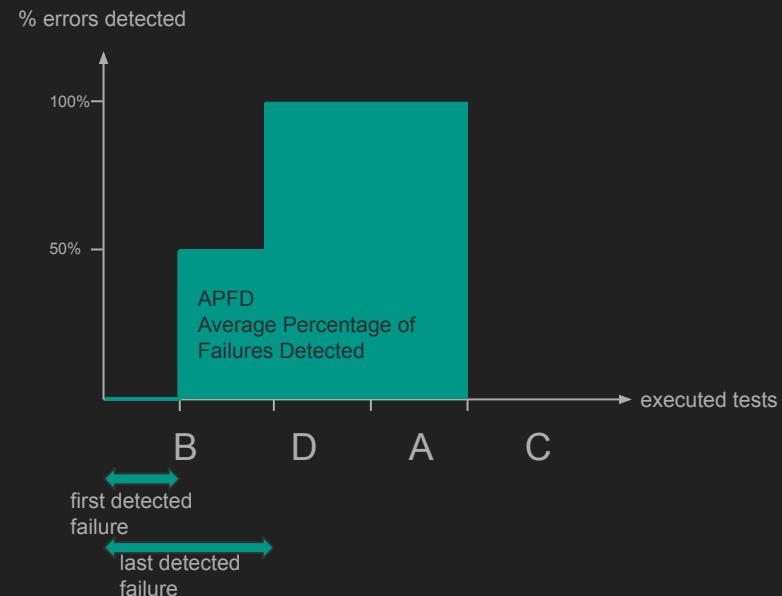
Perfect Ordering:



## Naive



## Perfect



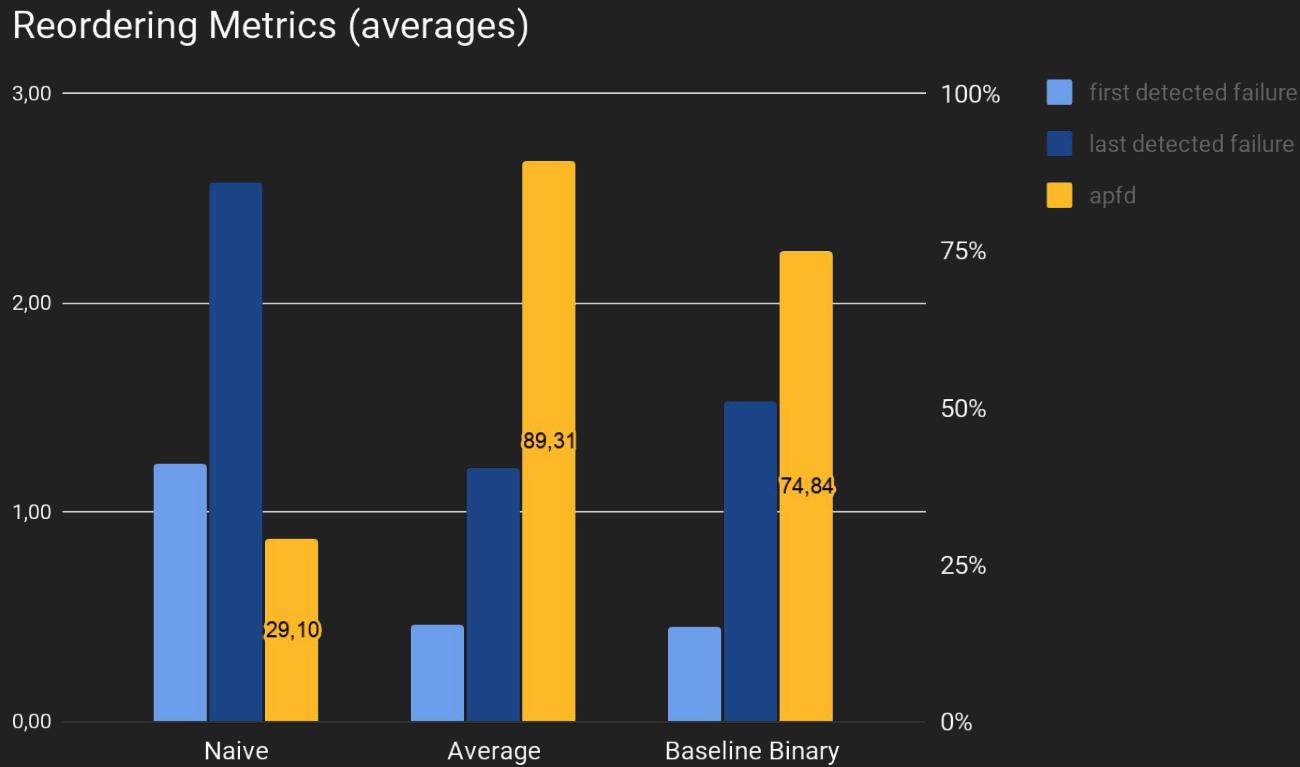
# How to order?

- Naive: A - B - C - D
- Average: Sort tests descending after failure probability
- Binary Predictor: Execute Predicted Failures First
  - Prediction: B, C, D fail
  - Ordering: B - C - D -A

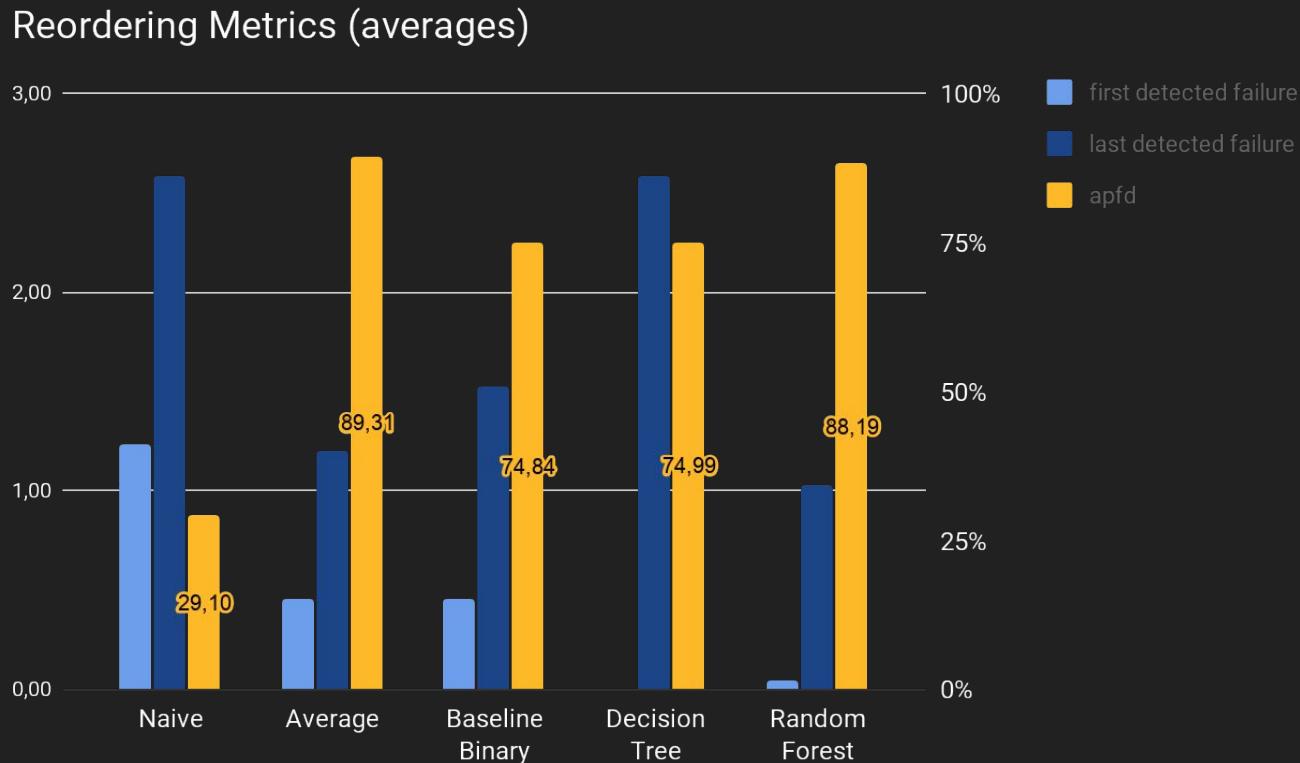
# Easiest Binary Predictor?

Just predict what failed previously

# Reordering evaluations

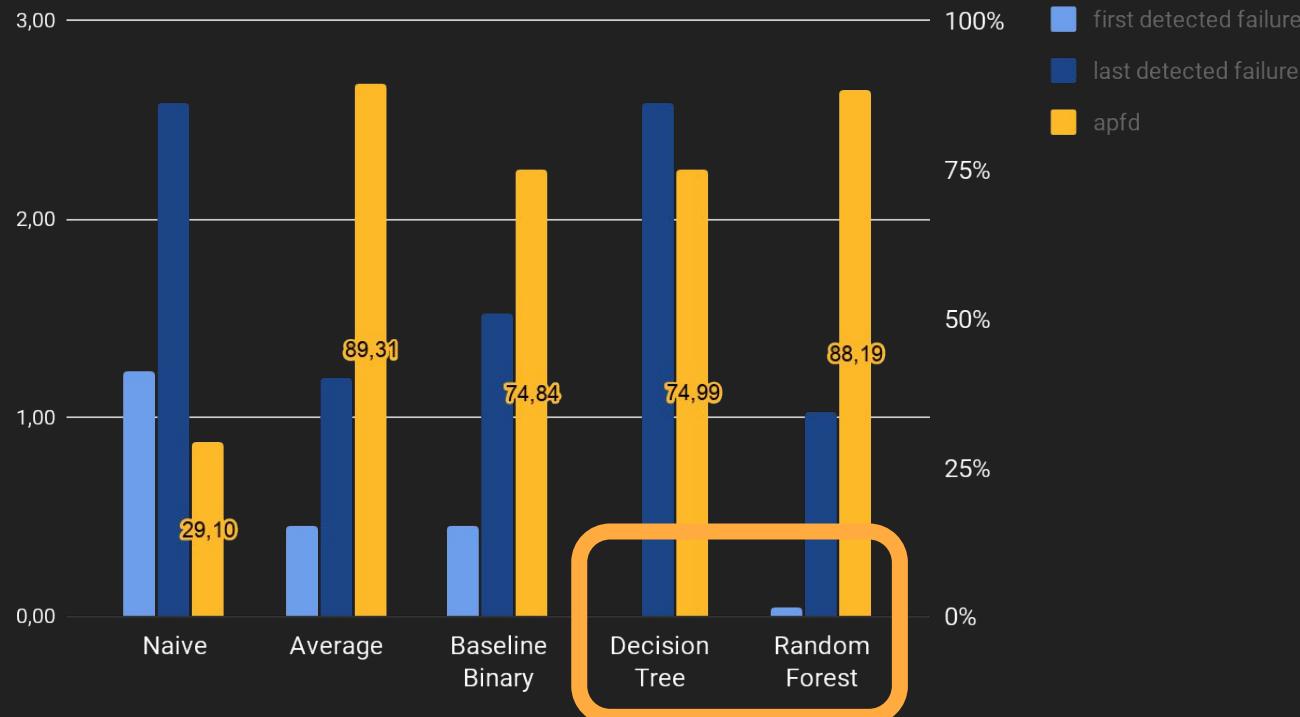


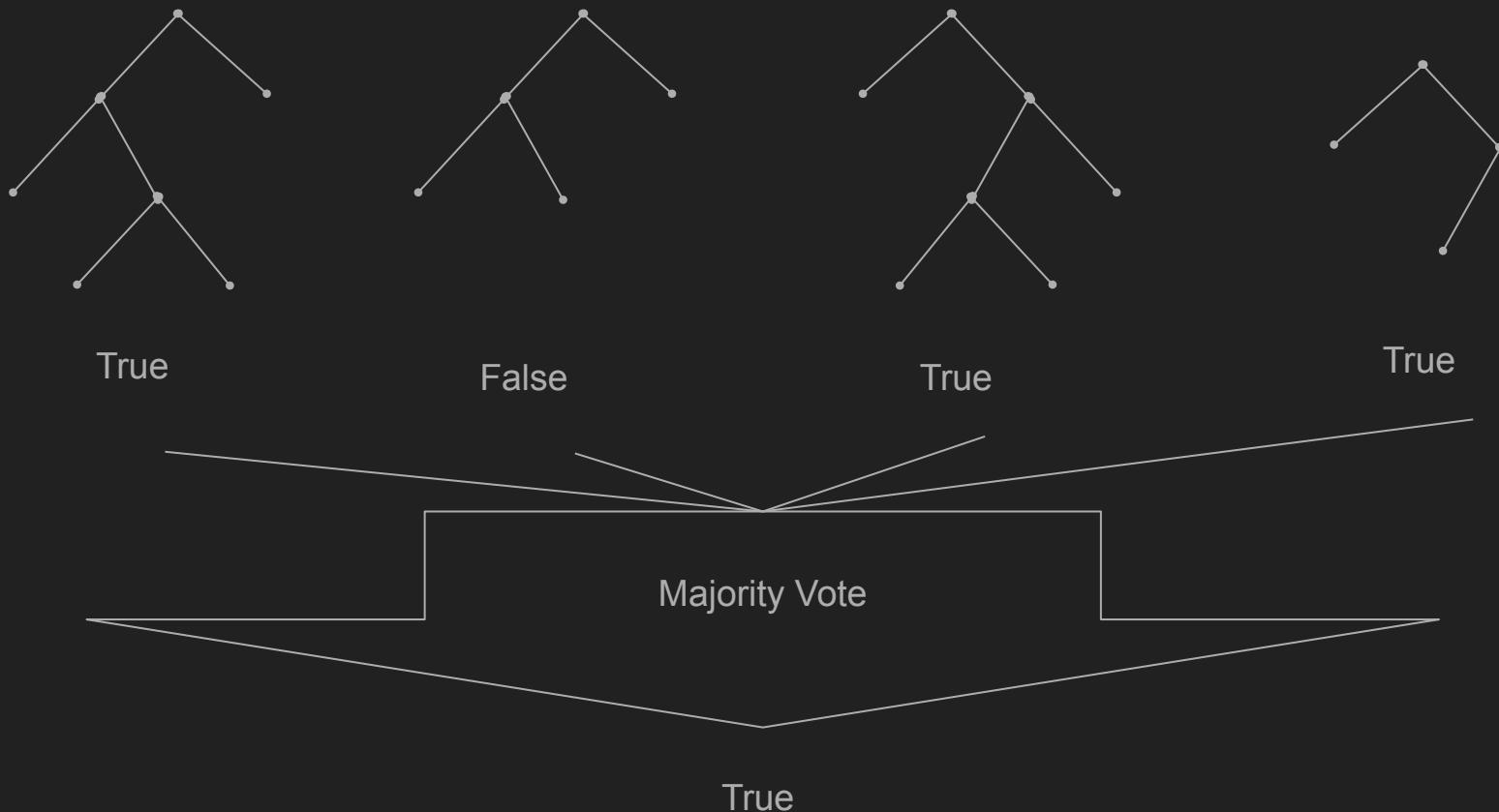
# Reordering evaluations



# Reordering evaluations

## Reordering Metrics (averages)





Can we improve?  
→ Feature Engineering

# → Semantic Information

```
1 def wsgi_errors_stream():
2     """Find the most appropriate error stream for the application. If a request
3         is active, log to ``wsgi.errors``, otherwise use ``sys.stderr``.
4
5     If you configure your own :class:`logging.StreamHandler`, you may want to
6     use this for the stream. If you are using file or dict configuration and
7     can't import this directly, you can refer to it as
8     ``ext://flask.logging.wsgi_errors_stream``.
9
10    return request.environ["wsgi.errors"] if request else sys.stderr
11
12 def has_level_handler(logger):
13     """Check if there is a handler in the logging chain that will handle the
14     given logger's :meth:`effective_level` <-logging.Logger.getEffectiveLevel>.
15     """
16     level = logger.getEffectiveLevel()
17     current = logger
18
19     while current:
20         if any(handler.level <= level for handler in current.handlers):
21             return True
22
23         if not current.propagate:
24             break
25
26         current = current.parent
27
28     return False
29
30
31
32 #: Log messages to :func:`_flask.logging.wsgi_errors_stream` with the format
33 #: ``[%asctime)s] %(levelname)s in %(module)s: %(message)s``.
34 default_handler = logging.StreamHandler(wsgi_errors_stream)
35 default_handler.setFormatter(
36     logging.Formatter("[%asctime)s] %(levelname)s in %(module)s: %(message)s")
37 )
38
39
40 def create_logger(app):
41     """Get the Flask app's logger and configure it if needed.
```

Very similar method  
names

```
1 def test_options_work(app, client):
2     @app.route("/", methods=["GET", "POST"])
3     def index():
4         return "Hello World"
5
6     rv = client.open("", method="OPTIONS")
7     assert sorted(rv.allow) == ["GET", "HEAD", "OPTIONS", "POST"]
8     assert rv.data == b""
9
10
11 def test_options_on_multiple_rules(app, client):
12     @app.route("/", methods=["GET", "POST"])
13     def index():
14         return "Hello World"
15
16     @app.route("/", methods=["PUT"])
17     def index_put():
18         return "Aha!"
19
20     rv = client.open("", method="OPTIONS")
21     assert sorted(rv.allow) == ["GET", "HEAD", "OPTIONS", "POST", "PUT"]
22
23
24 def test_provide_automatic_options_attr():
25     app = flask.Flask(__name__)
26
27     def index():
28         return "Hello World!"
29
30     index.provide_automatic_options = False
31     app.route("/") (index)
32     rv = app.test_client().open("", method="OPTIONS")
33     assert rv.status_code == 405
34
35     app = flask.Flask(__name__)
36
37     def index2():
38         return "Hello World!"
39
40     index2.provide_automatic_options = True
41     app.route("/", methods=["OPTIONS"]) (index2)
42     rv = app.test_client().open("", method="OPTIONS")
43     assert sorted(rv.allow) == ["OPTIONS"]
```

```
mutant_id                                     352
current_line                                  rv = None
line_number_changed                           402
modified_file_path                          src/flask/ctx.py
modified_method                                pop
previous_line                                 /tmp/tmp_abq2rnu
repo_path                                    False
outcome                                       13
test_id                                         tests/test_appctx.py::test_clean_pop
full_name                                      test_clean_pop
name                                           tests/test_appctx.py
filepath                                      0.00476146
duration                                       True
setup_outcome                                 0.00162125
setup_duration                               False
call_outcome                                  0.000889778
call_duration                                 None
teardown_outcome                            NaN
teardown_duration                           6
edit_distance_method_name_test_name
Name: 831224, dtype: object
```

```
mutant_id                                     352
current_line                                  rv = None
line_number_changed                           402
modified_file_path                           src/flask/ctx.py
modified_method                                pop
previous_line                                 /tmp/tmp_abq2rnu
repo_path                                    False
outcome                                       13
test_id                                         13
full_name                                     tests/test_appctx.py
name                                           test_clean_pop
filepath                                      tests/test_context.py
duration                                       0.00476146
setup_outcome                                 True
setup_duration                                0.00162125
call_outcome                                  False
call_duration                                 0.000889778
teardown_outcome                             None
teardown_duration                            NaN
edit_distance_method_name_test_name          6
Name: 831224, dtype: object
```

## Source

```
def pop(self, exc=_sentinel):
    """Pops the request context and unbinds it by doing that. This will
    also trigger the execution of functions registered by the
    :meth:`~flask.Flask.teardown_request` decorator.

    .. versionchanged:: 0.9
        Added the 'exc' argument.

    """
    app_ctx = self._implicit_app_ctx_stack.pop()
    clear_request = False

    try:
        if not self._implicit_app_ctx_stack:
            self.preserved = False
            self._preserved_exc = None
            if exc is _sentinel:
                exc = sys.exc_info()[1]
            self.app.do_teardown_request(exc)

            request_close = getattr(self.request, "close", None)
            if request_close is not None:
                request_close()
            clear_request = True
    finally:
        rv = _request_ctx_stack.pop()

        # get rid of circular dependencies at the end of the request
        # so that we don't require the GC to be active.
        if clear_request:
            rv.request.environ["werkzeug.request"] = None
```

## Test

```
def test_clean_pop(app):
    app.testing = False
    called = []

    @app.teardown_request
    def teardown_req(error=None):
        1 / 0

    @app.teardown_appcontext
    def teardown_app(error=None):
        called.append("TEARDOWN")

    try:
        with app.test_request_context():
            called.append(flask.current_app.name)
    except ZeroDivisionError:
        pass

    assert called == ["flask_test", "TEARDOWN"]
    assert not flask.current_app
```

## Mutant

```
def pop(self, exc=_sentinel):
    """Pops the request context and unbinds it by doing that. This will
    also trigger the execution of functions registered by the
    :meth:`~flask.Flask.teardown_request` decorator.

    .. versionchanged:: 0.9
        Added the 'exc' argument.

    """
    app_ctx = self._implicit_app_ctx_stack.pop()
    clear_request = False

    try:
        if not self._implicit_app_ctx_stack:
            self.preserved = False
            self._preserved_exc = None
            if exc is _sentinel:
                exc = sys.exc_info()[1]
            self.app.do_teardown_request(exc)

            request_close = getattr(self.request, "close", None)
            if request_close is not None:
                request_close()
            clear_request = True
    finally:
        rv = _request_ctx_stack.pop()  # rv = None

    # get rid of circular dependencies at the end of the request
    # so that we don't require the GC to be active.
    if clear_request:
        rv.request.environ["werkzeug.request"] = None
```

## Test

```
def test_clean_pop(app):
    app.testing = False
    called = []

    @app.teardown_request
    def teardown_req(error=None):
        1 / 0

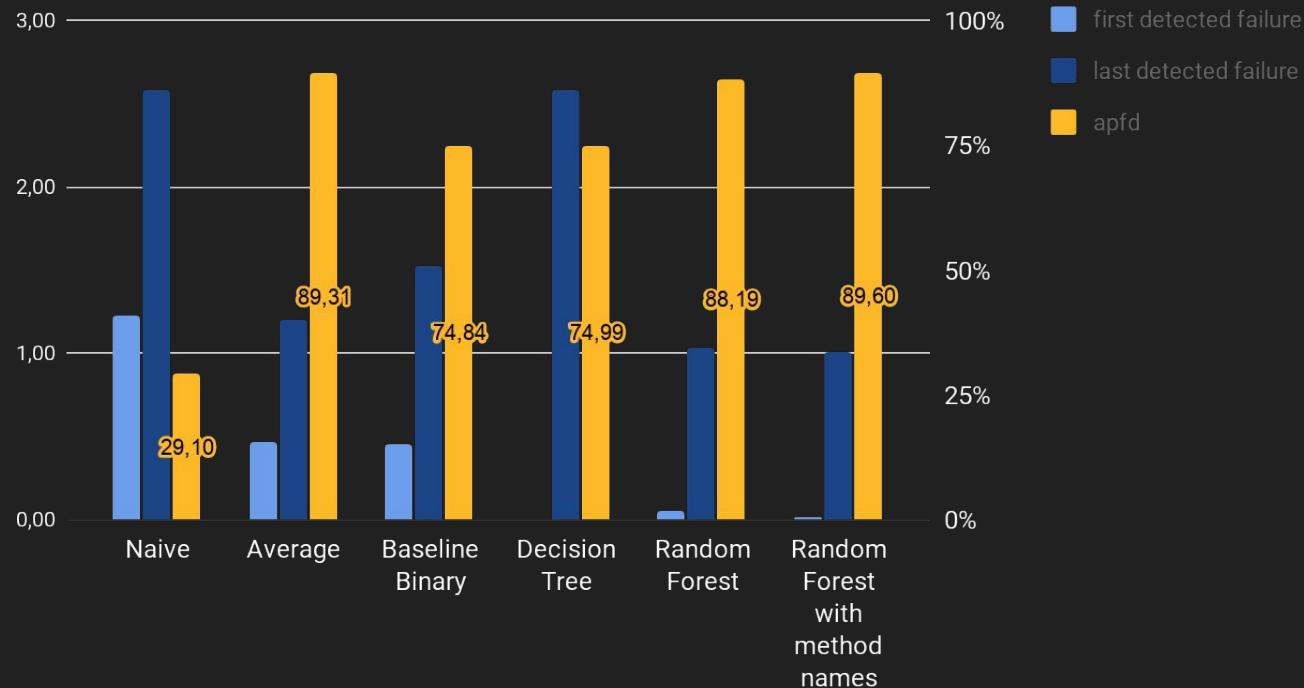
    @app.teardown_appcontext
    def teardown_app(error=None):
        called.append("TEARDOWN")

    try:
        with app.test_request_context():
            called.append(flask.current_app.name)
    except ZeroDivisionError:
        pass

    assert called == ["flask_test", "TEARDOWN"]
    assert not flask.current_app
```

# Reordering evaluations

Reordering Metrics (averages)

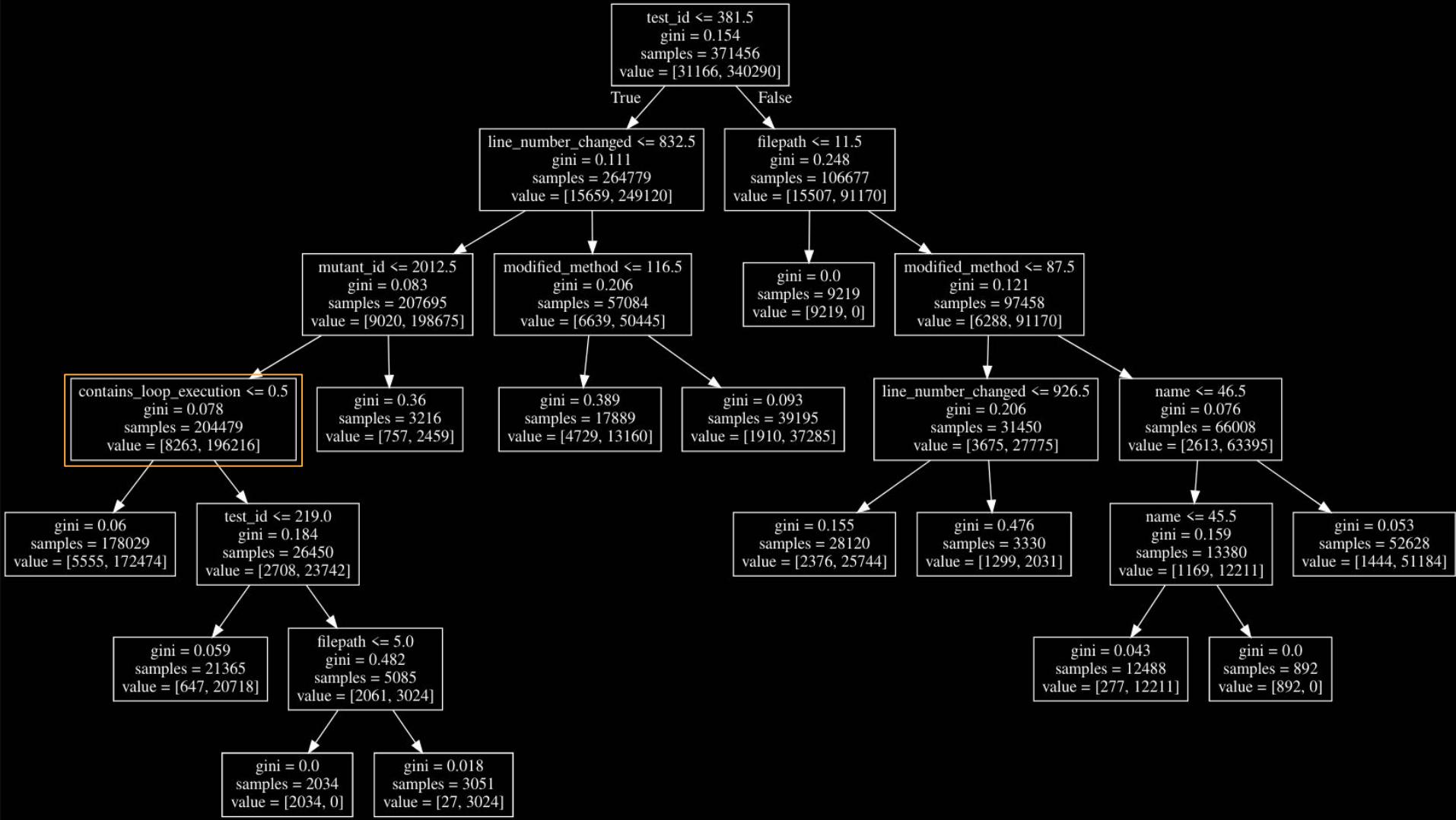


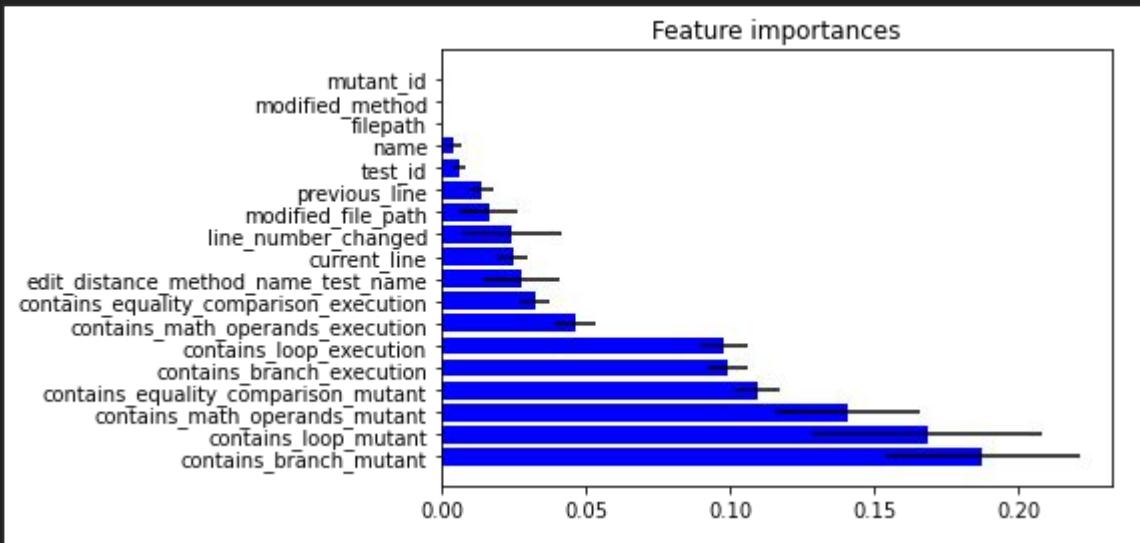
# → Context

```
1 def wsgi_error_stream():
2     """Find the most appropriate error stream for the application. If a request
3     is active, log to ``wsgi.errors``, otherwise use ``sys.stderr``.
4
5     If you configure your own :class:`logging.StreamHandler`, you may want to
6     use this for the stream. If you are using file or dict configuration and
7     can't import this directly, you can refer to it as
8     ``ext://flask.logging.wsgi_errors_stream``.
9
10    """
11
12    return request.environ["wsgi.errors"] if request else sys.stderr
13
14 def has_level_handler(logger):
15     """Check if there is a handler in the logging chain that will handle the
16     given logger's :meth:`effective level <logging.Logger.getEffectiveLevel>`."""
17
18     level = logger.getEffectiveLevel()
19     current = logger
20
21     while current:
22         if any(handler.level <= level for handler in current.handlers):
23             return True
24
25         if not current.propagate:
26             break
27
28         current = current.parent
29
30     return False
31
32 #: Log messages to :func:`'-flask.logging.wsgi_errors_stream'` with the format
33 #: ``[%asctime)s] %(levelname)s in %(module)s: %(message)s``.
34 default_handler = logging.StreamHandler(wsgi_errors_stream)
35 default_handler.setFormatter(
36     logging.Formatter("[%asctime)s] %(levelname)s in %(module)s: %(message)s")
37 )
38
39
40 def create_logger(app):
41     """Get the Flask app's logger and configure it if needed.
```

Contain both +  
operand

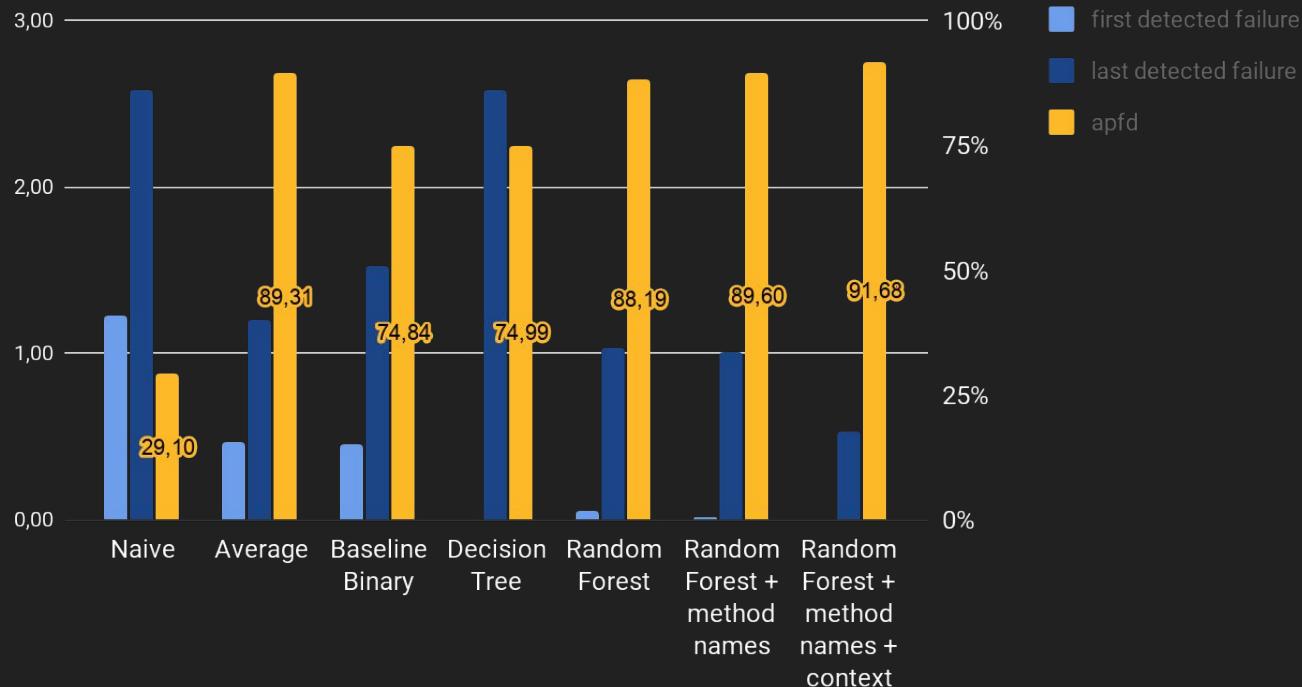
```
1 def test_options_work(app, client):
2     @app.route("/", methods=["GET", "POST"])
3     def index():
4         return "Hello World"
5
6     rv = client.open("", method="OPTIONS")
7     assert sorted(rv.allow) == ["GET", "HEAD", "OPTIONS", "POST"]
8     assert rv.data == b""
9
10
11 def test_options_on_multiple_rules(app, client):
12     @app.route("/", methods=["GET", "POST"])
13     def index():
14         return "Hello World"
15
16     @app.route("/", methods=["PUT"])
17     def index_put():
18         return "Aha!"
19
20     rv = client.open("", method="OPTIONS")
21     assert sorted(rv.allow) == ["GET", "HEAD", "OPTIONS", "POST", "PUT"]
22
23
24 def test_provide_automatic_options_attr():
25     app = flask.Flask(__name__)
26
27     def index():
28         return "Hello World!"
29
30     index.provide_automatic_options = False
31     app.route("/") (index)
32     rv = app.test_client().open("", method="OPTIONS")
33     assert rv.status_code == 405
34
35     app = flask.Flask(__name__)
36
37     def index2():
38         return "Hello World!"
39
40     index2.provide_automatic_options = True
41     app.route("", methods=["OPTIONS"]) (index2)
42     rv = app.test_client().open("", method="OPTIONS")
43     assert sorted(rv.allow) == ["OPTIONS"]
```





# Reordering evaluations

Reordering Metrics (averages)



# How to go on

Other classifiers

Better features

Recurrent?

...

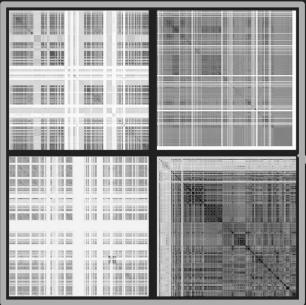
# Difficulties

- limited real world data

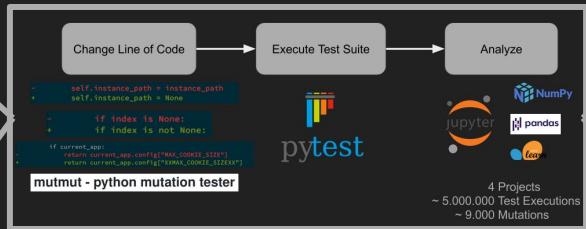
```
github=> select COUNT(gh_lang), gh_lang from travistorrent_8_2_2017 group by gh_lang limit 10;  
      count | gh_lang  
-----+-----  
    456793 | java  
     1823 | javascript  
 3243979 | ruby  
(3 rows)
```

- mutation testing is not that easy

# Zooming out

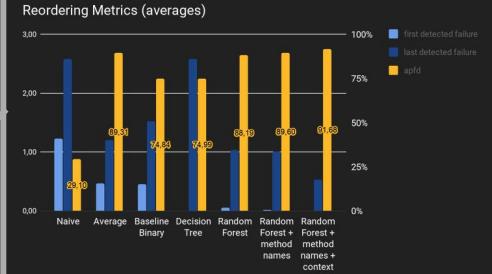


## Mutation Testing



Finding errors  
in software

## Reordering evaluations



Test your tests