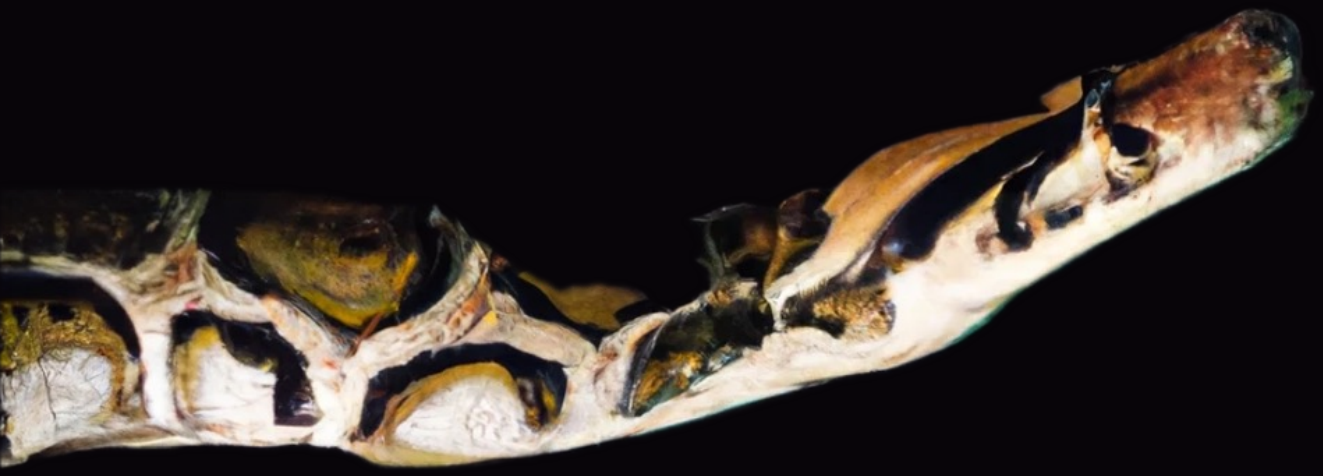
Let’s create a Python Debugger together



Johannes Bechberger

mostlynerdless.de

(033) PRO 2 2.13047 6415
correct 2.13067 6415

Relays 6-2 in 033 failed special speed test
In relay " 11.00 test.
Relays changed

1700 Started Cosine Tape (Sine check)
1525 Started Mult + Adder Test.

1545 

Relay #70 Panel F
(moth) in relay.

First actual case of bug being found.

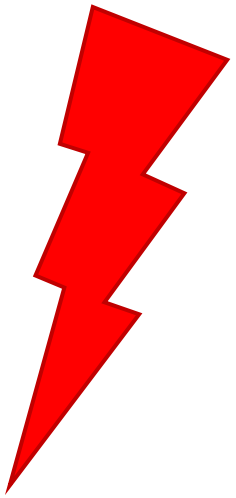
~~1645~~ 1630 Antaugut started.
1700 closed down.

Relay
2145
Relay 3370

“If debugging is the process of removing software bugs, then programming must be the process of putting them in.

— Edsger Dijkstra

```
→ python3 counter.py \
          lines counter.py

0
```



```
→ python3 counter.py \
          lines counter.py

26
```

Let’s look at the code

```
def main():

    match cmd := sys.argv[1]:
        case "lines":
            count = count_code_lines(Path(sys.argv[2]))
            print(count)
        case "help":
            print_help()
        case _:
            raise ValueError(f"Unknown operation {cmd}")
```

```
def is_code_line(line: str) -> bool:
    return line.isspace() and line.strip().startswith("#")



def count_code_lines(file: Path) -> int:
    count = 0
    with file.open('r') as f:
        for line in f:
            if is_code_line(line):
                count += 1
    return count
```

Any ideas?

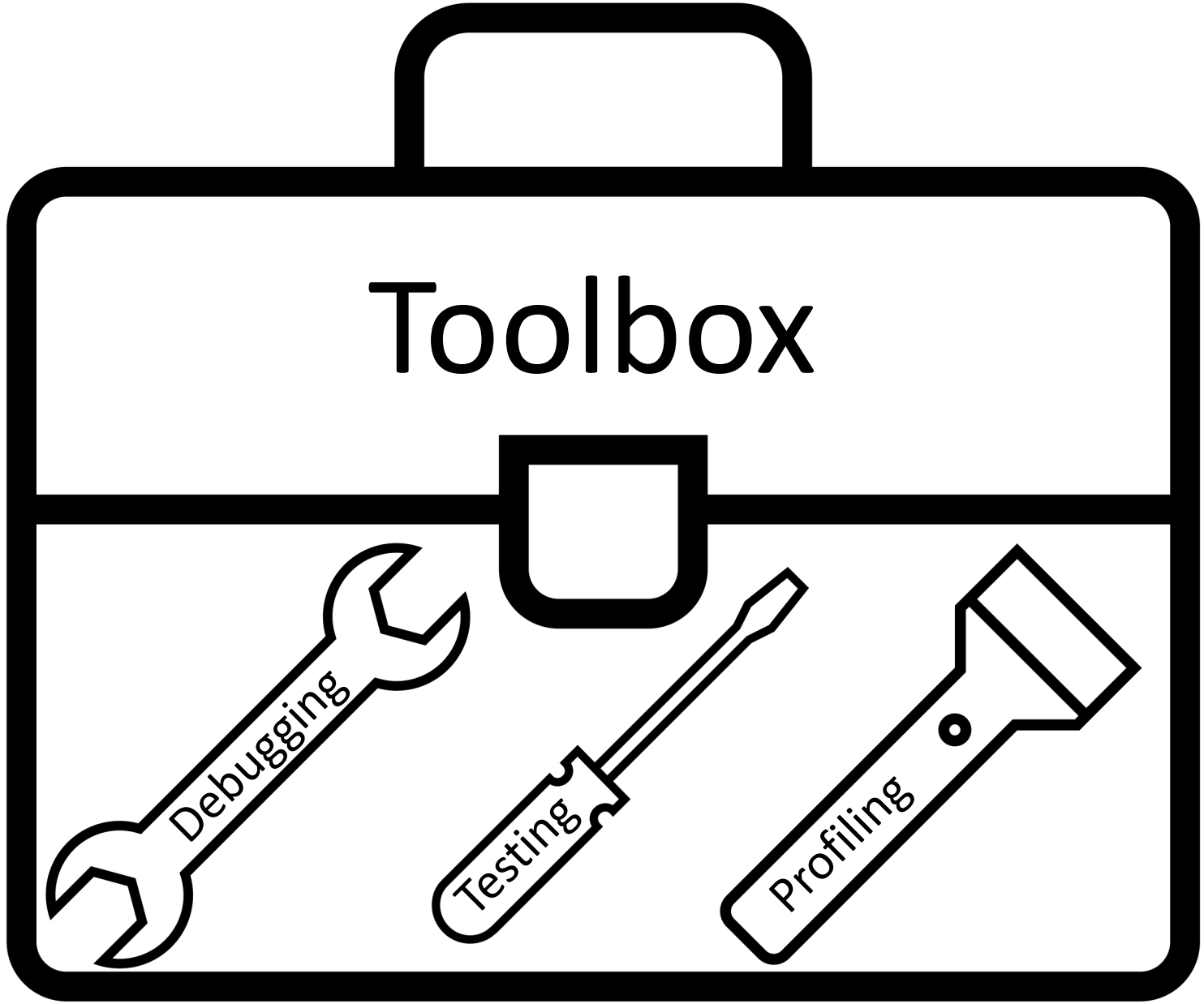
Debuggers are your friend

Who of you used a debugger before?

“ Why debug?

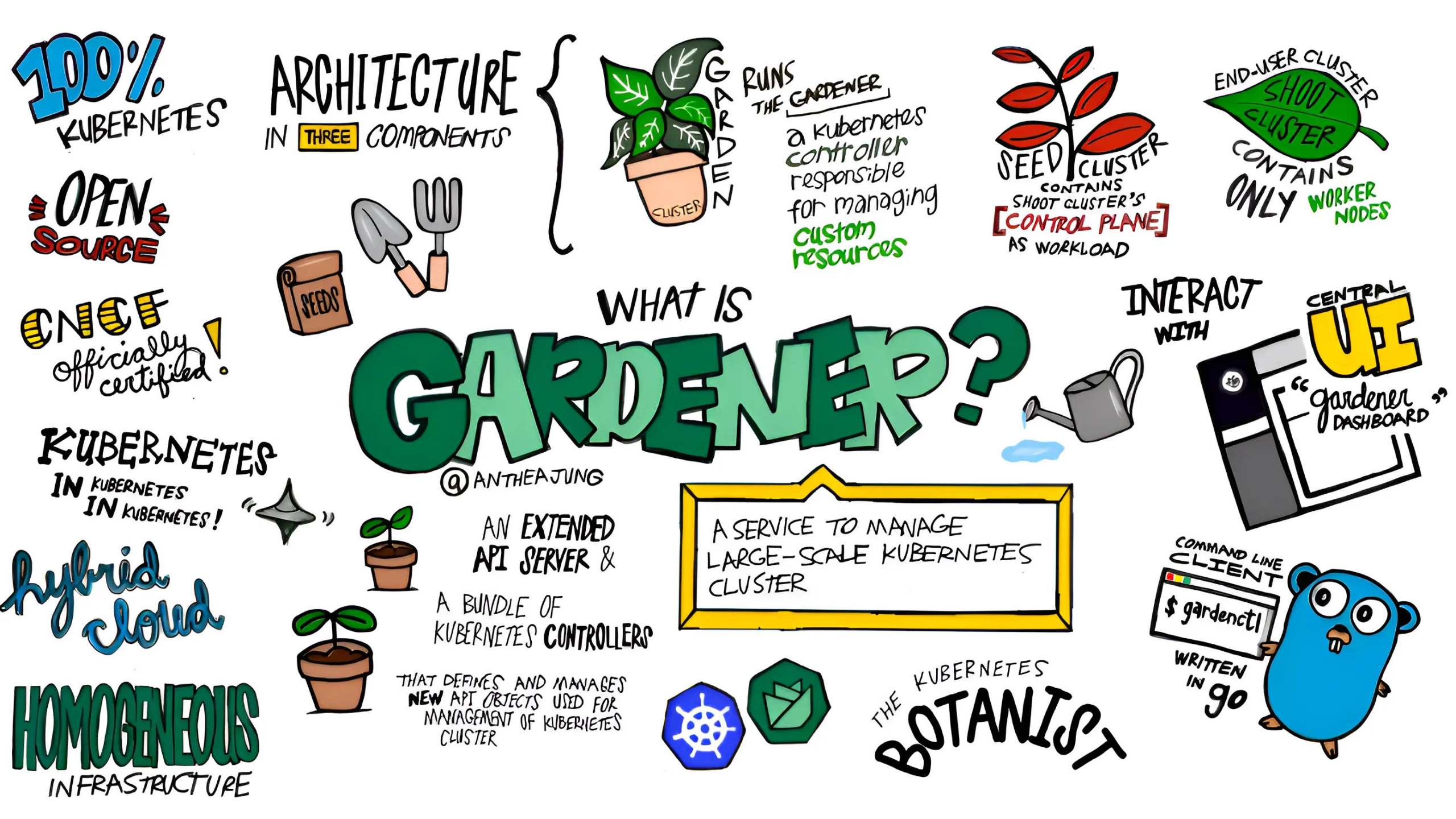
- Find and fix bugs!
- Analyze the code
- Add more logging on the fly
- Change behavior on the fly
- Analyze memory issues
- And much more

— Egor Ushakov


Toolbox
Debugging
Testing
Profiling


jar profiler


Sap
Machine


100% KUBERNETES
OPEN SOURCE
CNCF officially certified!
KUBERNETES IN KUBERNETES IN KUBERNETES!
hybrid cloud
HOMOGENEOUS INFRASTRUCTURE
ARCHITECTURE IN THREE COMPONENTS
SEEDS
GARDEN
CLUSTER
RUNS THE GARDENER
a kubernetes controller responsible for managing custom resources
SEED CLUSTER
CONTAINS SHOOT CLUSTER'S [CONTROL PLANE] AS WORKLOAD
END-USER CLUSTER
SHOOT CLUSTER
CONTAINS ONLY WORKER NODES
WHAT IS GARDENER?
@ANTHEAJUNG
INTERACT WITH
CENTRAL UI
"gardener DASHBOARD"
A SERVICE TO MANAGE LARGE-SCALE KUBERNETES CLUSTER
AN EXTENDED API SERVER &
A BUNDLE OF KUBERNETES CONTROLLERS
THAT DEFINES AND MANAGES NEW API OBJECTS USED FOR MANAGEMENT OF KUBERNETES CLUSTER
COMMAND LINE CLIENT
$ gardenctl
WRITTEN IN go
THE KUBERNETES BOTANIST

We could use an existing debugger...

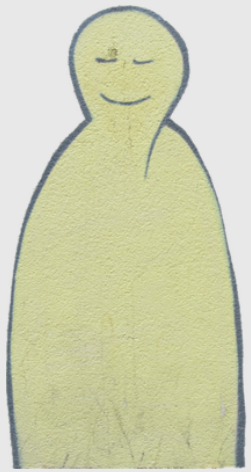
```
5    def is_code_line(line: str) -> bool:   line: 'import sys\n'
         return line.isspace() and line.strip().startswith("#")
```

Debuggers are no rocket science, so ...

https://github.com/parttimenerd/python-dbg/

Java has built-in debugging support...

But Python?



An article series where I show you how to write a fully functional Python debugger.

Let's create a Python Debugger together: Part 4 (Python 3.12 edition)

Posted on **November 10, 2023**

The third part of my journey down the Python debugger rabbit hole (part 1, part 2, and part 3).

In this article, we'll be looking into how changes introduced in Python 3.12 can help us with one of the most significant pain points of our current debugger implementation: The Python interpreter essentially calls our callback at every line of code, regardless if we have a breakpoint in the currently running method. But why is this the case?

Continue reading →

Posted in **Computer Science**, **Python** | Tagged **Debugging**, **Let's create a debugger together**, **Python** | **Leave a reply**

Let's create a Python Debugger together: Part 3 (Refactoring)

Posted on **November 6, 2023**

Does the interpreter "know" breakpoints?

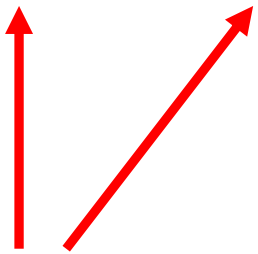
No.

Any ideas?

```
def is_code_line(line: str) -> bool:
    dbg();return line.isspace() and line.strip().startswith("#


def count_code_lines(file: Path) -> int:
    dbg();count = 0
    dbg();with file.open('r') as f:
            dbg();for line in f:
                    dbg();if is_code_line(line):
                                dbg();count += 1
    dbg();return count
```

dbg(); line

```
def dbg():
    if at_breakpoint(file, line):
        dbg_shell()
```



?

sys._getframe

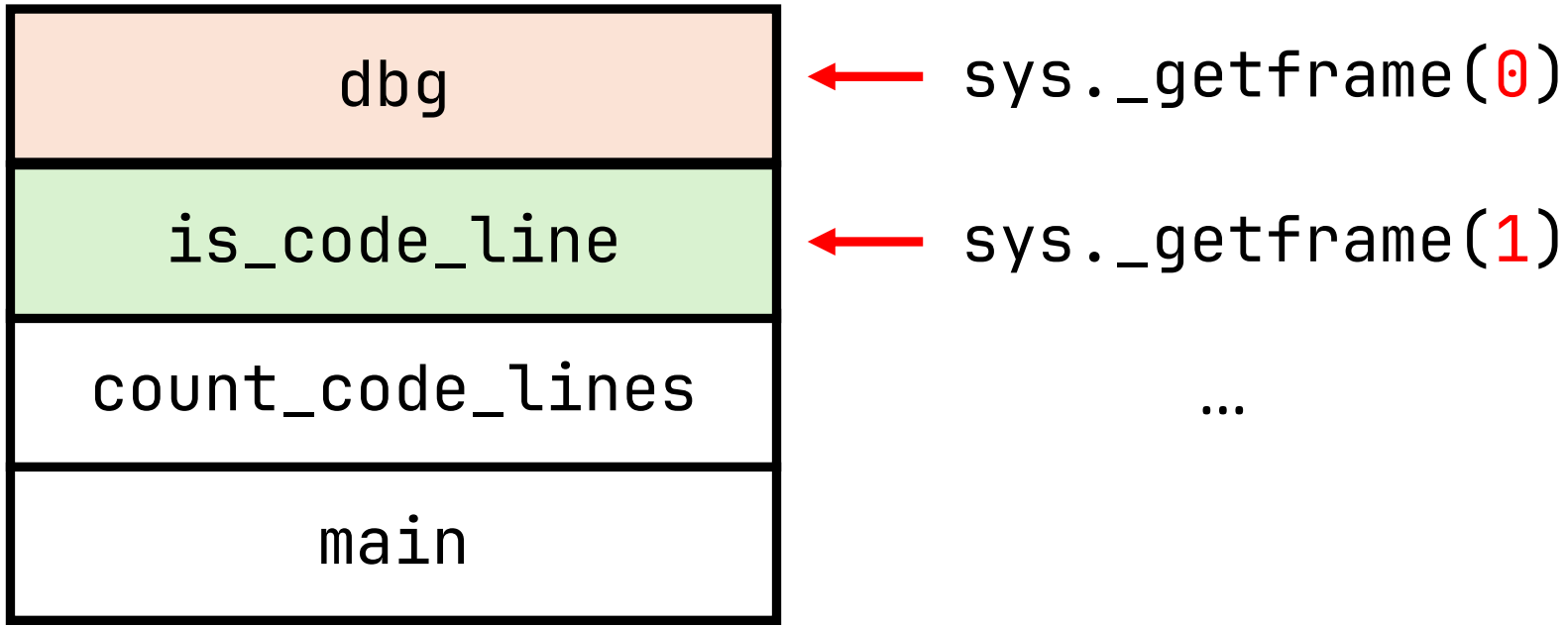
sys._getframe

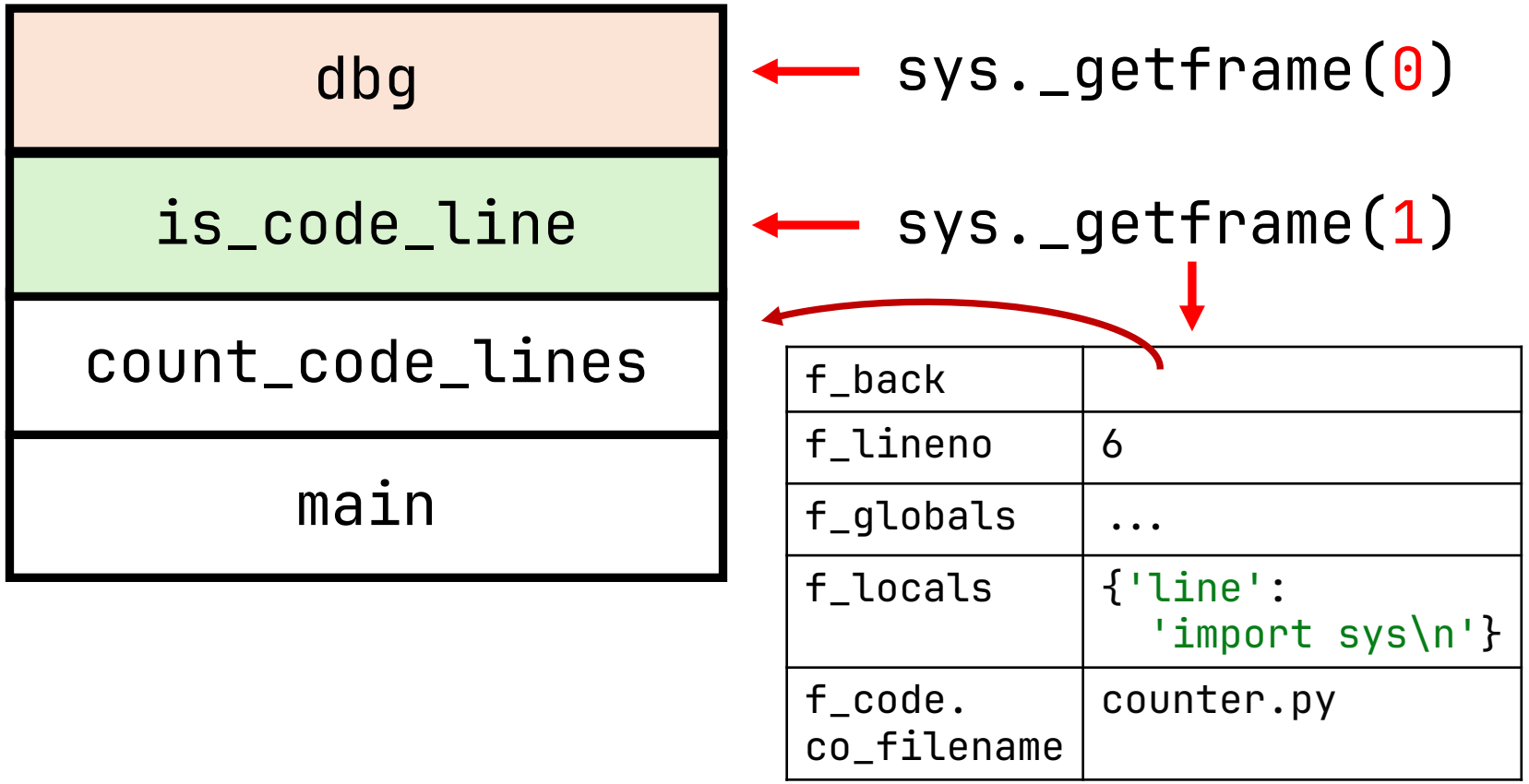
sys._getframe

CPython implementation detail

> locals(), globals(), sys._getframe(), sys.exc_info(), and sys.settrace **work in PyPy, but they incur a performance penalty that can be huge by disabling the JIT over the enclosing JIT scope.**

– https://www.pypy.org/performance.html


dbg
is_code_line
count_code_lines
main
sys._getframe(0)
sys._getframe(1)
…


dbg
is_code_line
count_code_lines
main
sys._getframe(0)
sys._getframe(1)
f_back
f_lineno
6
f_globals
...
f_locals
{'line':
'import sys\n'}
f_code.
co_filename
counter.py

dbg(); line

```
def dbg():


    if at_breakpoint(file, line):
        dbg_shell()
```

dbg(); line

```
def dbg():
    frame = sys._getframe(1)
    line = frame.f_lineno
    file = Path(frame.f_code.co_filename).stem
    if at_breakpoint(file, line):
        dbg_shell(frame)
```

dbg(); line

```
def dbg():
    frame = sys._getframe(1)
    line = frame.f_lineno
    file = Path(frame.f_code.co_filename).stem
    if at_breakpoint(file, line):
        dbg_shell(frame)
```

dbg(); line

```
def dbg():
    frame = sys._getframe(1)
    line = frame.f_lineno
    file = Path(frame.f_code.co_filename).stem
    if at_breakpoint(file, line):
        dbg_shell(frame)


def at_breakpoint(file: str, line: int) → bool:
    return file == "counter" and line == 6
```

Demo: counter0.py

But how do we automate this?

The pre-3.12 way

sys.settrace

sys.settrace(handler)

```
Event = Union['call', 'line', 'return', 'exception', 'opcode']


def handler(frame: FrameType, event: Event, arg):
    pass
```

```
                                                    handler(frame, 'call', None)
def is_code_line(line: str) -> bool:
    return line.isspace() and line.strip().startswith("#")



def count_code_lines(file: Path) -> int:
    count = 0
    with file.open('r') as f:                       handler(frame, 'call', None)
        for line in f:
            if is_code_line(line):
                count += 1
    return count
```

Demo settrace1.py

```
event: call main
event: call count_code_lines
event: call is_code_line
event: call is_code_line
event: call is_code_line
event: call is_code_line
...
```

sys.settrace(handler)

```
def handler(frame: FrameType, event: Event, arg) \
        → Optional[Callable[[FrameType, Event, Any], None]]:
    return inner_handler
```

sys.settrace(handler)

```
def inner_handler(frame: FrameType, event: Event, arg):
    pass


def handler(frame: FrameType, event: Event, arg) \
        → Optional[Callable[[FrameType, Event, Any], None]]:
    return inner_handler
```

Demo settrace2.py

```
event: call is_code_line
inner: line 6
inner: return 6
inner: line 12
inner: line 13
...
```

dbg(); line

```
def dbg():

    frame = sys._getframe(1)
    line = frame.f_lineno
    file = Path(frame.f_code.co_filename).stem
    if at_breakpoint(file, line):
        dbg_shell(frame)


def at_breakpoint(file: str, line: int) → bool:
    return file == "counter" and line == 6
```

dbg(); line

```
def inner_handler(frame: FrameType, event: str, arg):


    line = frame.f_lineno
    file = Path(frame.f_code.co_filename).stem
    if at_breakpoint(file, line):
        dbg_shell(frame)


def at_breakpoint(file: str, line: int) → bool:
    return file == "counter" and line == 6
```

dbg(); line

```
def inner_handler(frame: FrameType, event: str, arg):
    if event ≠ 'line':
        return
    line = frame.f_lineno
    file = Path(frame.f_code.co_filename).stem
    if at_breakpoint(file, line):
        dbg_shell(frame)


def at_breakpoint(file: str, line: int) → bool:
    return file == "counter" and line == 6
```

Demo settrace3.py

```
event: call main
event: call count_code_lines
event: call is_code_line
in break point at line 6

>>> line
'import sys\n'
```

dbg(); line

```
def inner_handler(frame: FrameType, event: str, arg):
    if event ≠ 'line':
        return
    line = frame.f_lineno
    file = Path(frame.f_code.co_filename).stem
    if at_breakpoint(file, line):
        dbg_shell(frame)


def at_breakpoint(file: str, line: int) → bool:
    return file == "counter" and line == 6
```

make configurable

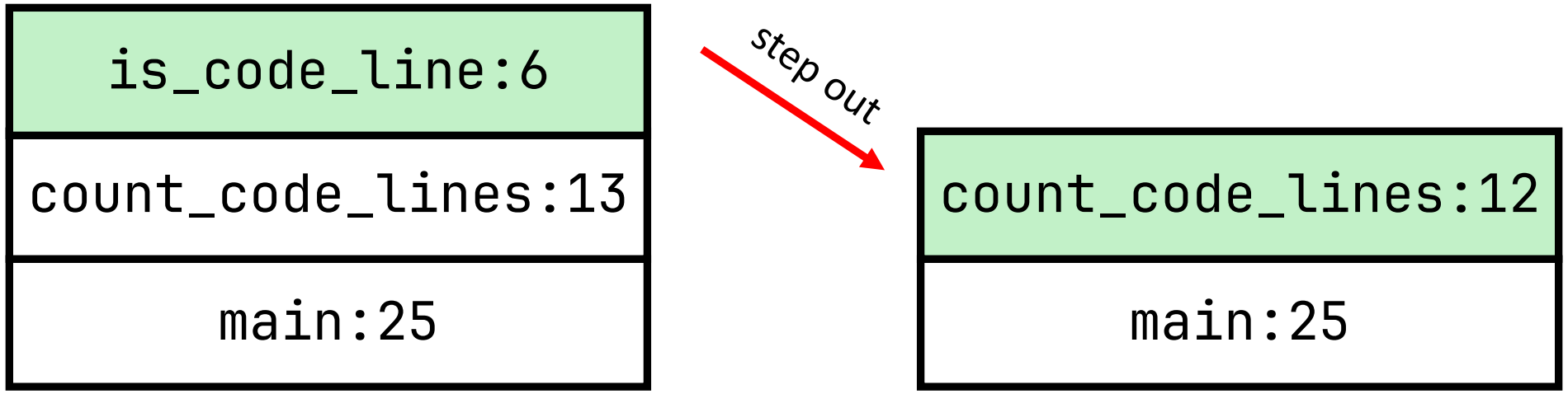
```
first_line or Breakpoint(file,
line) in current_breakpoints
```

Demo settrace4.py

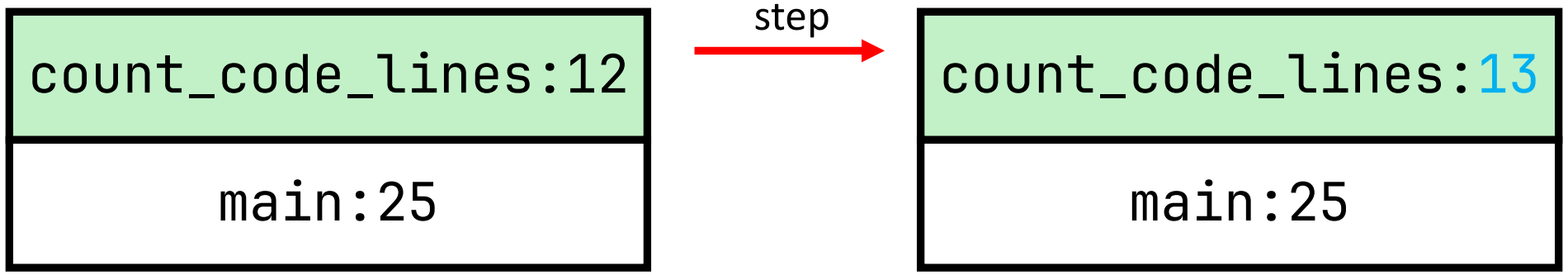
```
event: call main
in break point at line 23

>>> br('counter', 6)
>>>
event: call count_code_lines
event: call is_code_line
in break point at line 6

>>> line
'import sys\n'
```

Single Stepping

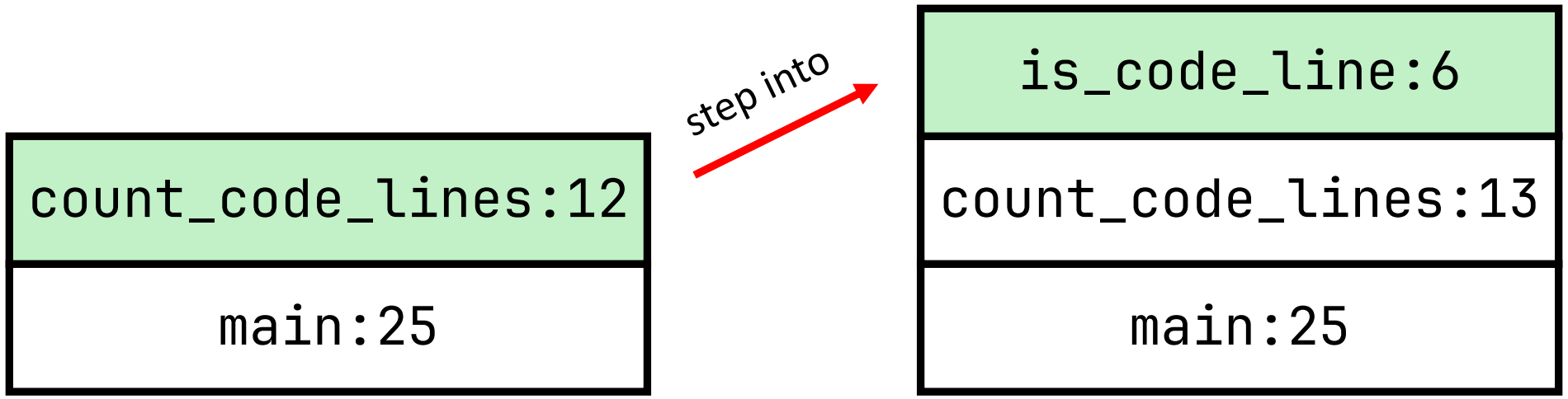
Just extend `at_breakpoint`



Just extend `at_breakpoint`



Just extend `at_breakpoint`



Do we get line events for every function?

```
def is_code_line(line: str) -> bool:
    return line.isspace() and line.strip().startswith("#")


def count_code_lines(file: Path) -> int:
    count = 0
    with file.open('r') as f:
        for line in f:
            if is_code_line(line):
                count += 1
    return count
```

handler(frame, 'call', None)

add breakpoint

handler(frame, …, None)

Problems?

Performance?

Any ideas to improve it?

Make `at_breakpoint` faster

Add a new API

Python 3.12 and PEP 669

PEP 669 – Low Impact Monitoring for CPython

Author: Mark Shannon <mark at hotpy.org>

Discussions-To: Discourse thread

Status: Accepted

Type: Standards Track

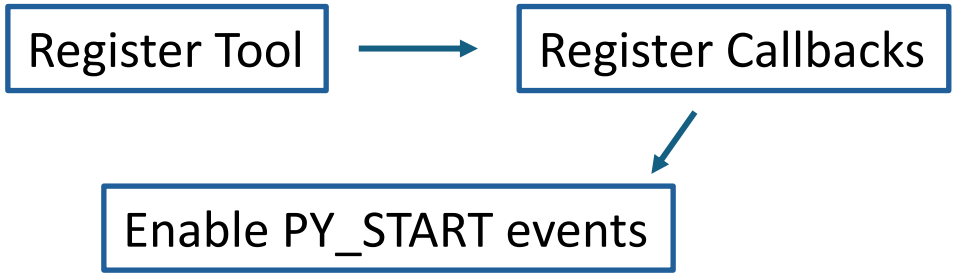
Created: 18-Aug-2021

Python-Version: 3.12

Post-History: 07-Dec-2021, 10-Jan-2022

Resolution: Discourse message

```
# some aliases and constants
mon = sys.monitoring
E = mon.events
TOOL_ID = mon.DEBUGGER_ID

# register the tool
mon.use_tool_id(TOOL_ID, "dbg")
```




```
# some aliases and constants
mon = sys.monitoring
E = mon.events
TOOL_ID = mon.DEBUGGER_ID

# register the tool
mon.use_tool_id(TOOL_ID, "dbg")

# register callbacks for the events we are interested in
mon.register_callback(TOOL_ID, E.LINE, line_handler)
mon.register_callback(TOOL_ID, E.PY_START, start_handler)

def start_handler(code: CodeType, offset: int):
    pass

def line_handler(code: CodeType, line: int) -> DISABLE|Any:
    pass
```

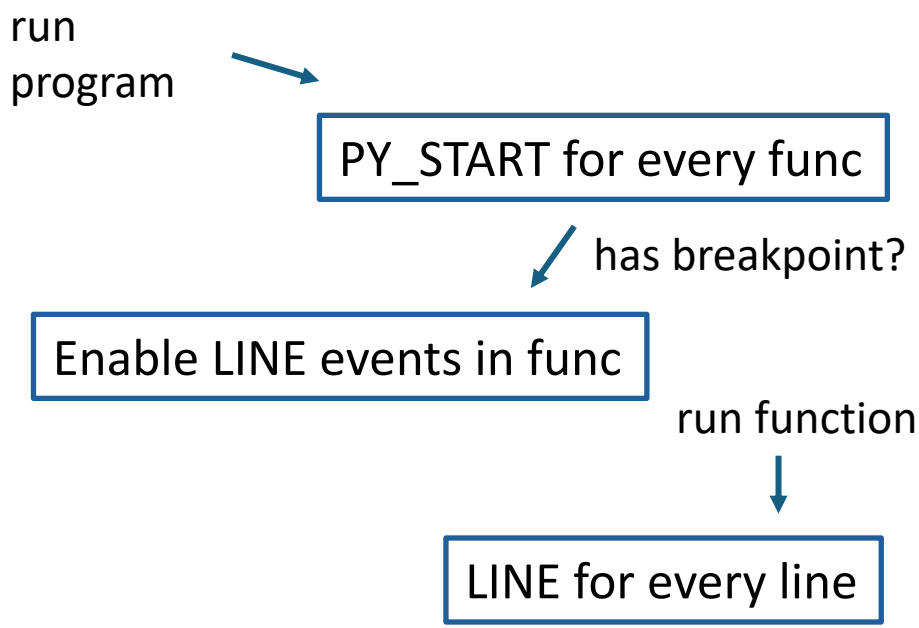
disable till
mon.restart_ever

```
# some aliases and constants
mon = sys.monitoring
E = mon.events
TOOL_ID = mon.DEBUGGER_ID

# register the tool
mon.use_tool_id(TOOL_ID, "dbg")

# register callbacks for the events we are interested in
mon.register_callback(TOOL_ID, E.LINE, line_handler)
mon.register_callback(TOOL_ID, E.PY_START, start_handler)
```

disable till
`mon.restart_events()`

```
def start_handler(code: CodeType, offset: int):
    pass

def line_handler(code: CodeType, line: int) → DISABLE|Any:
    pass
```

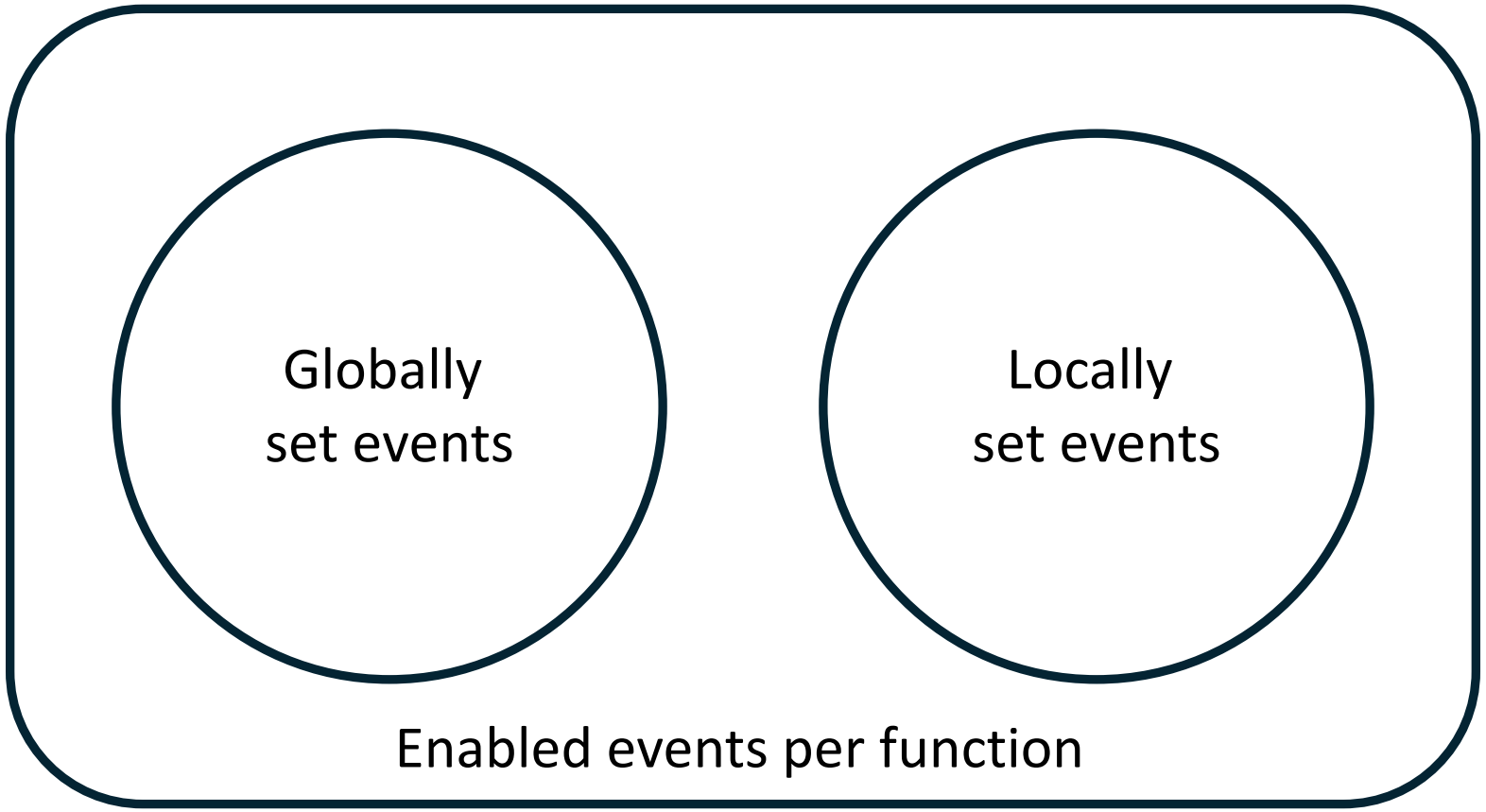
```
# some aliases and constants
mon = sys.monitoring
E = mon.events
TOOL_ID = mon.DEBUGGER_ID

# register the tool
mon.use_tool_id(TOOL_ID, "dbg")

# register callbacks for the events we are interested in
mon.register_callback(TOOL_ID, E.LINE, line_handler)
mon.register_callback(TOOL_ID, E.PY_START, start_handler)

# enable PY_START event globally
mon.set_events(TOOL_ID, E.PY_START)

# Later
mon.set_local_events(TOOL_ID, code, E.LINE)
```



> The biggest opportunity of PEP 669 isn't even the speed, it's the fact that a debugger built on top of it will **automatically support all threads**.

— Łukasz Langa

https://github.com/python/cpython/issues/103103#issuecomment-1488312628

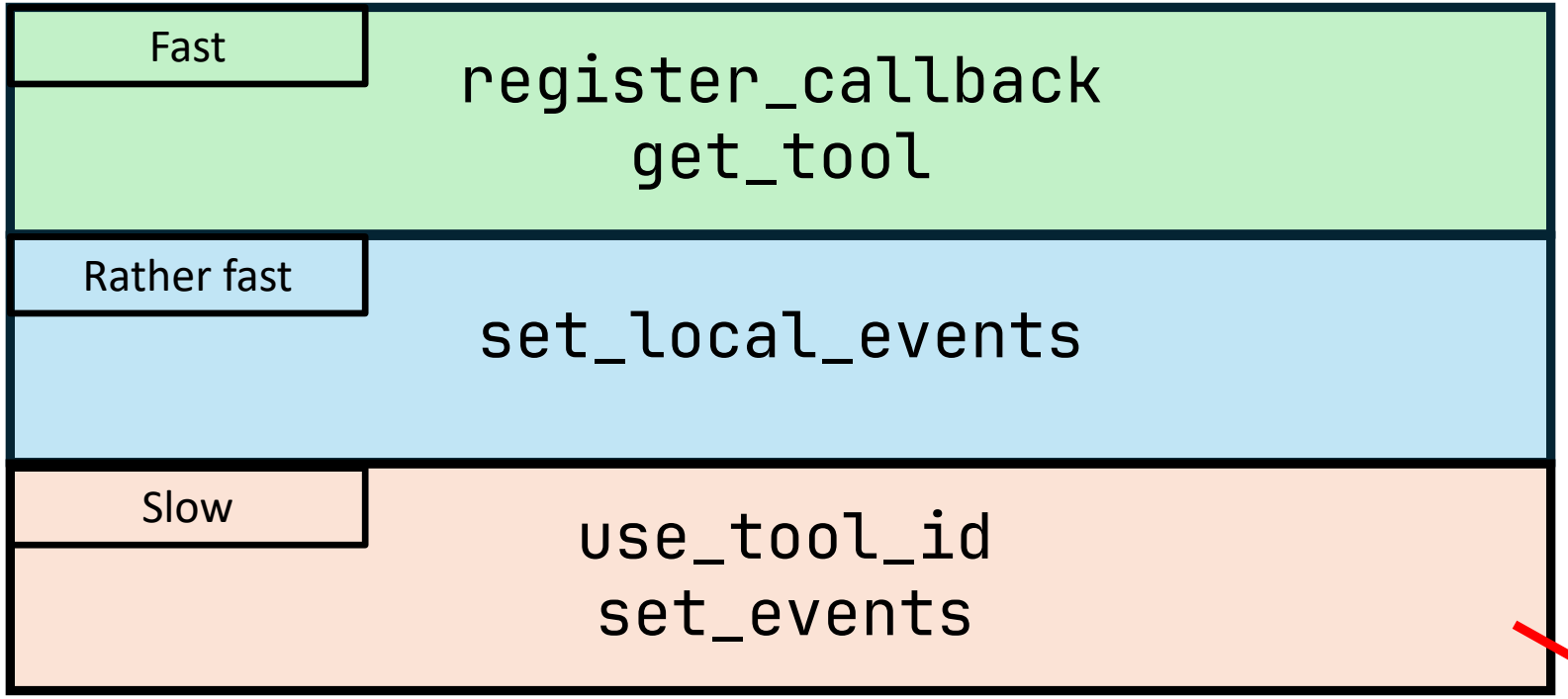

Globally
set events
Locally
set events
Enabled events per function

The power is in the fine-grained configuration

You can set events in f for f

```python
def line_handler(code: CodeType, line_number: int):
    print(f"  {code.co_name}: {line_number}")

mon.register_callback(tool_id, E.LINE, line_handler)

def f():
    print("hello")
    mon.set_local_events(tool_id, f.__code__, E.LINE)
    print("inner")
    mon.set_local_events(tool_id, f.__code__, 0)
    print("end")

f()

# Output
hello
  f: 18
inner
  f: 19
end
```

What's fast?


Fast
register_callback
get_tool
Rather fast
set_local_events
Slow
use_tool_id
set_events
The earlier the faster

Back to the debugger

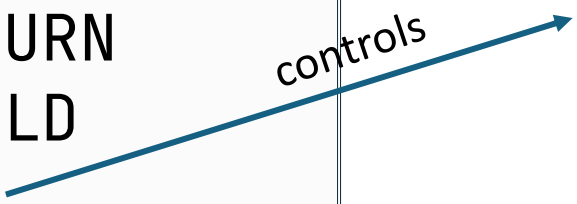
```
def start_handler(code: CodeType, _: int):
    # ... handle first call

    file = Path(code.co_filename).stem
    if has_breakpoint(file, code.co_firstlineno,
                      len(list(code.co_lines()))):
        print(f"enable line events for {code.co_name}")
        enable_line_events(code)
    print(f"start {code.co_name}")
```

```
def line_handler(code: CodeType, line: int):
    print(f"line {line} in {code.co_name}")
    if at_breakpoint(code.co_name, line):
        print(f"in break point at line {line}")
        dbg_shell(sys._getframe(1))
```

Event kinds

Local Events

PY_START
PY_RESUME
PY_RETURN
PY_YIELD
CALL
LINE
INSTRUCTION
JUMP
BRANCH
STOP_ITERATION



Ancillary Events

C_RAISE
C_RETURN

Other Events

PY_RAISE
PY_UNWIND
PY_THROW
EXCEPTION_
HANDLED

not tied to specific location

Performance

Hacking pyperformance
for fun and profit...

```
def inner_handler(*args):
    pass


def handler(*args):
    return inner_handler

sys.settrace(handler)
```

VS

VS

```
def line_handler(*args):
    pass

def start_handler(*args):
    pass


mon.use_tool_id(TOOL_ID, "dbg")
mon.register_callback(...)
mon.set_events(TOOL_ID,
  E.PY_START)


mon.set_events(TOOL_ID,
  E.PY_START | E.LINE)
```

sys.settrace

monitoring

Python Performance Benchmark Suite

Navigation

Quick search

Go

The Python Performance Benchmark Suite

The `pyperformance` project is intended to be an authoritative source of benchmarks for all Python implementations. The focus is on real-world benchmarks, rather than synthetic benchmarks, using whole applications when possible.

- pyperformance documentation
- pyperformance GitHub project (source code, issues)
- Download pyperformance on PyPI

pyperformance is distributed under the MIT license.

Documentation:

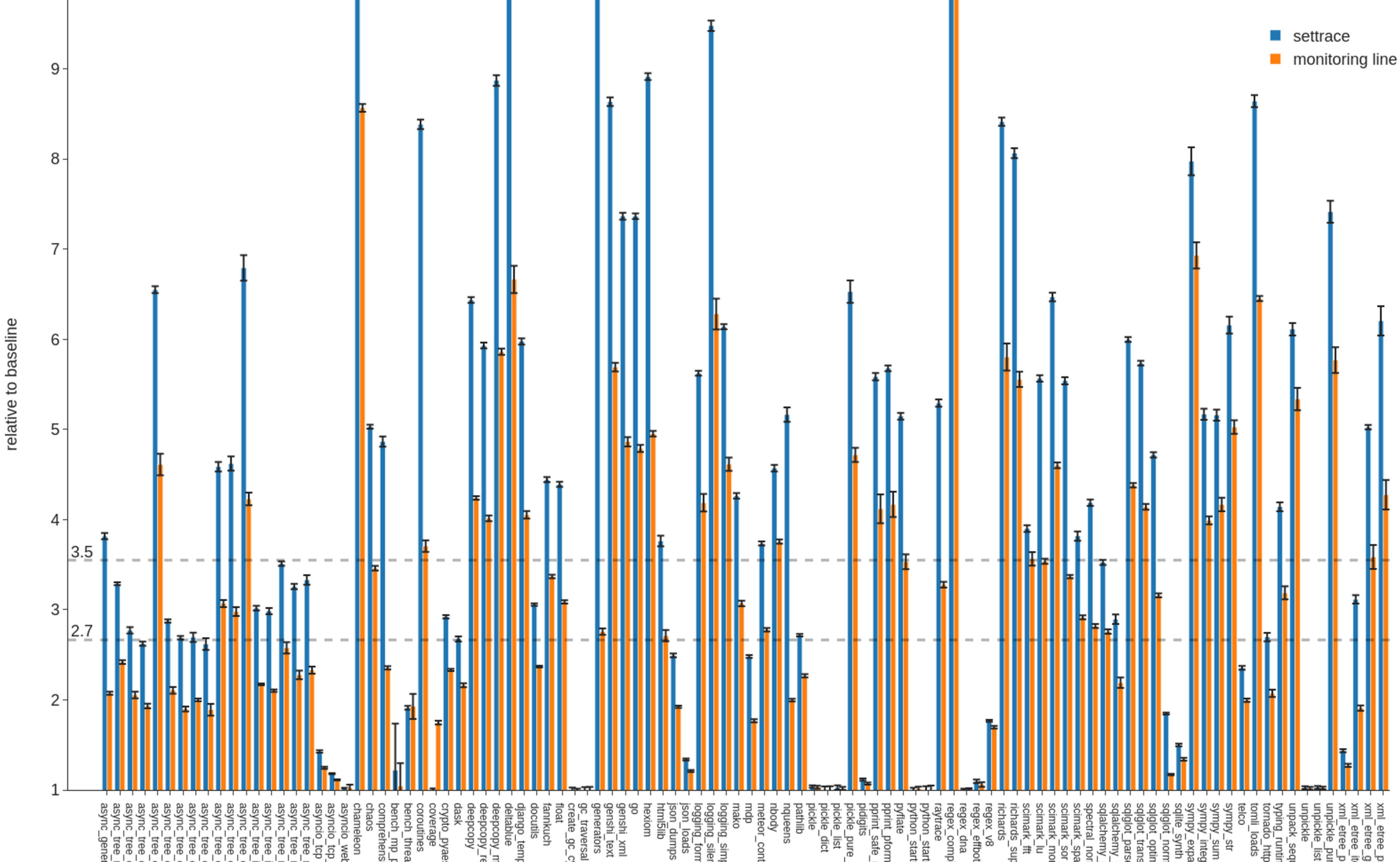
modified version: https://github.com/parttimenerd/pyperformance/tree/dbg

3.5x runtime **VS** 1.2x runtime

VS 2.7x runtime

sys.settrace

monitoring


settrace
monitoring line
relative to baseline
1
2
3
4
5
6
7
8
9
3.5
2.7

Is it used?

gh-103103: Prototype of a new debugger based on PEP 669 #103496

Draft **gaogaotiantian** wants to merge 8 commits into `python:main` from `gaogaotiantian:pep669-dbg`

Conversation 0 | Commits 8 | Checks 14 | Files changed 3

gaogaotiantian commented on Apr 13, 2023 • edited — Contributor

This is the prototype of the new bdb/pdb for PEP 669.

Task list:

Mechanism:

- [x] Breakpoint
- [x] Code control
- [x] Ctrl+D to exit
- [ ] Run as a module
  - [ ] execute script
  - [ ] execute module
- [ ] Post-mortem debugging

Commands

- [ ] help
- [x] where

not yet in pdb

but IDEs like PyCharm 2023.3 use it

Reviewers

No reviews

Assignees

No one assigned

Labels

awaiting review

Projects

None yet

Milestone

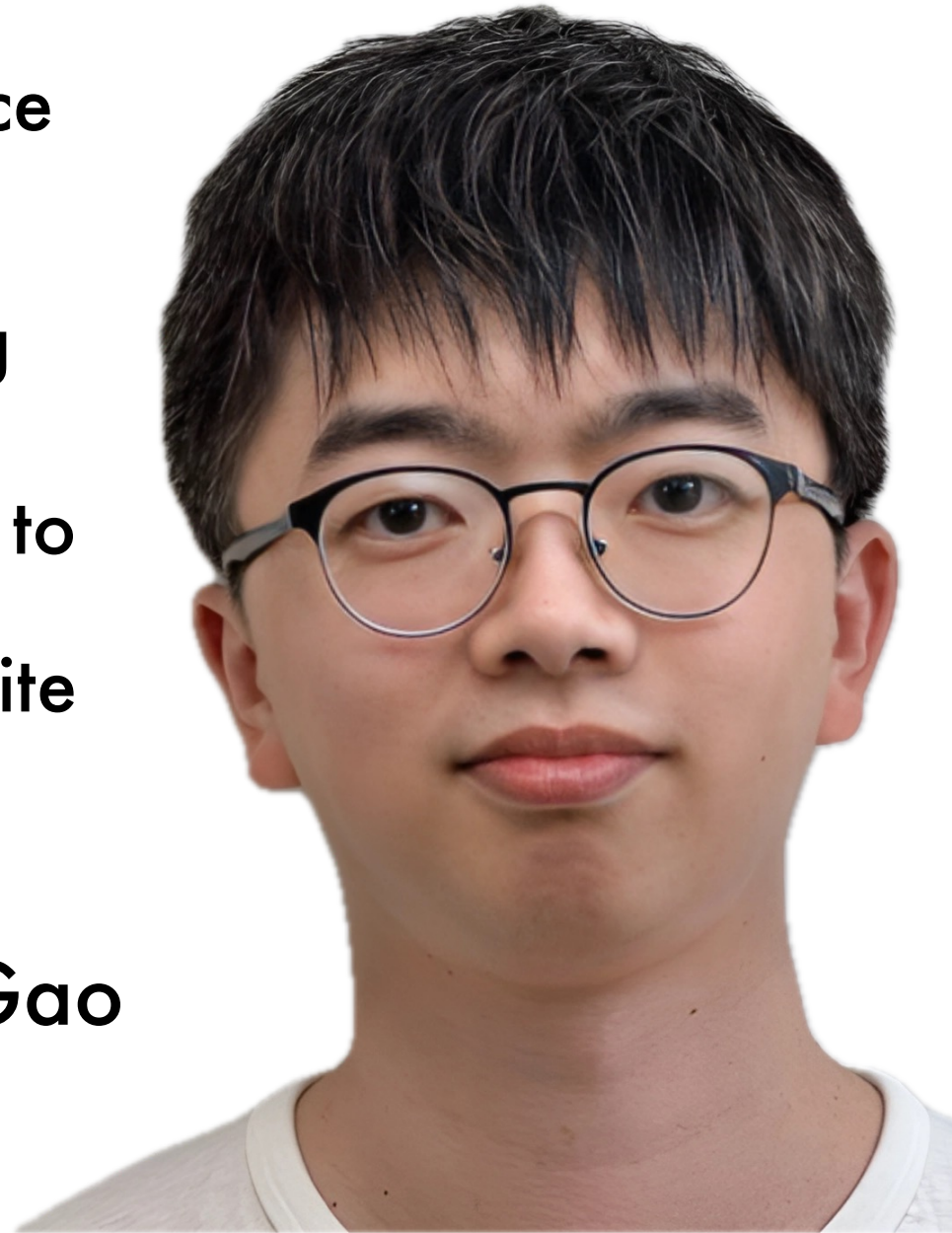
No milestone

Development

Successfully merging thi

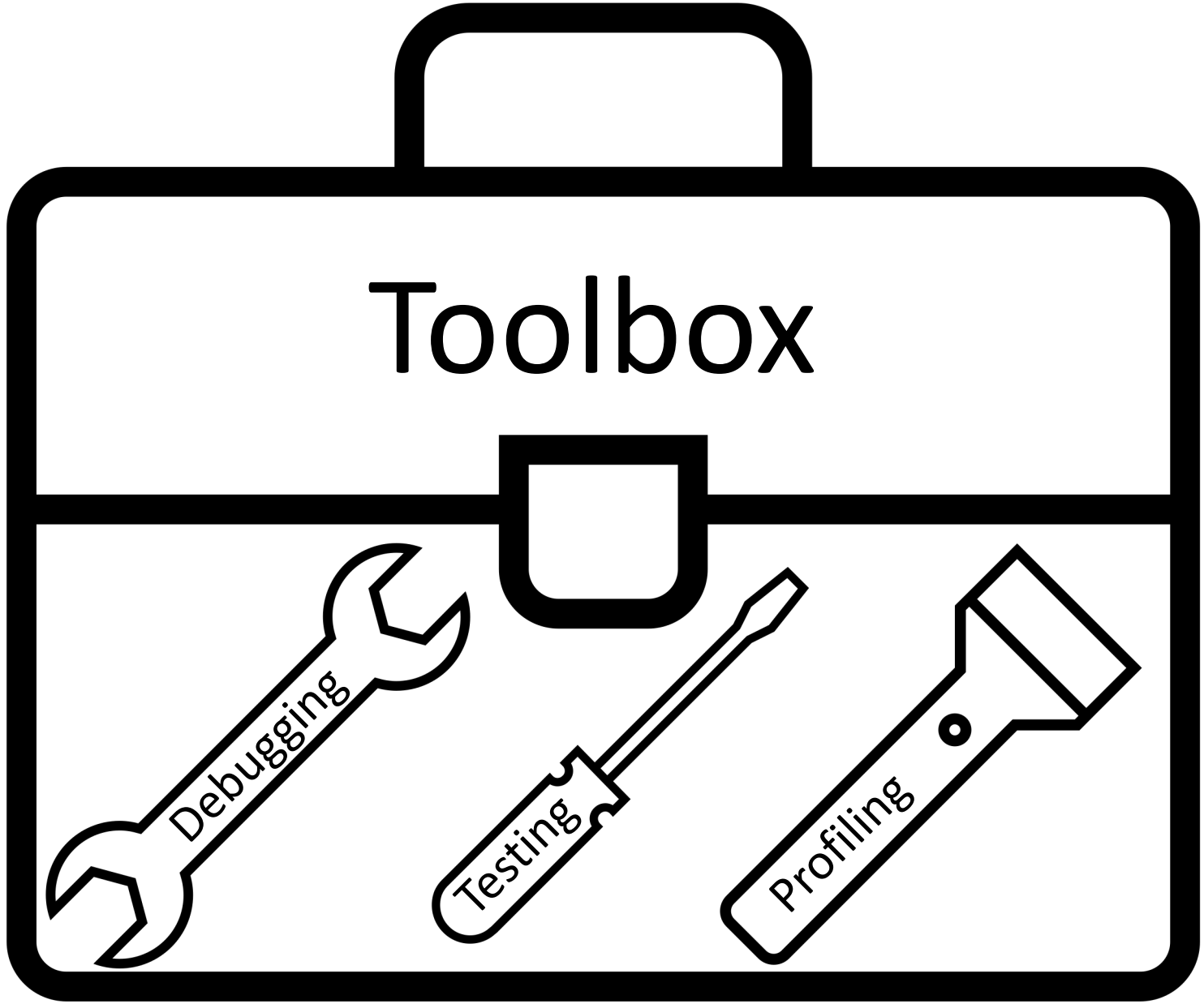
> After #103082, we will have the chance to build a much faster debugger. For breakpoints, we do not need to trigger trace function all the time and checking for the line number. [...]
>
> The bad news is - it's almost impossible to do a completely backward compatible transition because the mechanism is quite different.

— Tian Gao



https://github.com/python/cpython/issues/103103#issue-1644836791

Putting it all together


Toolbox
Debugging
Testing
Profiling

@parttimen3rd on Twitter
parttimenerd on GitHub
mostlynerdless.de

@SweetSapMachine
sapmachine.io

Feedback

Resources