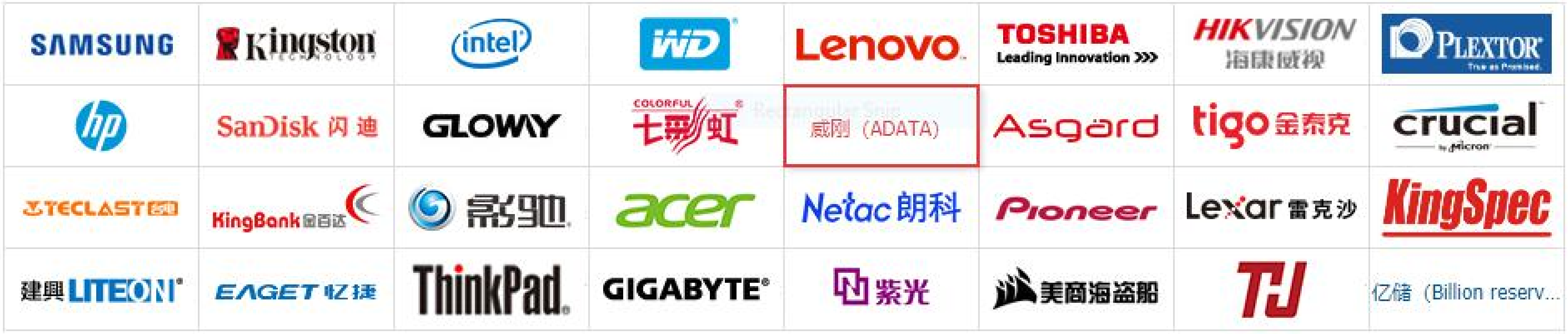
# Why SSD developers need pynvme?

## and why pynvme needs SPDK?

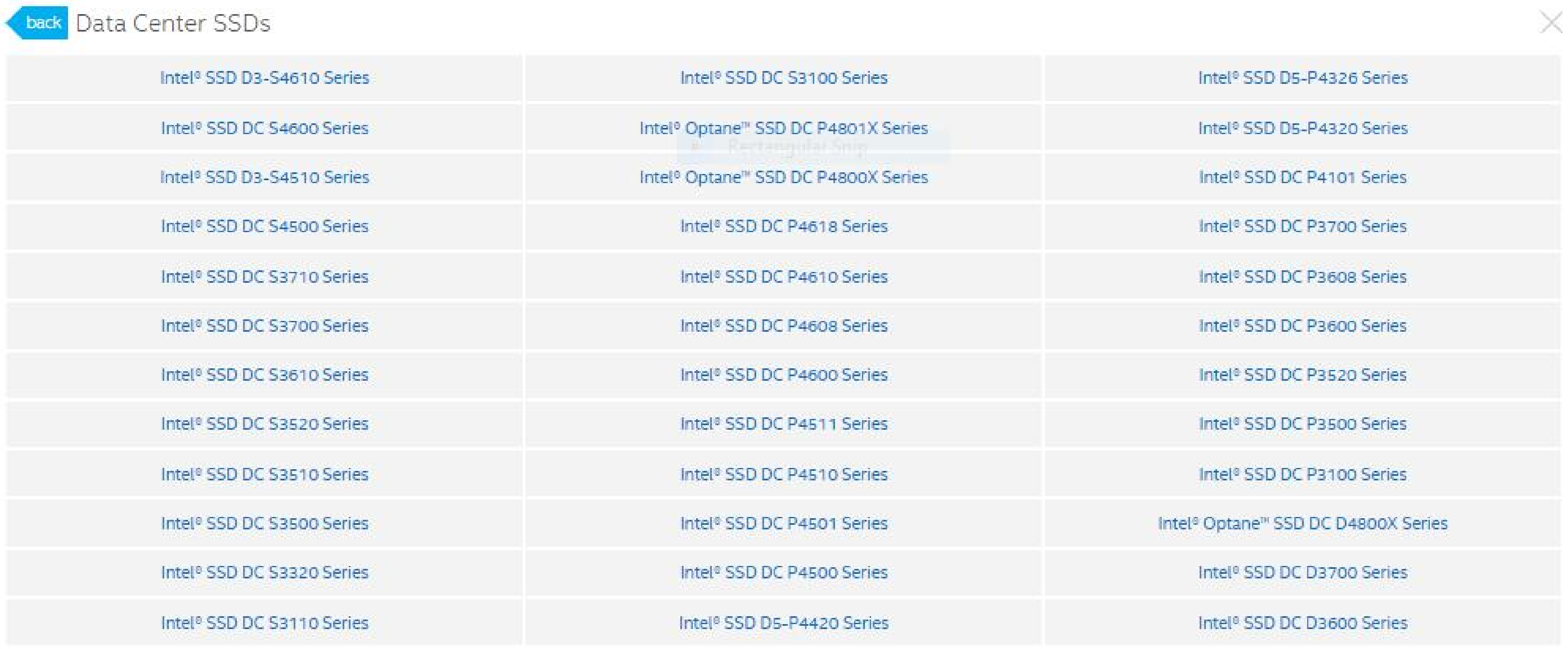
https://github.com/cranechu/pynvme

## SSD Testing



| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SAMSUNG | Kingston TECHNOLOGY | intel | WD | Lenovo. | TOSHIBA Leading Innovation >>> | HIKVISION 海康威视 | PLEXTOR True as Promised. |
| hp | SanDisk 闪迪 | GLOWAY | COLORFUL 七彩虹 | 威刚 （ADATA） | Asgard | tigo 金泰克 | crucial by Micron |
| TECLAST 台电 | KingBank 金百达 | 影驰 | acer | Netac 朗科 | Pioneer | Lexar 雷克沙 | KingSpec |
| 建興 LITEON | EAGET 忆捷 | ThinkPad | GIGABYTE | 紫光 | 美商海盗船 | TJ | 亿储 （Billion reserv... |

## SSD Testing



back Data Center SSDs

| | | |
|---|---|---|
| Intel® SSD D3-S4610 Series | Intel® SSD DC S3100 Series | Intel® SSD D5-P4326 Series |
| Intel® SSD DC S4600 Series | Intel® Optane™ SSD DC P4801X Series | Intel® SSD D5-P4320 Series |
| Intel® SSD D3-S4510 Series | Intel® Optane™ SSD DC P4800X Series | Intel® SSD DC P4101 Series |
| Intel® SSD DC S4500 Series | Intel® SSD DC P4618 Series | Intel® SSD DC P3700 Series |
| Intel® SSD DC S3710 Series | Intel® SSD DC P4610 Series | Intel® SSD DC P3608 Series |
| Intel® SSD DC S3700 Series | Intel® SSD DC P4608 Series | Intel® SSD DC P3600 Series |
| Intel® SSD DC S3610 Series | Intel® SSD DC P4600 Series | Intel® SSD DC P3520 Series |
| Intel® SSD DC S3520 Series | Intel® SSD DC P4511 Series | Intel® SSD DC P3500 Series |
| Intel® SSD DC S3510 Series | Intel® SSD DC P4510 Series | Intel® SSD DC P3100 Series |
| Intel® SSD DC S3500 Series | Intel® SSD DC P4501 Series | Intel® Optane™ SSD DC D4800X Series |
| Intel® SSD DC S3320 Series | Intel® SSD DC P4500 Series | Intel® SSD DC D3700 Series |
| Intel® SSD DC S3110 Series | Intel® SSD D5-P4420 Series | Intel® SSD DC D3600 Series |

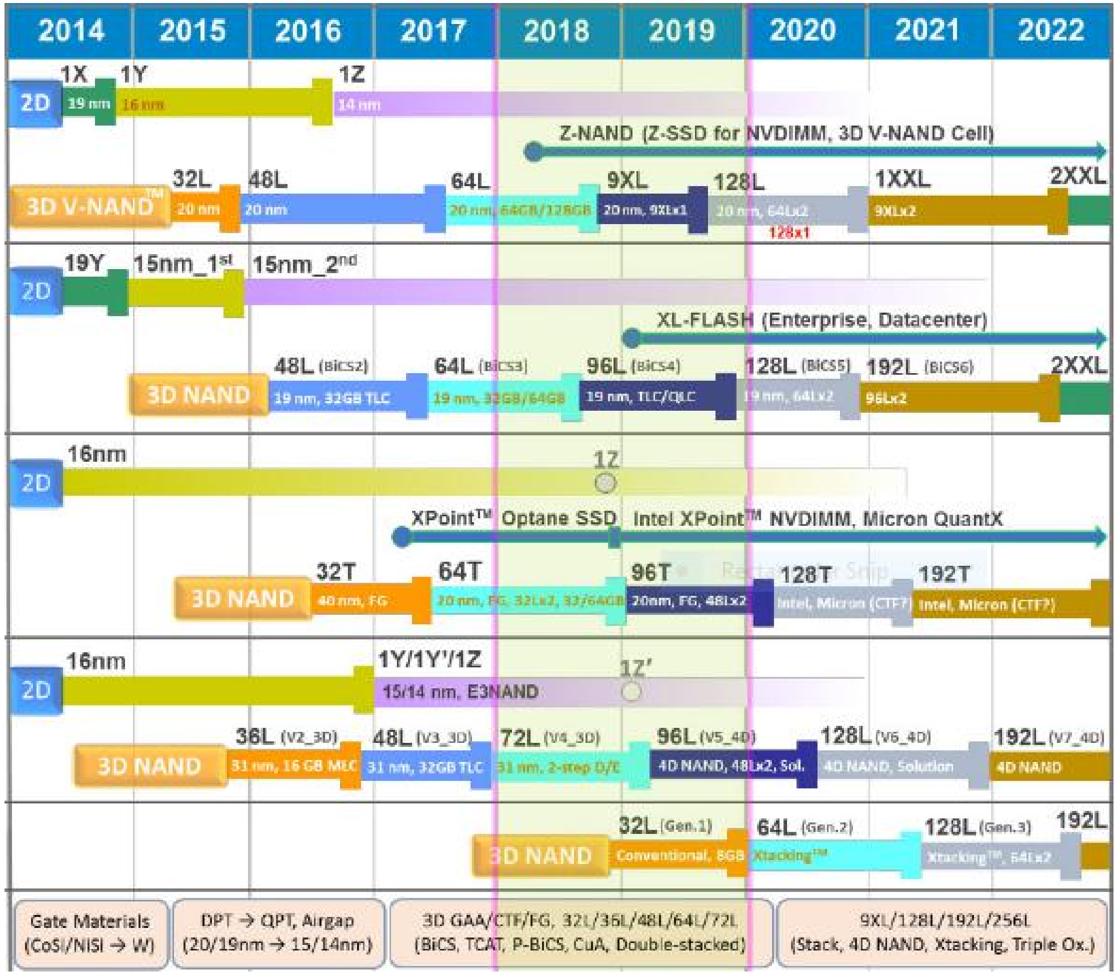
## SSD Testing

MARVELL®
SandForce®
MICROCHIP®
SiliconMotion
STARBLAZE
YEESTOR
NETINT
SAGE MICROELECTRONIQUE
INNOGRIT
NGD systems
FADU
PHISON Knows What You Need Phison Electronics Corp.
MaXio
CNEXLABS

# SSD Testing

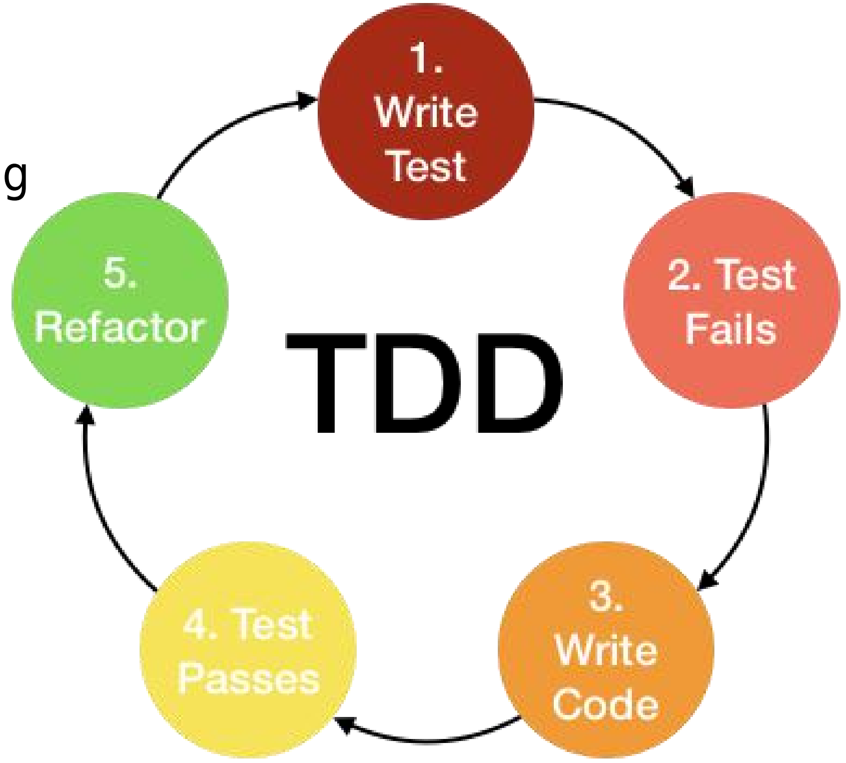
**NVMe spec:**

- 1.0e (Jan. 2013)
- 1.1b (July 2014)
- 1.2 (Nov. 2014)
    - 1.2a (Oct. 2015)
    - 1.2b (June 2016)
    - 1.2.1 (June 2016)
- 1.3 (May 2017)
    - 1.3a (Oct. 2017)
    - 1.3b (May 2018)
    - 1.3c (May 2018)
    - 1.3d (March 2019)
- 1.4 (June 2019)



# Agile and TDD

- Challenge
  - NAND is changing
  - Applications and specifications are changing
  - Diversity on NAND and controllers
  - Continous Qualification, testing cost
- SSD development should be …
  - fast iterated
  - customer-oriented
  - open to change
- Waterfall v.s. Agile
  - Test-driven development (TDD)



## Test Driver

- Embedded devices provide very limited resources
- We need A test-dedicated NVMe driver in host platforms:
  - exports device's features to host
  - exports device's flaws to host
  - exports device's performance to host
  - friendly to test script development
  - friendly to firmware debug
  - friendly to CI

## Existed Tools

| | tnvme | DM | fio | *Marks |
|---|---|---|---|---|
| feature | √ | √ | × | × |
| performance | × | √ | √ | √ |
| scripts | √ | × | √ | × |
| debug | × | √ | × | × |
| CI | √ | × | √ | × |
| driver | dnvme | OFA | Linux | Windows |

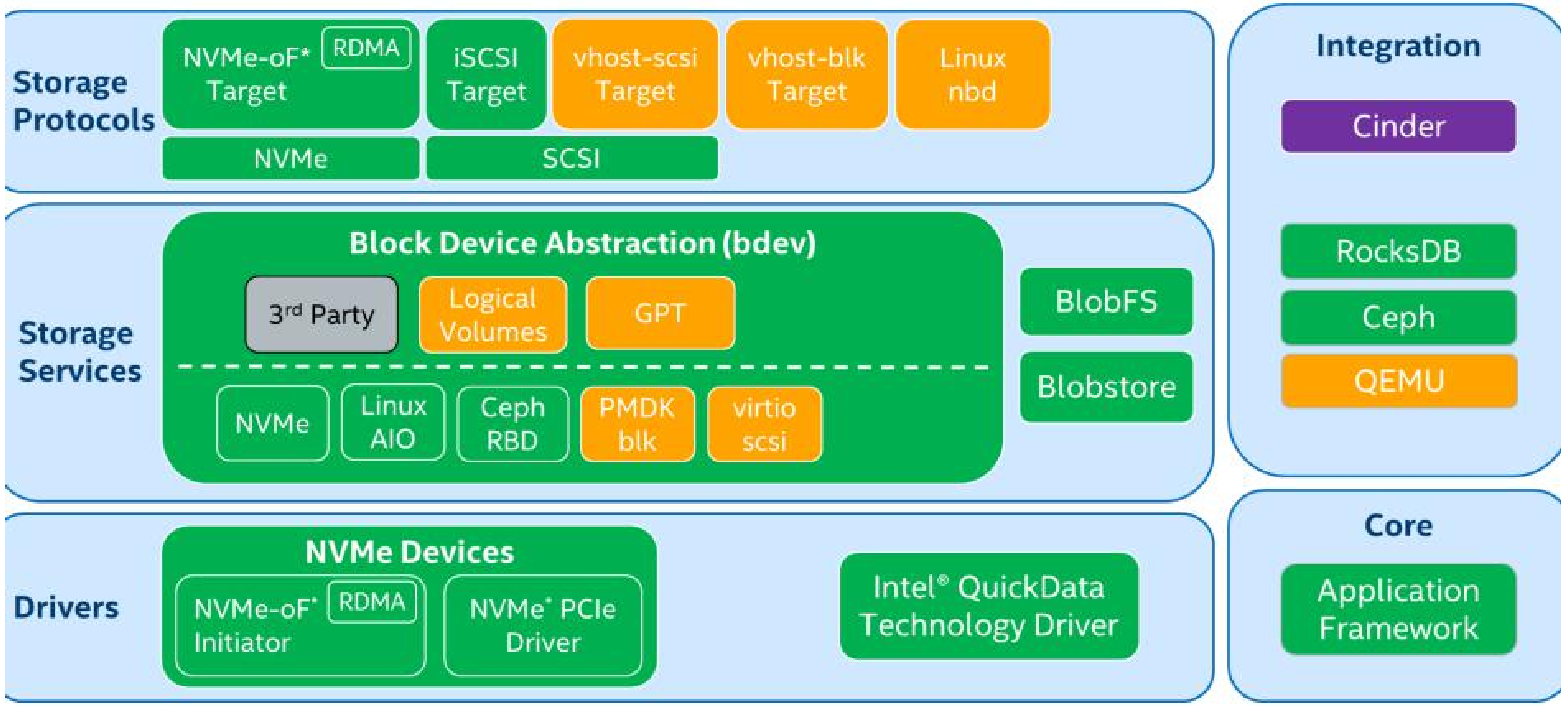
## pynvme

The pynvme is a python extension module.

Users can operate NVMe SSD intuitively in Python scripts. It is designed for NVMe SSD testing with performance considered.

Integrated with third-party tools, vscode and pytest, pynvme provides a convenient and professional solution to test NVMe devices.

# Pynvme is based on SPDK/DPDK



## Why SPDK?

√ user space:
- easy for debugging
- maintainness

√ well modularized:
- jsonrpc: for debug
- memzone: share memory between processinges
- crc32

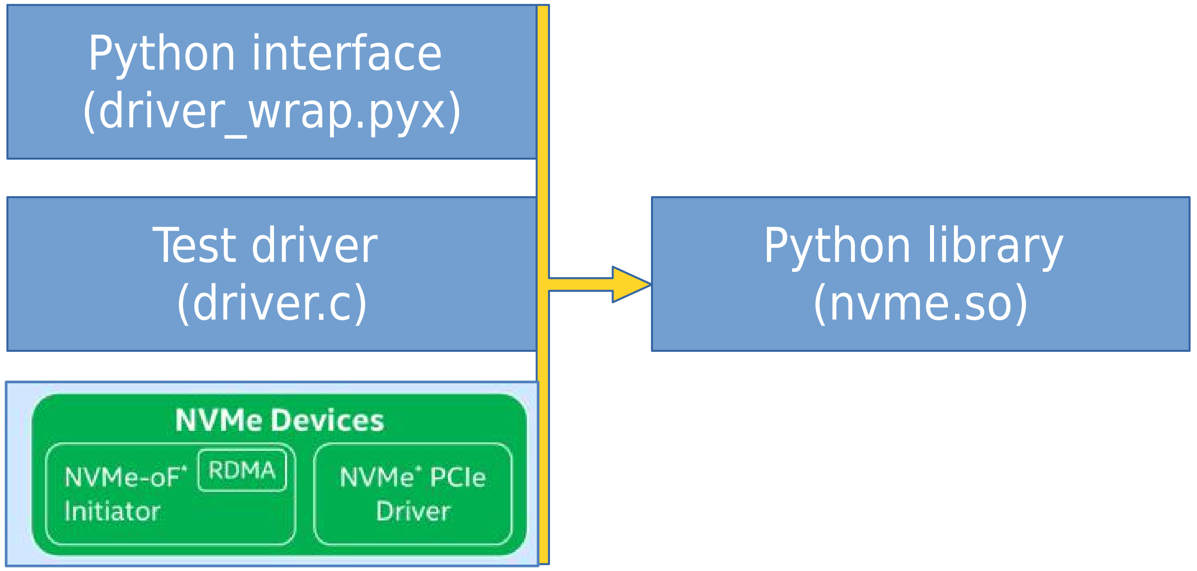
√ best performance:
- test efficiency
- stress test

√ open and active
- SSD, NVMe, NAND are all keeping changing!

## Pynvme Architecture

Build python library with Cython:

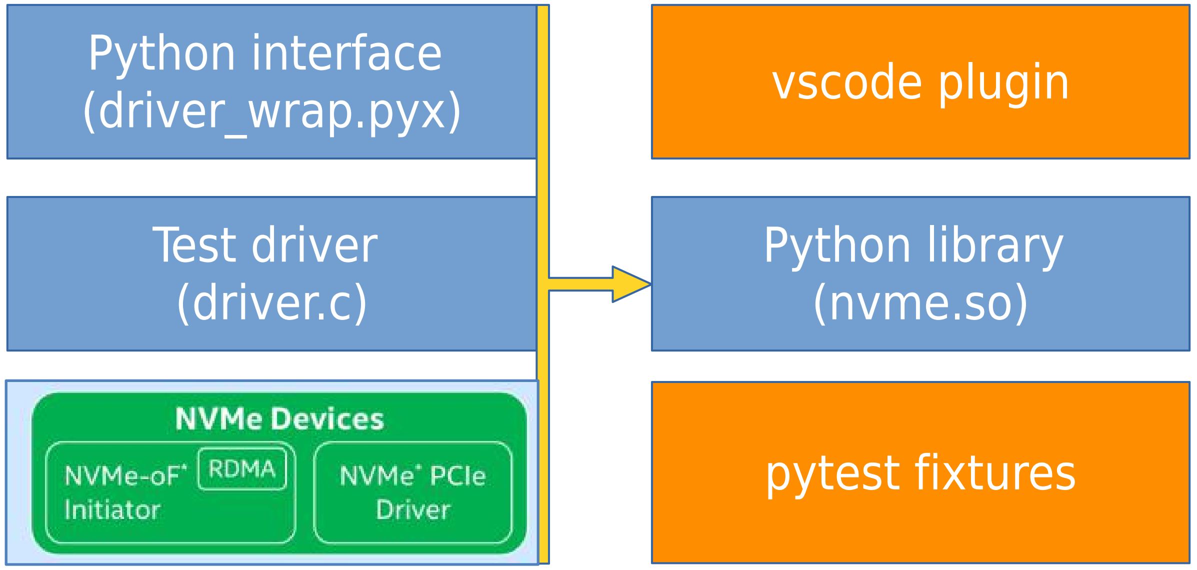
- setup.py
- driver.c
- driver.h
- cdriver.pxd
- driver_wrap.pyx
- Makefile



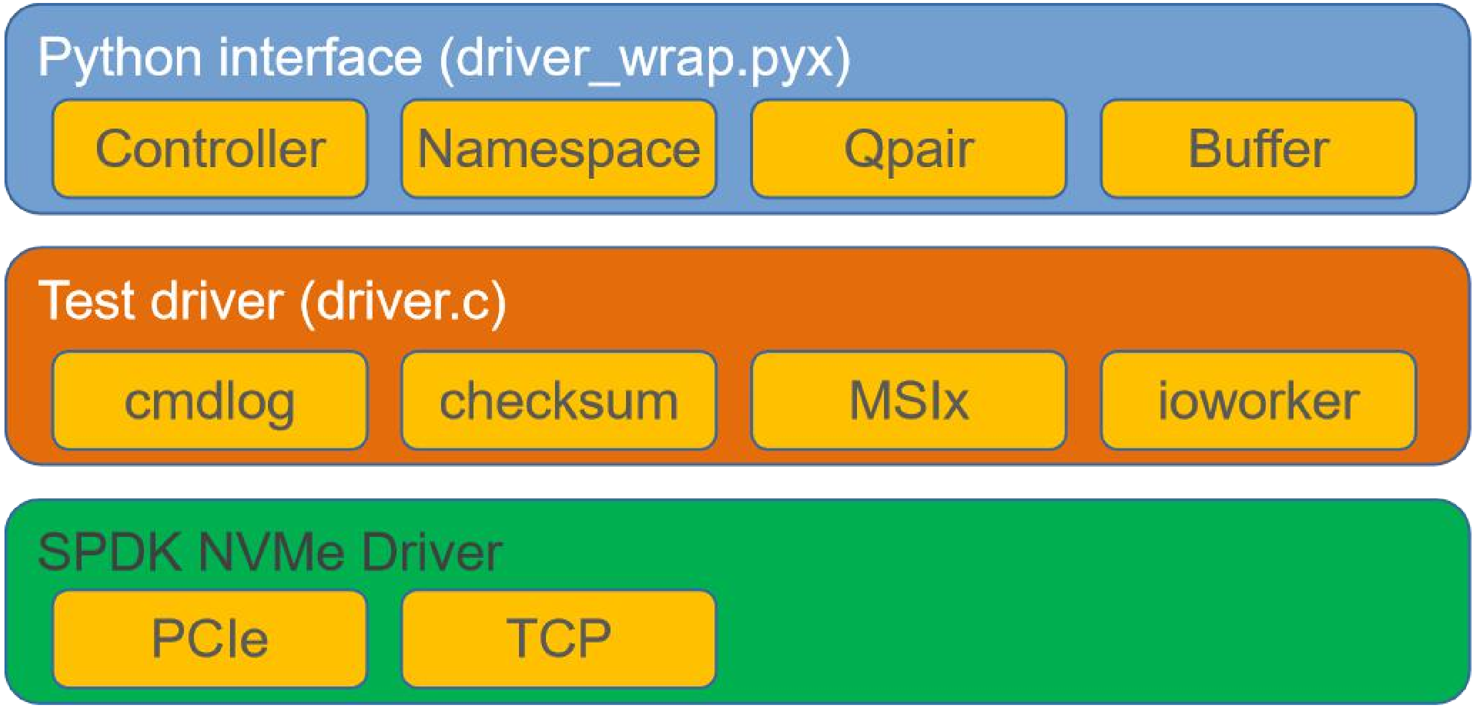
# Pynvme Architecture

Organize test cases in pytest:

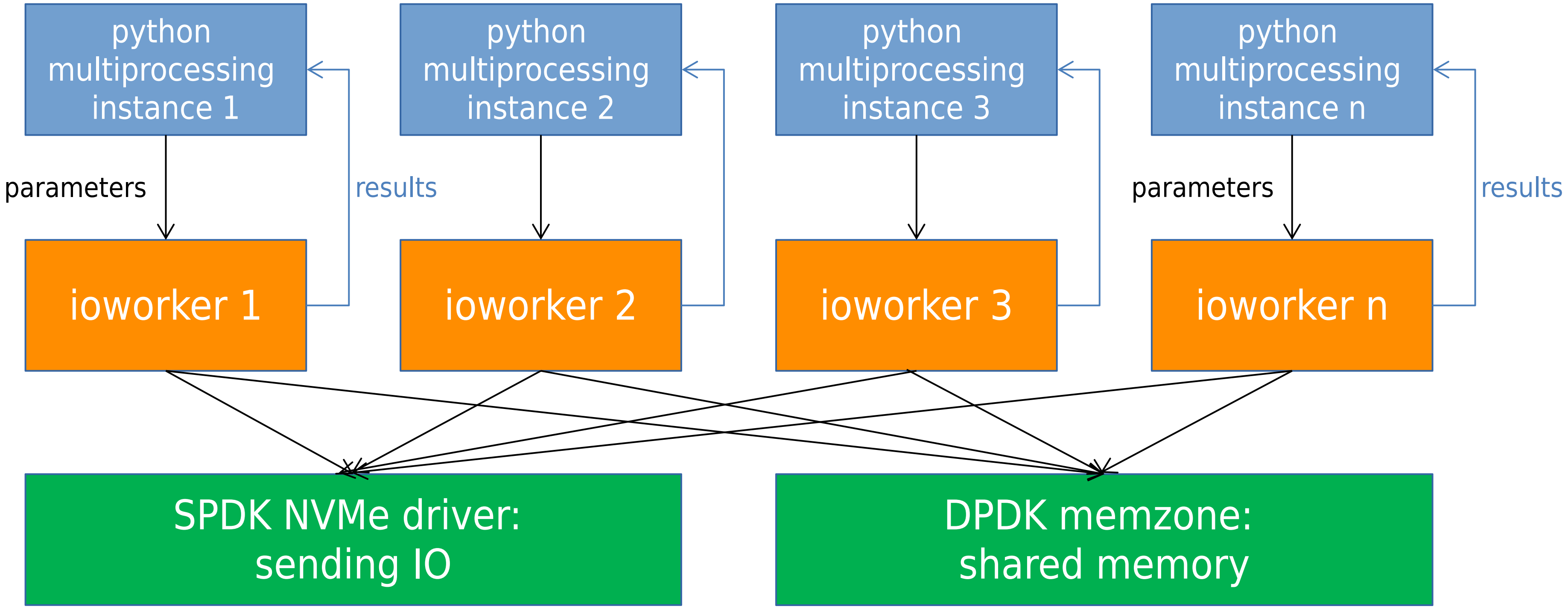
- mvme.so
- pytest.ini
- conftest.py
- driver_test.py



## Pynvme Architecture



# IOWorker


python multiprocessing instance 1
python multiprocessing instance 2
python multiprocessing instance 3
python multiprocessing instance n
parameters
results
parameters
results
ioworker 1
ioworker 2
ioworker 3
ioworker n
SPDK NVMe driver: sending IO
DPDK memzone: shared memory

## Why Python?

√Many beautiful and mature libraries

- Cython
- pytest
- logging
- multiprocessing
- pydoc
- os, io, time, pytemperature, statistics, yaml, json, struct, matplotlib, ...

√Friendly to test script development

- VSCode, Emacs, Pycharm, ...

√Friendly to CI: develop firmware softly

pipeline passed

- Introducing software methodologies, processes and tools to firmware.

## Pytest Execution

- '''The pytest framework makes it easy to write small tests, yet scales to support complex functional testing for applications and libraries.'''

- '''pytest fixtures offer dramatic improvements over the classic xUnit style of setup/teardown functions'''

- use “make test” to start pytest sessions
  - make test
  - make test TESTS=scripts
  - make test TESTS=scripts/demo_test.py
  - make test TESTS=scripts/utility_test.py::test_download_firmware
- find test logs in test.log

## Fixtures of pynvme

- create/delete test objects. in conftest.py:
  - nvme0
  - nvme0n1
  - pcie
  - ...
- parametrize of tests
  - @pytest.mark.parametrize("qcount", [1, 2, 4, 8, 15])
  - @pytest.mark.parametrize("repeat", range(10))
- test control
  - @pytest.mark.skip("nvme over tcp")

- doc: [https://docs.pytest.org/en/latest/fixture.html](https://docs.pytest.org/en/latest/fixture.html)

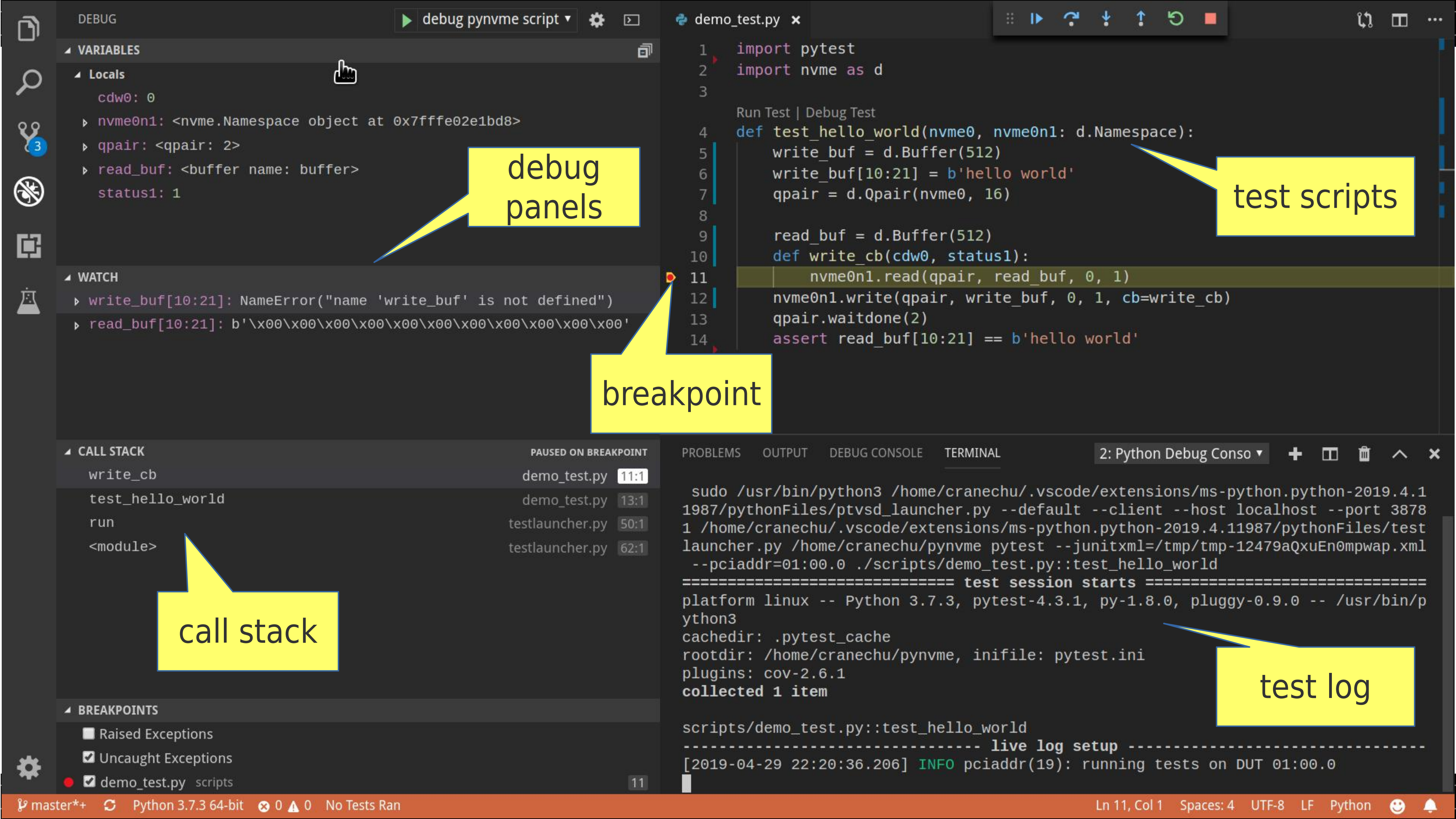
# Visual Studio Code

- VSCode is the most popular IDE.
    - root user is not recommended by vscode, so users need to run sudo without a password: *sudo visudo*

- Pynvme also providers an extension to monitor device status and cmdlog in every qpair. To install the extension:
    - *code --install-extension pynvme-console-1.x.x.vsix*

- Add DUT pci address to .vscode/settings.json
    - get the BDF address with *lspci*

- *make setup; code .* # launch the vscode



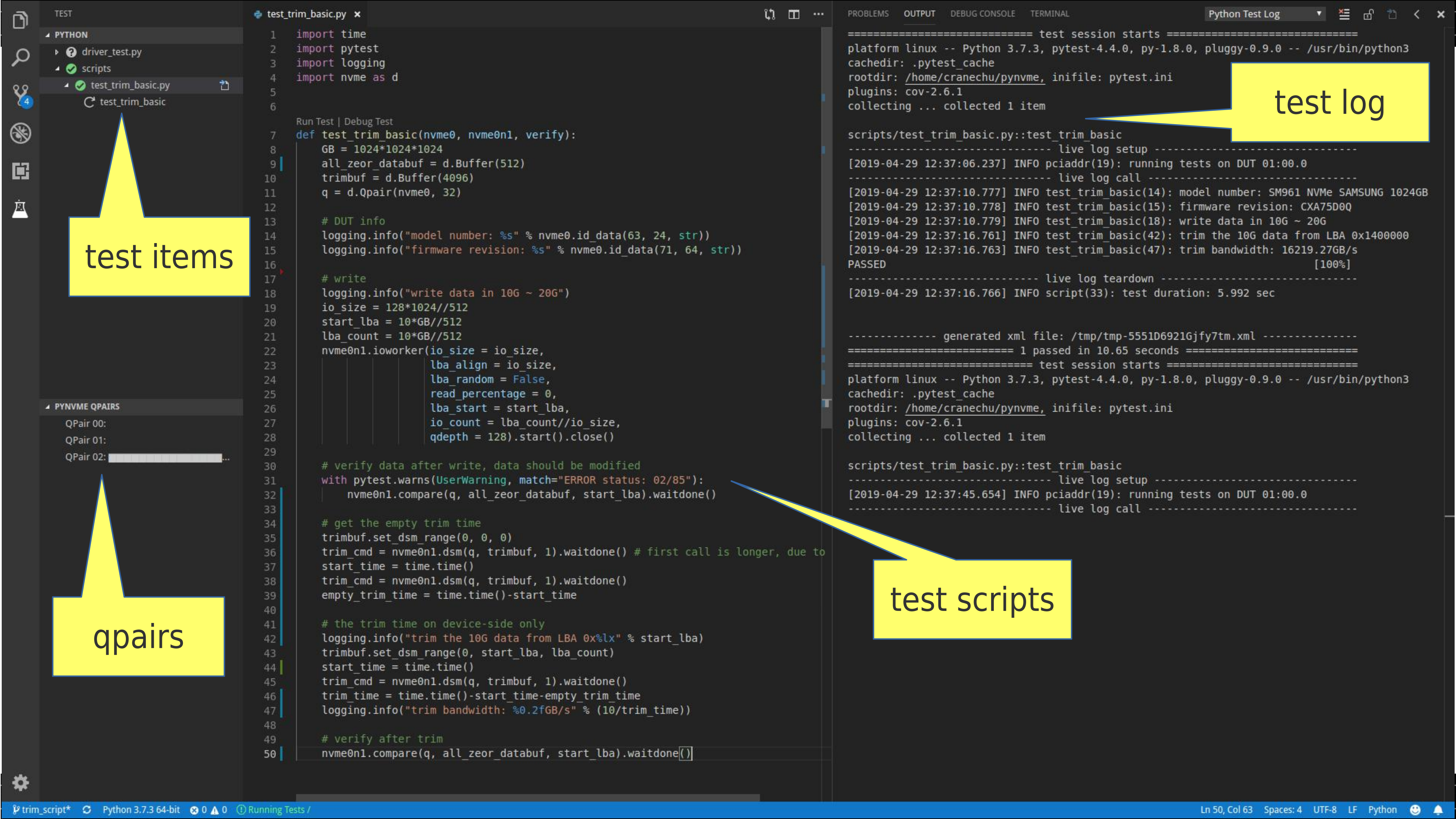
```
cdw0: 0
nvme0n1: <nvme.Namespace object at 0x7fffe02e1bd8>
qpair: <qpair: 2>
read_buf: <buffer name: buffer>
status1: 1
```

```
write_buf[10:21]: NameError("name 'write_buf' is not defined")
read_buf[10:21]: b'\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00'
```

```
write_cb            demo_test.py   11:1
test_hello_world    demo_test.py   13:1
run                 testlauncher.py 50:1
<module>            testlauncher.py 62:1
```

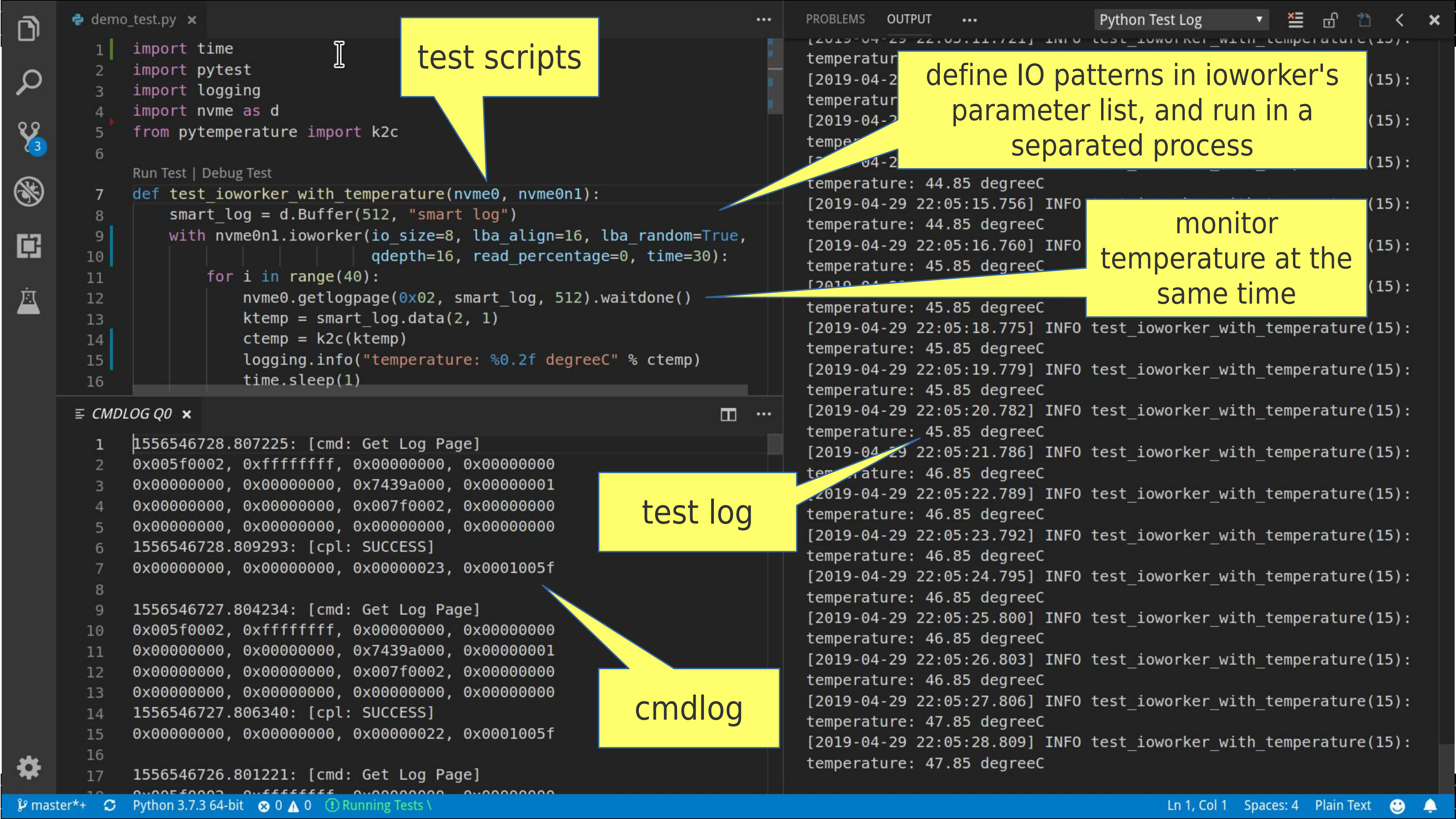
```python
import pytest
import nvme as d

def test_hello_world(nvme0, nvme0n1: d.Namespace):
    write_buf = d.Buffer(512)
    write_buf[10:21] = b'hello world'
    qpair = d.Qpair(nvme0, 16)

    read_buf = d.Buffer(512)
    def write_cb(cdw0, status1):
        nvme0n1.read(qpair, read_buf, 0, 1)
    nvme0n1.write(qpair, write_buf, 0, 1, cb=write_cb)
    qpair.waitdone(2)
    assert read_buf[10:21] == b'hello world'
```

```
 sudo /usr/bin/python3 /home/cranechu/.vscode/extensions/ms-python.python-2019.4.1
1987/pythonFiles/ptvsd_launcher.py --default --client --host localhost --port 3878
1 /home/cranechu/.vscode/extensions/ms-python.python-2019.4.11987/pythonFiles/test
launcher.py /home/cranechu/pynvme pytest --junitxml=/tmp/tmp-12479aQxuEn0mpwap.xml
 --pciaddr=01:00.0 ./scripts/demo_test.py::test_hello_world
============================== test session starts ===============================
platform linux -- Python 3.7.3, pytest-4.3.1, py-1.8.0, pluggy-0.9.0 -- /usr/bin/p
ython3
cachedir: .pytest_cache
rootdir: /home/cranechu/pynvme, inifile: pytest.ini
plugins: cov-2.6.1
collected 1 item

scripts/demo_test.py::test_hello_world
-------------------------------- live log setup ---------------------------------
[2019-04-29 22:20:36.206] INFO pciaddr(19): running tests on DUT 01:00.0
```



```python
import time
import pytest
import logging
import nvme as d


def test_trim_basic(nvme0, nvme0n1, verify):
    GB = 1024*1024*1024
    all_zeor_databuf = d.Buffer(512)
    trimbuf = d.Buffer(4096)
    q = d.Qpair(nvme0, 32)

    # DUT info
    logging.info("model number: %s" % nvme0.id_data(63, 24, str))
    logging.info("firmware revision: %s" % nvme0.id_data(71, 64, str))

    # write
    logging.info("write data in 10G ~ 20G")
    io_size = 128*1024//512
    start_lba = 10*GB//512
    lba_count = 10*GB//512
    nvme0n1.ioworker(io_size = io_size,
                     lba_align = io_size,
                     lba_random = False,
                     read_percentage = 0,
                     lba_start = start_lba,
                     io_count = lba_count//io_size,
                     qdepth = 128).start().close()

    # verify data after write, data should be modified
    with pytest.warns(UserWarning, match="ERROR status: 02/85"):
        nvme0n1.compare(q, all_zeor_databuf, start_lba).waitdone()

    # get the empty trim time
    trimbuf.set_dsm_range(0, 0, 0)
    trim_cmd = nvme0n1.dsm(q, trimbuf, 1).waitdone() # first call is longer, due to
    start_time = time.time()
    trim_cmd = nvme0n1.dsm(q, trimbuf, 1).waitdone()
    empty_trim_time = time.time()-start_time

    # the trim time on device-side only
    logging.info("trim the 10G data from LBA 0x%lx" % start_lba)
    trimbuf.set_dsm_range(0, start_lba, lba_count)
    start_time = time.time()
    trim_cmd = nvme0n1.dsm(q, trimbuf, 1).waitdone()
    trim_time = time.time()-start_time-empty_trim_time
    logging.info("trim bandwidth: %0.2fGB/s" % (10/trim_time))

    # verify after trim
    nvme0n1.compare(q, all_zeor_databuf, start_lba).waitdone()
```

```
============================ test session starts ============================
platform linux -- Python 3.7.3, pytest-4.4.0, py-1.8.0, pluggy-0.9.0 -- /usr/bin/python3
cachedir: .pytest_cache
rootdir: /home/cranechu/pynvme, inifile: pytest.ini
plugins: cov-2.6.1
collecting ... collected 1 item

scripts/test_trim_basic.py::test_trim_basic
-------------------------------- live log setup -------------------------------
[2019-04-29 12:37:06.237] INFO pciaddr(19): running tests on DUT 01:00.0
-------------------------------- live log call --------------------------------
[2019-04-29 12:37:10.777] INFO test_trim_basic(14): model number: SM961 NVMe SAMSUNG 1024GB
[2019-04-29 12:37:10.778] INFO test_trim_basic(15): firmware revision: CXA75D0Q
[2019-04-29 12:37:10.779] INFO test_trim_basic(18): write data in 10G ~ 20G
[2019-04-29 12:37:16.761] INFO test_trim_basic(42): trim the 10G data from LBA 0x1400000
[2019-04-29 12:37:16.763] INFO test_trim_basic(47): trim bandwidth: 16219.27GB/s
PASSED                                                                   [100%]
------------------------------ live log teardown ------------------------------
[2019-04-29 12:37:16.766] INFO script(33): test duration: 5.992 sec


-------------- generated xml file: /tmp/tmp-5551D6921Gjfy7tm.xml --------------
========================== 1 passed in 10.65 seconds ==========================
============================ test session starts ============================
platform linux -- Python 3.7.3, pytest-4.4.0, py-1.8.0, pluggy-0.9.0 -- /usr/bin/python3
cachedir: .pytest_cache
rootdir: /home/cranechu/pynvme, inifile: pytest.ini
plugins: cov-2.6.1
collecting ... collected 1 item

scripts/test_trim_basic.py::test_trim_basic
-------------------------------- live log setup -------------------------------
[2019-04-29 12:37:45.654] INFO pciaddr(19): running tests on DUT 01:00.0
-------------------------------- live log call --------------------------------
```

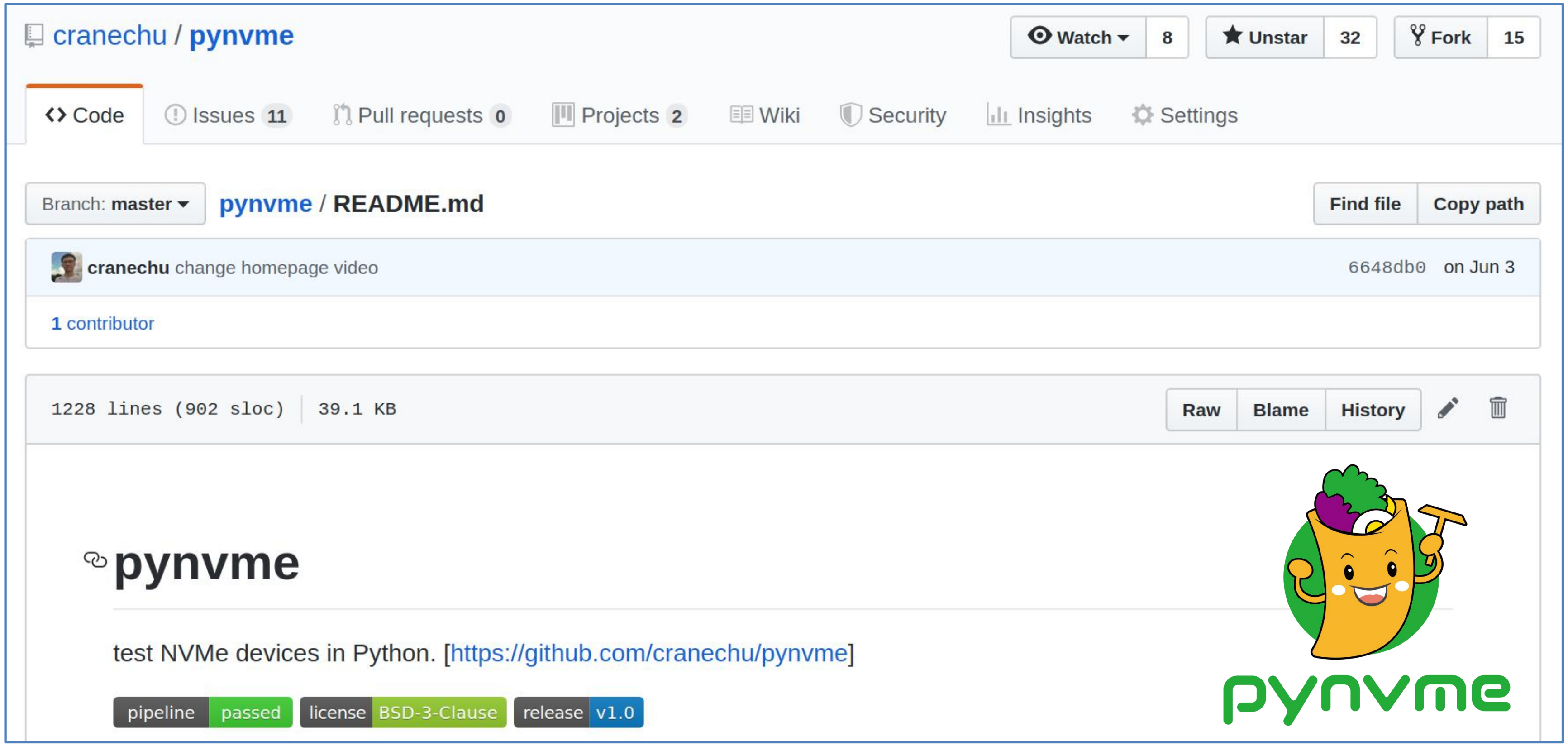


```python
import time
import pytest
import logging
import nvme as d
from pytemperature import k2c

def test_ioworker_with_temperature(nvme0, nvme0n1):
    smart_log = d.Buffer(512, "smart log")
    with nvme0n1.ioworker(io_size=8, lba_align=16, lba_random=True,
                          qdepth=16, read_percentage=0, time=30):
        for i in range(40):
            nvme0.getlogpage(0x02, smart_log, 512).waitdone()
            ktemp = smart_log.data(2, 1)
            ctemp = k2c(ktemp)
            logging.info("temperature: %0.2f degreeC" % ctemp)
            time.sleep(1)
```

```
1556546728.807225: [cmd: Get Log Page]
0x005f0002, 0xffffffff, 0x00000000, 0x00000000
0x00000000, 0x00000000, 0x7439a000, 0x00000001
0x00000000, 0x00000000, 0x007f0002, 0x00000000
0x00000000, 0x00000000, 0x00000000, 0x00000000
1556546728.809293: [cpl: SUCCESS]
0x00000000, 0x00000000, 0x00000023, 0x0001005f

1556546727.804234: [cmd: Get Log Page]
0x005f0002, 0xffffffff, 0x00000000, 0x00000000
0x00000000, 0x00000000, 0x7439a000, 0x00000001
0x00000000, 0x00000000, 0x007f0002, 0x00000000
0x00000000, 0x00000000, 0x00000000, 0x00000000
1556546727.806340: [cpl: SUCCESS]
0x00000000, 0x00000000, 0x00000022, 0x0001005f

1556546726.801221: [cmd: Get Log Page]
```

```
temperatur
[2019-04-2                                                    (15):
temperatur
[2019-04-2                                                    (15):
tempe
      04-2                                                    (15):
temperature: 44.85 degreeC
[2019-04-29 22:05:15.756] INFO                                (15):
temperature: 44.85 degreeC
[2019-04-29 22:05:16.760] INFO                                (15):
temperature: 45.85 degreeC
                                                              (15):
temperature: 45.85 degreeC
[2019-04-29 22:05:18.775] INFO test_ioworker_with_temperature(15):
temperature: 45.85 degreeC
[2019-04-29 22:05:19.779] INFO test_ioworker_with_temperature(15):
temperature: 45.85 degreeC
[2019-04-29 22:05:20.782] INFO test_ioworker_with_temperature(15):
temperature: 45.85 degreeC
[2019-04-29 22:05:21.786] INFO test_ioworker_with_temperature(15):
temperature: 46.85 degreeC
[2019-04-29 22:05:22.789] INFO test_ioworker_with_temperature(15):
temperature: 46.85 degreeC
[2019-04-29 22:05:23.792] INFO test_ioworker_with_temperature(15):
temperature: 46.85 degreeC
[2019-04-29 22:05:24.795] INFO test_ioworker_with_temperature(15):
temperature: 46.85 degreeC
[2019-04-29 22:05:25.800] INFO test_ioworker_with_temperature(15):
temperature: 46.85 degreeC
[2019-04-29 22:05:26.803] INFO test_ioworker_with_temperature(15):
temperature: 46.85 degreeC
[2019-04-29 22:05:27.806] INFO test_ioworker_with_temperature(15):
temperature: 47.85 degreeC
[2019-04-29 22:05:28.809] INFO test_ioworker_with_temperature(15):
temperature: 47.85 degreeC
```

# pynvme goes to 1.x


cranechu / pynvme

pynvme / README.md

cranechu change homepage video 6648db0 on Jun 3

1 contributor

1228 lines (902 sloc) | 39.1 KB

## pynvme

test NVMe devices in Python. [https://github.com/cranechu/pynvme]

pipeline passed | license BSD-3-Clause | release v1.0

## Thanks!

pynvme

Q & A

Live Demo