

TEST

PYNVME QPAIRS

0000:3d:00.0 Q00:

0000:3d:00.0 Q01: >>> CAZ-82256-Q1 NVMe LITEON 256GB

PYTHON

- scripts
- conformance
- 01\_admin\_cmd
- 02\_nvme\_cmd
- 03\_features
- 04\_registers
- 05\_controller
- arbitration\_test.py
- interrupt\_test.py
- prp\_test.py
- sq\_cq\_test.py
- sqe\_cqe\_test.py
- 06\_tcg
- ftl
- performance
- stress
- dirty\_power\_cycle\_test.py
- endurance\_test.py
- test\_ioworker\_jedec\_e...
- test\_ioworker\_jedec\_e...
- C test\_replay\_jedec\_clien...
- marathon\_test.py
- trace
- test\_examples.py

CMDLOG 0000:3d:00.0 Q00 X

1 2020-06-22 08:24:29.897073 [cmd001: Identify]  
 2 0x007d0006, 0x00000001, 0x00000000, 0x00000000  
 3 0x00000000, 0x00000000, 0x4ac0f000, 0x00000001  
 4 0x00000000, 0x00000000, 0x00000000, 0x00000000  
 5 0x00000000, 0x00000000, 0x00000000, 0x00000000  
 6 2020-06-22 08:24:29.897102: [cpl: SUCCESS]  
 7 0x00000000, 0x00000000, 0x0000000c, 0x0001007d  
 8  
 9 2020-06-22 08:24:29.896836 [cmd002: Identify]  
 10 0x007d0006, 0x00000001, 0x00000000, 0x00000000  
 11 0x00000000, 0x00000000, 0x4ac0f000, 0x00000001  
 12 0x00000000, 0x00000000, 0x00000000, 0x00000000  
 13 0x00000000, 0x00000000, 0x00000000, 0x00000000  
 14 2020-06-22 08:24:29.897059: [cpl: SUCCESS]  
 15 0x00000000, 0x00000000, 0x0000000b, 0x0001007d  
 16  
 17 2020-06-22 08:24:28.452258 [cmd003: Format NVM]  
 18 0x007d0080, 0x00000001, 0x00000000, 0x00000000  
 19 0x00000000, 0x00000000, 0x00000000, 0x00000000  
 20 0x00000000, 0x00000000, 0x00000000, 0x00000000  
 21 0x00000000, 0x00000000, 0x00000000, 0x00000000  
 22 2020-06-22 08:24:29.573384: [cpl: SUCCESS]  
 23 0x00000000, 0x00000000, 0x0000000a, 0x0001007d  
 24

Performance Gauge X

...  
 pynvme MB/s 104.96  
 IOPS K/s 009.72

PROBLEMS OUTPUT ... Python Test Log

root@...: /home/craneclay/pynvme, python -m pytest -v

plugins: cov-2.10.0

collected 1 item

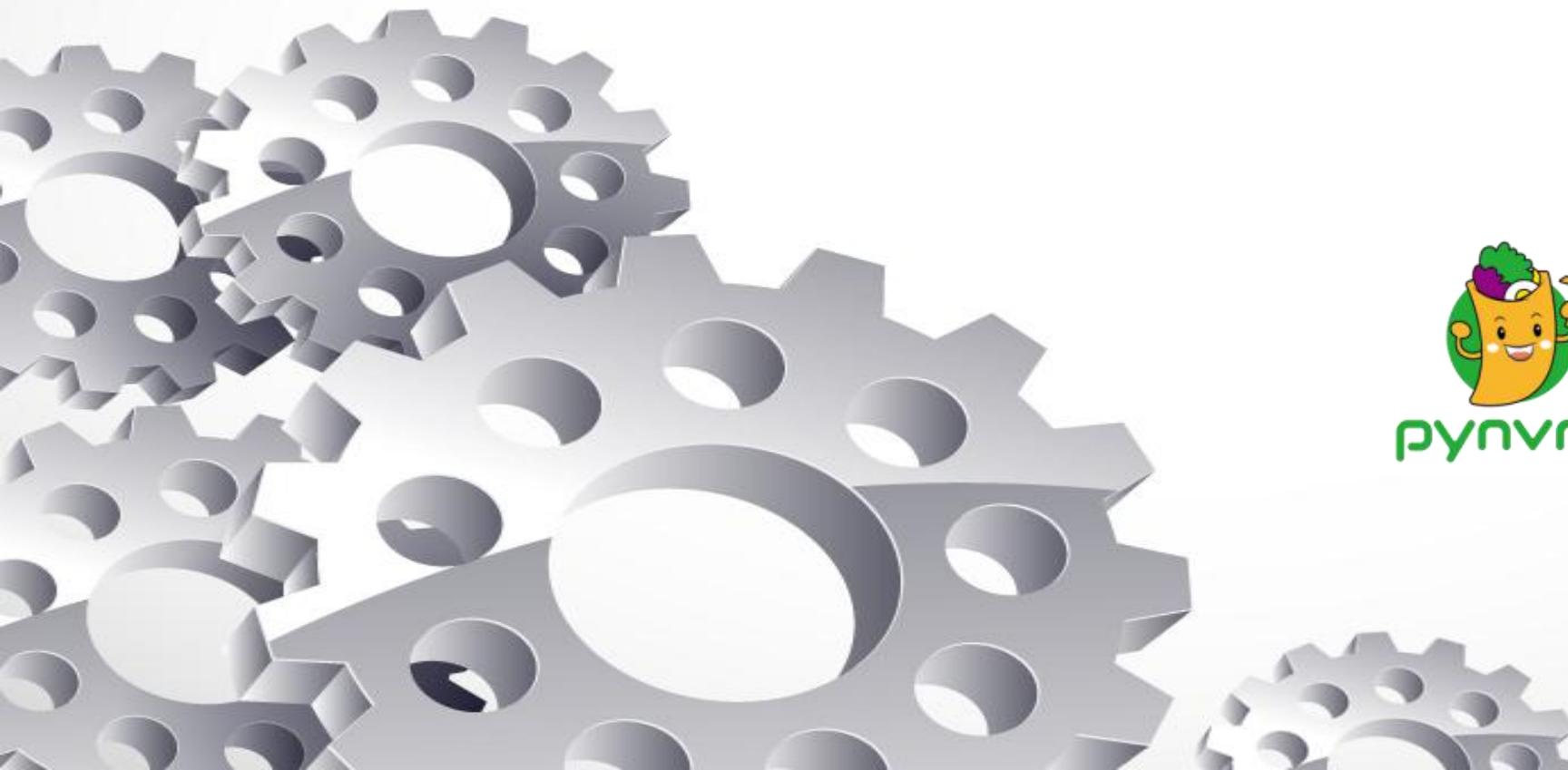
scripts/stress/endurance\_test.  
 py::test\_replay\_jedec\_client\_trace  
 ----- live log setup  
 -----  
 [2020-06-22 08:24:27.666] INFO script(60): setup random seed:  
 0x4400ee0c  
 ----- live log call  
 -----  
 [2020-06-22 08:24:32.194] INFO test\_replay\_jedec\_client\_trace  
 (95): replay batch 0  
 [2020-06-22 08:24:41.628] INFO test\_replay\_jedec\_client\_trace  
 (95): replay batch 1  
 [2020-06-22 08:24:45.792] INFO test\_replay\_jedec\_client\_trace  
 (95): replay batch 2  
 [2020-06-22 08:25:12.507] INFO test\_replay\_jedec\_client\_trace  
 (95): replay batch 3  
 [2020-06-22 08:25:31.836] INFO test\_replay\_jedec\_client\_trace  
 (95): replay batch 4  
 [2020-06-22 08:25:41.889] INFO test\_replay\_jedec\_client\_trace  
 (95): replay batch 5  
 [2020-06-22 08:25:45.449] INFO test\_replay\_jedec\_client\_trace  
 (95): replay batch 6  
 [2020-06-22 08:25:55.715] INFO test\_replay\_jedec\_client\_trace  
 (95): replay batch 7  
 [2020-06-22 08:26:09.297] INFO test\_replay\_jedec\_client\_trace



pynvme builds your own tests.

master\* Python 3.8.3 64-bit 0 △ 0 Running Tests / Ln 1, Col 1 Spaces: 4 Plain Text

# Requirement



pynvme builds your own tests.

# Changes in SSD

- SSD has been changing for the decade:
  - media:
    - SLC, MLC, TLC, QLC
    - 2D => 3D
    - PCM, 3D-Xpoint...
  - host:
    - PATA, SATA, PCIe/NVMe
    - open-channel
    - up coming: ZNS, KV, ... ?
  - DRAM
  - form factor
- Agile: good for the constant change and uncertainty

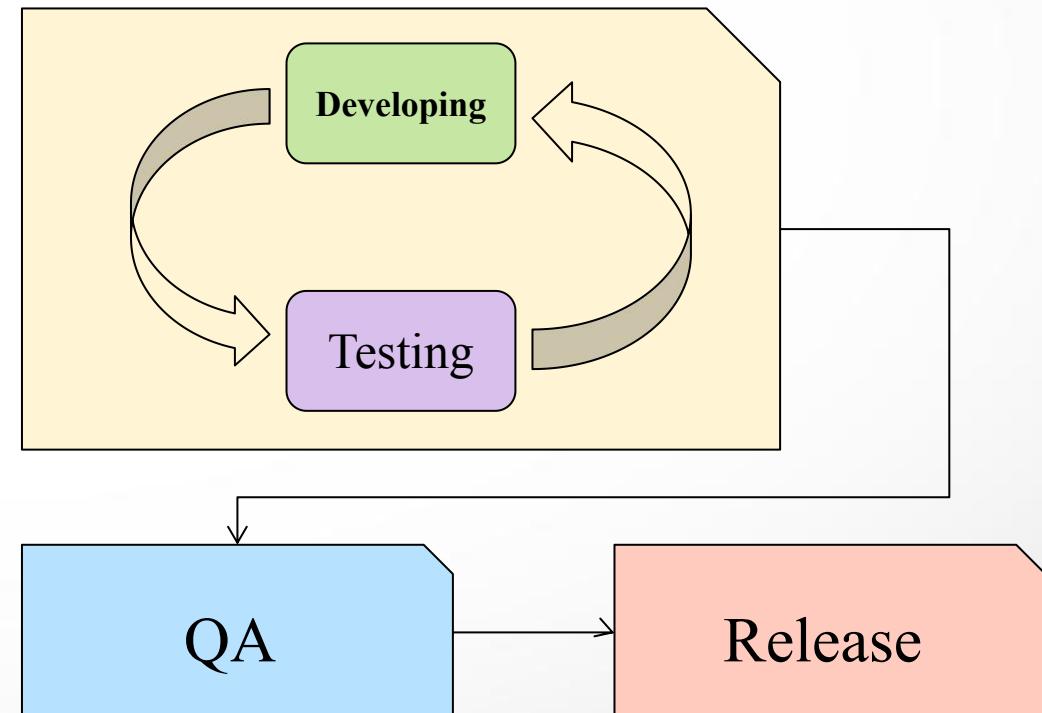


# Agile Testing



- Developing and Testing are done interactively and iteratively.
- QA verifies the product of Dev/Test for customers.
- Testing and QA are different. Testing tools and QA tools are also different.
- Most available tools in the market are QA tools.

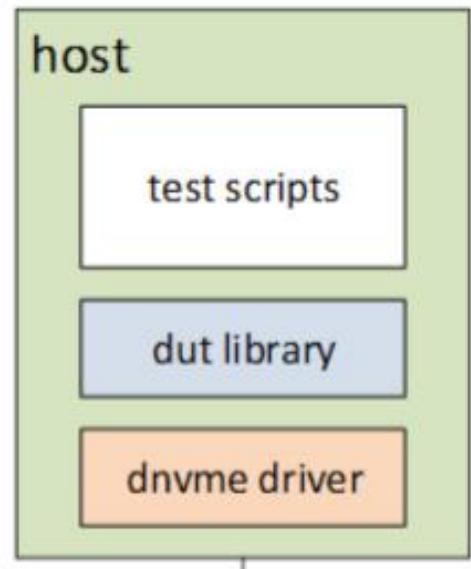
test	QA
for developer	for customer
before checkin	before release
automatic	manual
white-box	black-box
short	long
changing	stable



# Experience in a Startup: dnvme



- dnvme: @2015
  - wrap with python in userspace
  - functional tests
  - integrated with Jenkins
  - firmware engineers develop scripts
  - PASS IOL test on the first try
- challenges:
  - low performance:
    - IOPS, latency, consistency
    - test efficiency
    - stress tests
  - maintainness: kernel module
  - function coverage: PRP, ...
  - GPL License
- dnvme is good at NVMe test, but in-efficient on SSD test.



# Born for NVMe: SPDK



- SPDK is open from 2016
  - super high performance: 10M IOPS
  - user space application
  - based on DPDK environment, which abstracts low-level resources
    - PCIe
    - memory
- meet challenges:
  - low performance:
    - IOPS, latency, consistency
    - test efficiency
    - stress tests
  - maintainness: kernel module
  - function coverage: PRP, ...
  - BSD License



# SDC2020



A screenshot of a Google Chrome browser window showing the SDC 2020 website. The title bar reads "Activities Google Chrome". The tabs are: "WeChat/Weixin fo x", "Slack | \* hallway-c x", "SDC 2020 |", "NVMe | SDC 202 x", "Zoned Storage | S x", and "All Notes - Everno x". The address bar shows "storagedeveloper2020.org/nvme". Below the address bar, the navigation menu includes: "Gmail", "Drive", "Photos", "SGP", "ZHPS", "pynvme", "SSSTC w...", "pynvme", "GYTech", "Slack | nv...", and "SDC 2020 |". The main header has the "SDC 20" logo and links for "LOBBY", "AGENDA", "SPONSORS", "SPEAKERS", "BOFS", "SMB3 IO LAB", "PMEM BOOTCAMP", and "CONNECT AT SDC".



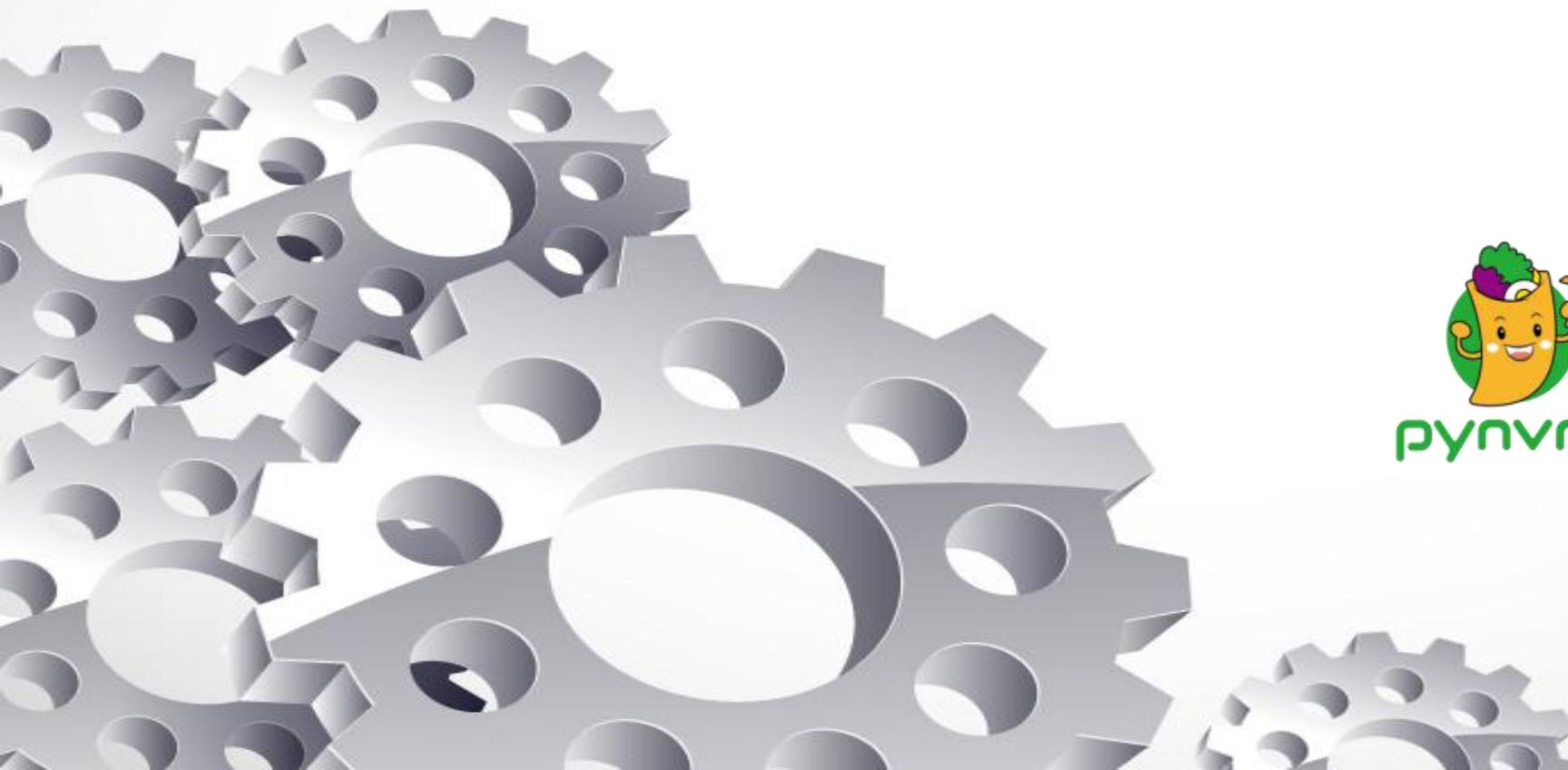
**pynvme: an open, fast and extensible NVMe SSD test tool**

Crane Chu  
GENG YUN Technology Pte Ltd

- Python tool for testing your NVMe design

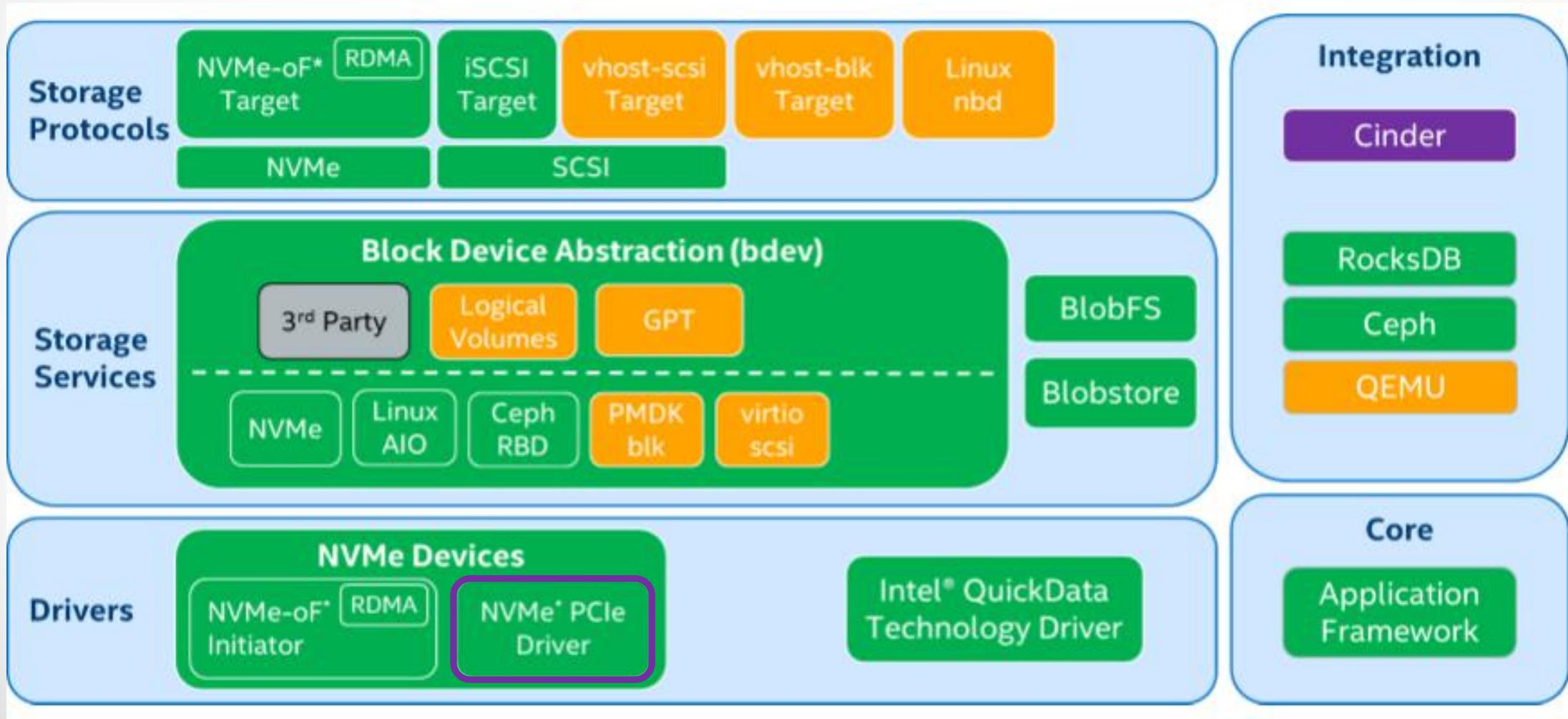
<https://www.youtube.com/watch?v=Yoru7vzVyL8>

# Design



pynvme builds your own tests.

# SPDK



# SPDK/DPDK



- Moving all of the necessary drivers into userspace, which avoids syscalls and enables zero-copy access from the application.
- Polling hardware for completions instead of relying on interrupts, which lowers both total latency and latency variance.
- Avoiding all locks in the I/O path, instead relying on message passing.

# Performance



fio (unit: K IOPS)

Q count	1	2	4
test 1	200	332	353
test 2	211	319	340
test 3	211	248	354

pynvme (unit: K IOPS)

Q count	1	2	4
test 1	358	359	359
test 2	358	358	359
test 3	358	356	359



# Performance: latency



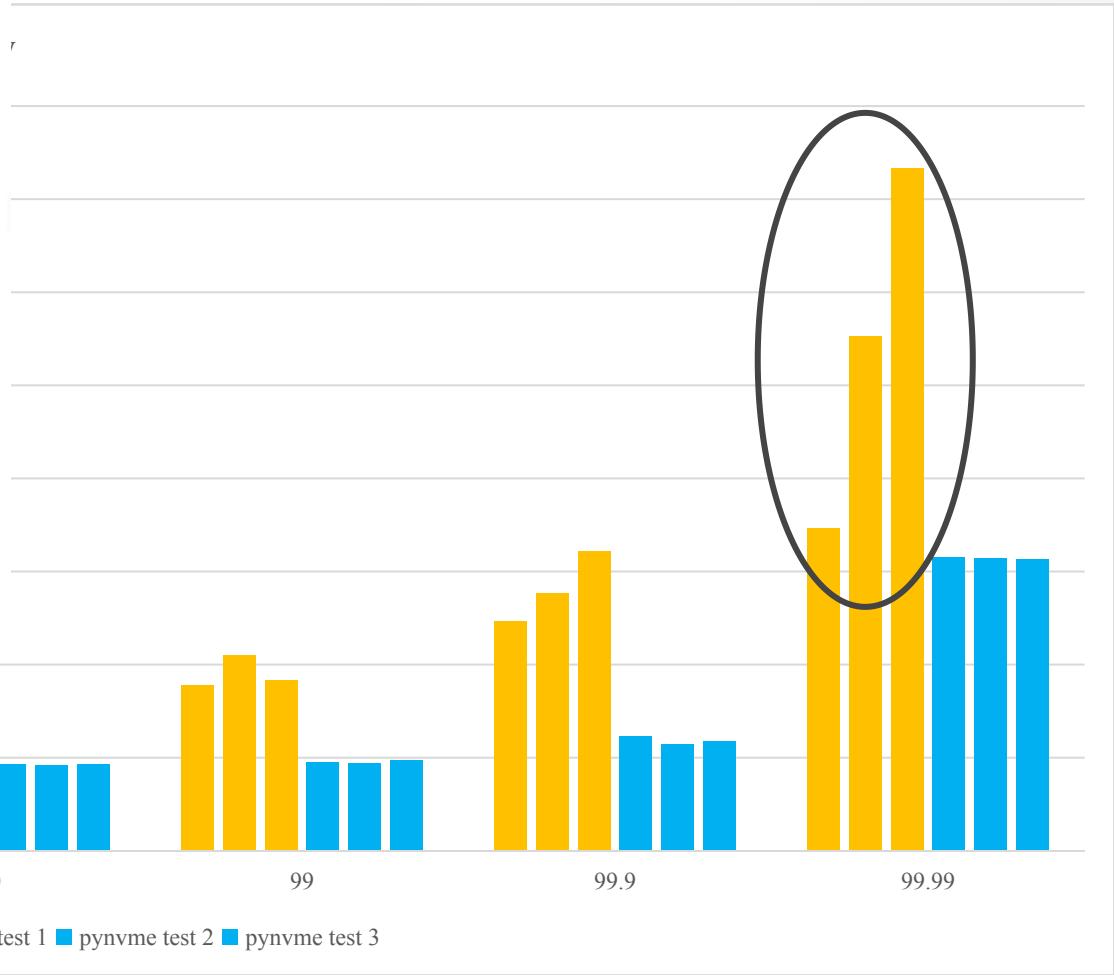
fio (unit: us)

percentile	1	10	50	90	99	99.9	99.99
1	289	297	314	322	355	494	693
2	273	277	289	318	420	553	1106
3	273	277	293	318	367	644	1467

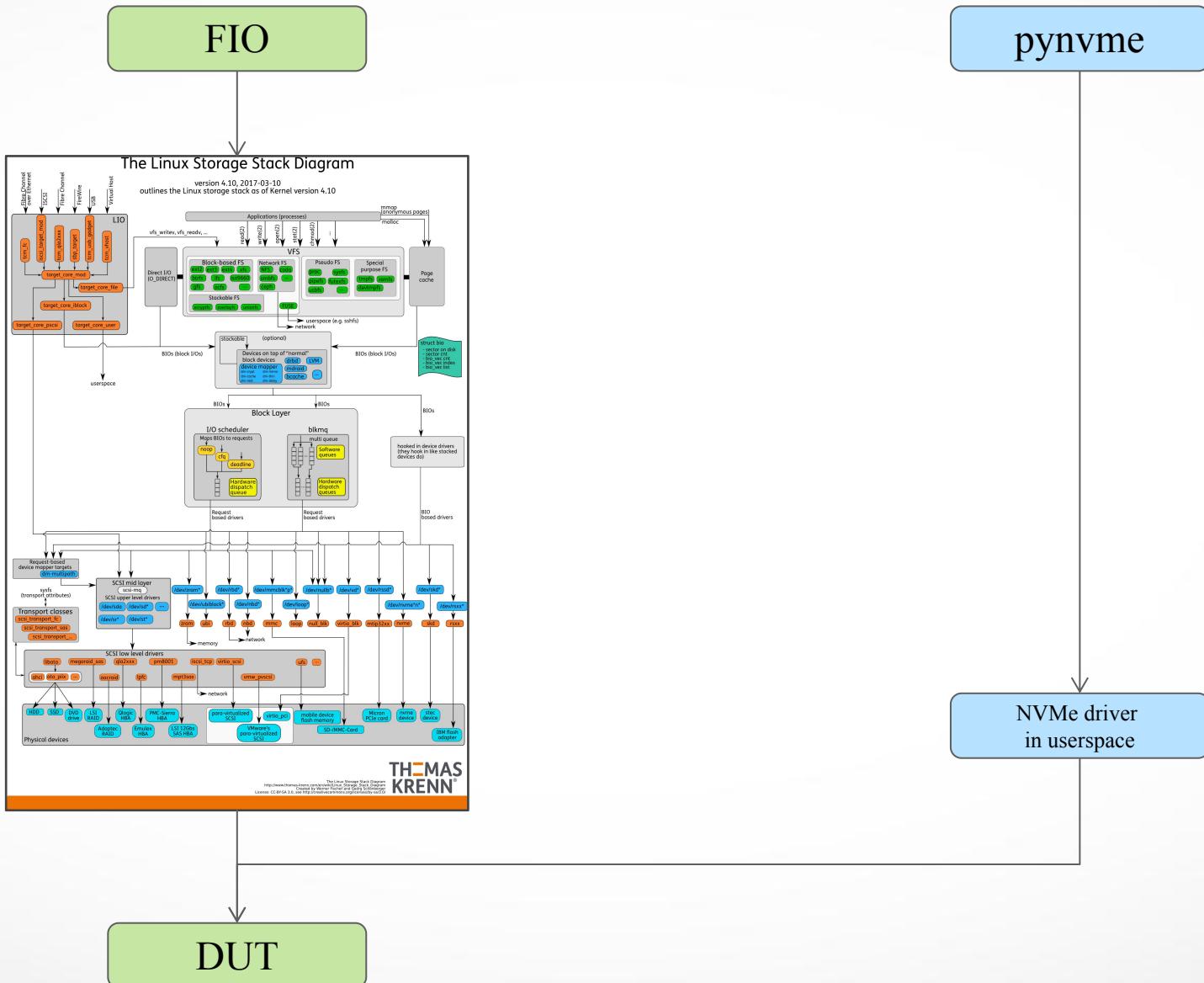
pynvme (unit: us)

percentile	1	10	50	90	99	99.9	99.99
1	171	173	175	185	190	246	630
2	171	173	175	184	189	229	628
3	169	172	175	185	195	235	626

■ fio test 1 ■ fio test 2 ■ fio test 3 ■ pynvme test 1 ■ pynvme test 2 ■ pynvme test 3



# Performance: design



# Architecture



library (ongoing):

KV

ZNS

TCG

psd

API:

controller

namespace

qpair

pcie

buffer

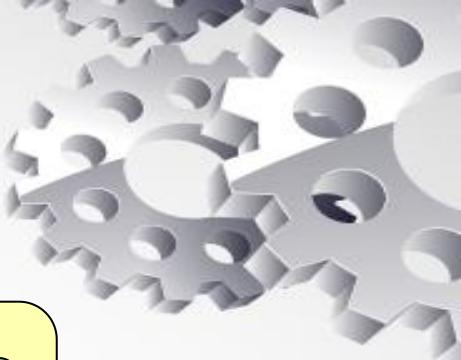
SPDK: nvme driver

cmdlog

checksum

ioworker

# psd: Python Space Driver



psd: IOSQ   IOCQ   SQE   CQE   PRPList

API: controller   namespace   qpair   pcie   buffer

SPDK: nvme driver   cmdlog   checksum   ioworker

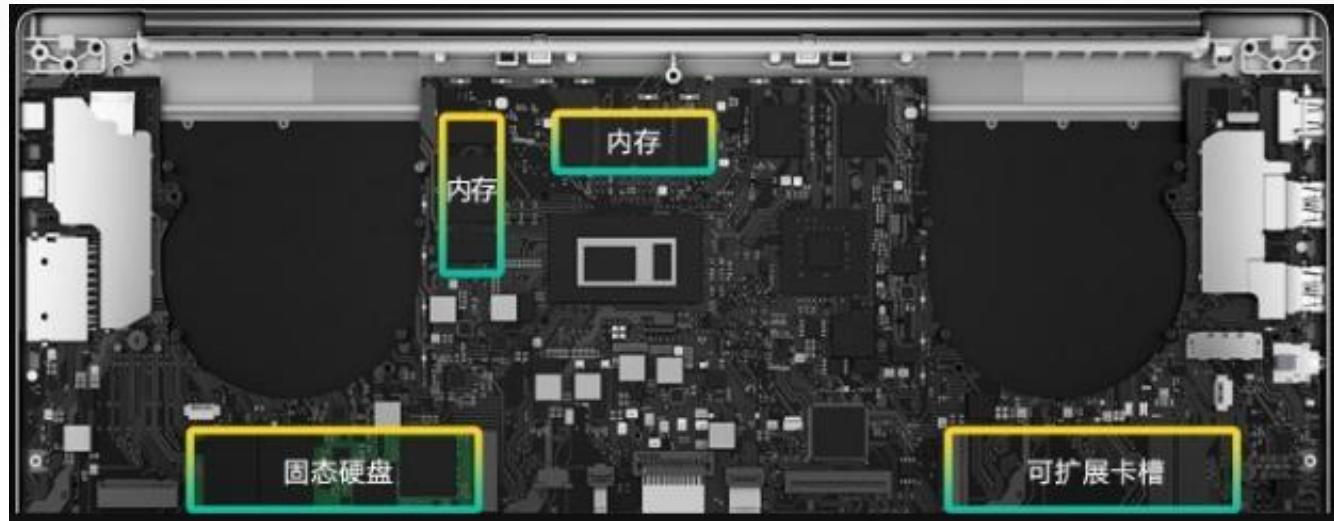
NVMe SSD

# Open Ecosystem



# Flexible Hardware Configuration

- Single Node
  - laptop
  - workstation
- Mass Deploy
  - server



# Install and Test

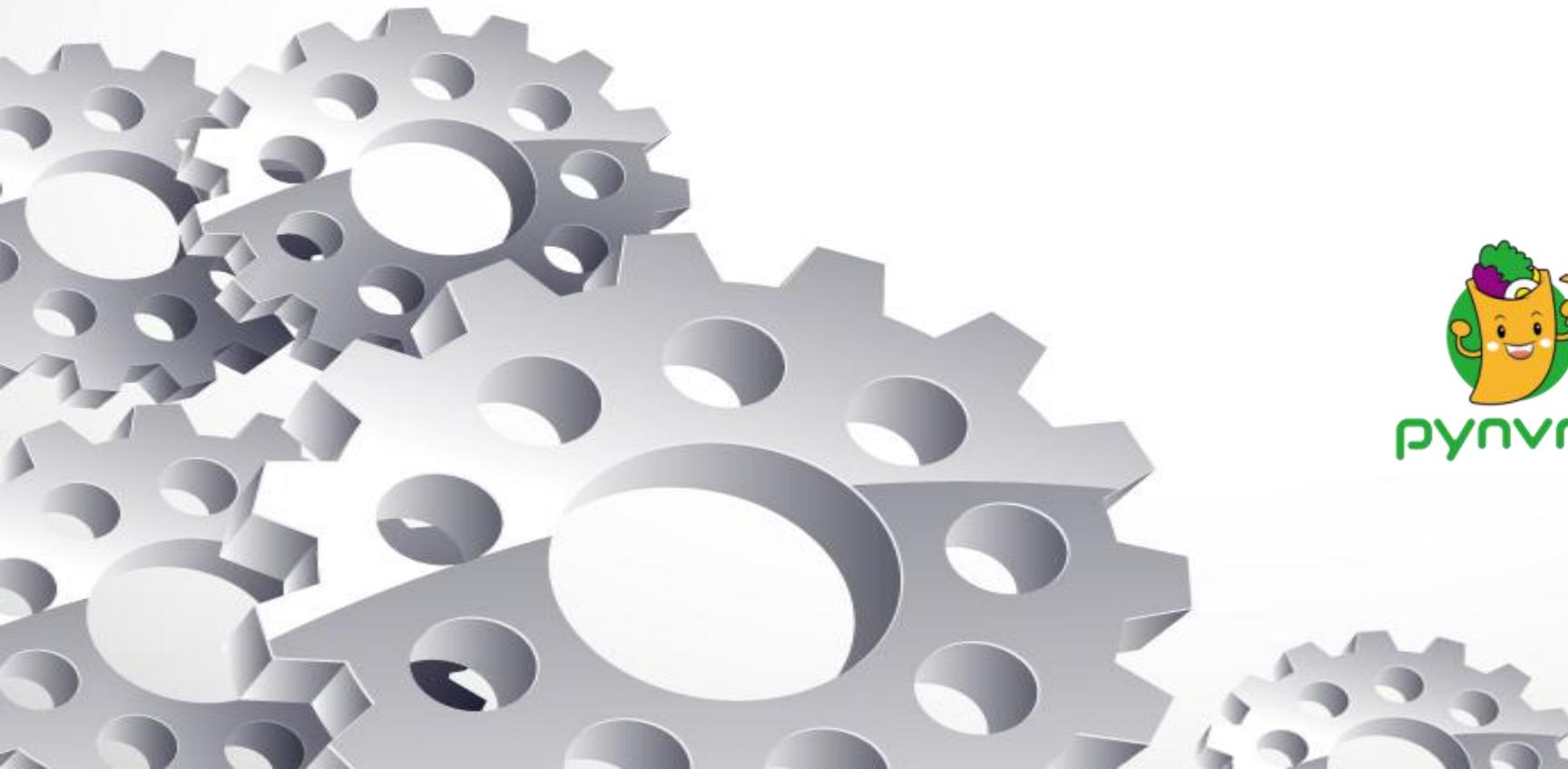


```
> git clone https://github.com/pynvme/pynvme
> cd pynvme
> ./install.sh

> make setup
> make test TESTS="driver_test.py::test_ioworker_iops_multiple_queue[1]"

> make test TESTS=scripts/stress/endurance_test.py::test_replay_jedec_client_trace
  pciaddr=02:00.0
> make test TESTS=scripts/stress/endurance_test.py::test_replay_jedec_client_trace
  pciaddr=172.168.5.44
```

# Scripts



pynvme builds your own tests.

# Test Scripts



```
1 import time
2 import pytest
3 import logging
4
5 import nvme as d
6
7
8 # intuitive, spec, qpair, vscode, debug, cmdlog, assert
9 def test_hello_world(nvme0, nvme0n1, qpair):
10     # prepare data buffer and IO queue
11     read_buf = d.Buffer(512)
12     write_buf = d.Buffer(512)
13     write_buf[10:21] = b'hello world'
14
15     # send write and read command
16     def write_cb(cdw0, status1): # command callback function
17         nvme0n1.read(qpair, read_buf, 0, 1)
18         nvme0n1.write(qpair, write_buf, 0, 1, cb=write_cb)
19
20     # wait commands complete and verify data
21     assert read_buf[10:21] != b'hello world'
22     qpair.waitdone(2)
23     assert read_buf[10:21] == b'hello world'
```

```
8     def test_quarch_dirty_power_cycle_single(nvme0, nvme0n1, subsystem, buf, verify):
9         # get the unsafe shutdown count before test
10        nvme0.getlogpage(2, buf, 512).waitdone()
11        orig_unsafe_count = buf.data(159, 144)
12        logging.info("unsafe shutdowns: %d" % orig_unsafe_count)
13        assert verify == True
14
15        # 128K random write
16        cmdlog_list = [None]*1000
17        with nvme0n1.ioworker(io_size=256,
18                               lba_random=True,
19                               read_percentage=30,
20                               region_end=256*1000*1000,
21                               time=30,
22                               qdepth=1024,
23                               output_cmdlog_list=cmdlog_list):
24            # sudden power loss before the ioworker end
25            time.sleep(10)
26            subsystem.poweroff()
27
28            # power on and reset controller
29            time.sleep(5)
30            subsystem.poweron()
31            time.sleep(0)
32            nvme0.reset()
```

# Test Scripts: dirty power cycle

- PCIe Card Module
- Torridon Interface Kit
- poweroff process
  - poweroff when ioworker is alive
  - remove device from system
- poweron process
  - poweron
  - remove kernel driver
  - rescan device
  - nvme initialization



# Features

- access PCI configuration space
  - access NVMe registers in BAR space
  - send any NVMe admin/IO commands
  - support callback functions for NVMe commands
  - support MSI/MSIx interrupts
  - transparent checksum verification on every LBA
  - generates IO workload of high performance and low latency
  - support multiple namespaces
  - support multiple tests on different controllers
  - integrate with the test framework pytest
  - integrate with VSCode to display cmdlog in GUI
  - support NVMe over TCP targets
- 
- doc: <https://pynvme.readthedocs.io/>



# Test Scripts: 3 ways of sending IO



```
8 # intuitive, spec, qpair, vscode, debug, cmdlog, assert
9 def test_hello_world(nvme0, nvme0n1, qpair):
10     # prepare data buffer and IO queue
11     read_buf = d.Buffer(512)
12     write_buf = d.Buffer(512)
13     write_buf[10:21] = b'hello world'
14
15     # send write and read command
16     def write_cb(cdw0, status1): # command callback function
17         nvme0n1.read(qpair, read_buf, 0, 1)
18         nvme0n1.write(qpair, write_buf, 0, 1, cb=write_cb)
```

```
def test_ioworker_simplified(nvme0n1):
    nvme0n1.ioworker(io_size=2, time=2).start().close()
```

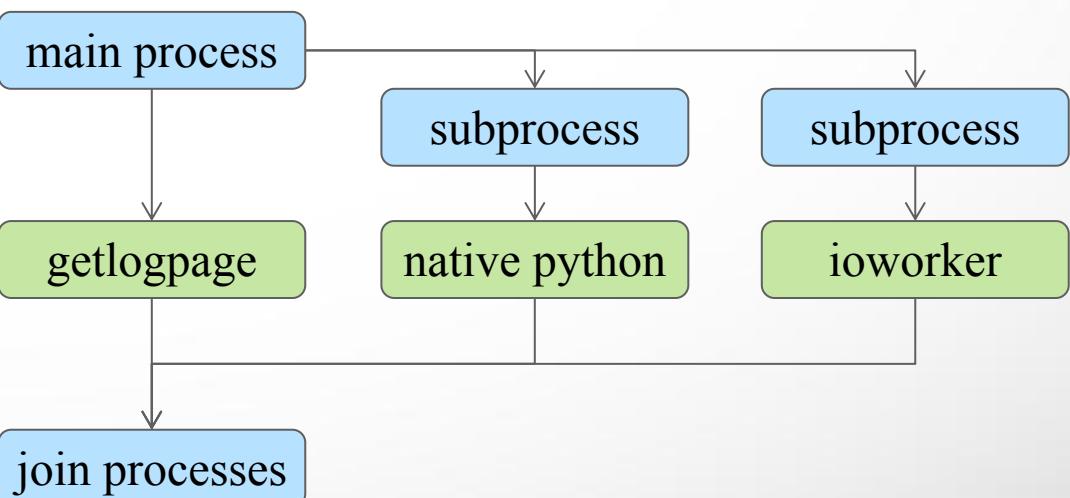
```
698 def test_write_before_power_cycle(nvme0, subsystem):
699     cq = IOCQ(nvme0, 1, 128, PRP(2*1024))
700     sq = IOSQ(nvme0, 1, 128, PRP(8*1024), cqid=1)
701
702     #burst write
703     for i in range(127):
704         cmd = SQE(1, 1)
705         buf = PRP(512, ptype=32, pvalue=i)
706         cmd.prp1 = buf
707         cmd[10] = i
708         sq[i] = cmd
709
710     # write 127 512byte at one shot
711     sq.tail = 127
```

# Test Scripts: multiprocessing



```
72 def test_ioworker_with_temperature_and_trim(nvme0, nvme0n1):
73     # start trim process
74     import multiprocessing
75     mp = multiprocessing.get_context("spawn")
76     p = mp.Process(target = subprocess Trim,
77                     args = (nvme0.addr.encode('utf-8'),
78                             300000))
79     p.start()
80
81     # start read/write ioworker and admin commands
82     smart_log = d.Buffer(512, "smart log")
83     with nvme0n1.ioworker(io_size=8, lba_align=16,
84                           lba_random=True, qdepth=16,
85                           read_percentage=67, iops=10000, time=10):
86         for i in range(15):
87             nvme0.getlogpage(0x02, smart_log, 512).waitdone()
88             ktemp = smart_log.data(2, 1)
89
90             from pytemperature import k2c
91             logging.info("temperature: %0.2f degreeC" % k2c(ktemp))
92             time.sleep(1)
93
94     # wait trim process complete
95     p.join()
96
```

```
60     # ioworker with admin commands, multiprocessing, log, cmdlog, pythonic
61     def subprocess Trim(pciaddr, loops):
62         nvme0 = d.Controller(pciaddr)
63         nvme0n1 = d.Namespace(nvme0)
64         q = d.Qpair(nvme0, 8)
65         buf = d.Buffer(4096)
66         buf.set_dsm_range(0, 8, 8)
67
68         # send trim commands
69         for i in range(loops):
70             nvme0n1.dsm(q, buf, 1).waitdone()
71
```



# Test Scripts: NVMe initialization for WRR

```
9  def nvme_init_wrr(nvme0):
10     logging.info("user defined nvme init")
11
12     nvme0[0x14] = 0
13     while not (nvme0[0x1c]&0x1) == 0: pass
14
15     # 3. set admin queue registers
16     nvme0.init_adminq()
17
18     # 4. set register cc
19     if (nvme0.cap>>17) & 0x1:
20         logging.info("set WRR arbitration")
21         nvme0[0x14] = 0x00460800
22     else:
23         nvme0[0x14] = 0x00460000
24
25     # 5. enable cc.en
26     nvme0[0x14] = nvme0[0x14] | 1
27
28     # 6. wait csts.rdy to 1
29     while not (nvme0[0x1c]&0x1) == 1: pass
30
31     # 7. identify controller
32     nvme0.identify(Buffer(4096)).waitdone()
33
34     # 8. create and identify all namespace
35     nvme0.init_ns()
36
37     # 9. set/get num of queues
38     nvme0.setfeatures(0x7, cdw11=0x00ff00ff).waitdone()
39     nvme0.getfeatures(0x7).waitdone()
```

```
42    def test_ioworker_with_wrr(pcie):
43        nvme0 = Controller(pcie, nvme_init_func=nvme_init_wrr)
44
45        if (nvme0.cap>>17) & 0x1 == 0:
46            pytest.skip("WRR is not supported")
47
48        # 8:4:2
49        assert nvme0[0x14] == 0x00460801
50        nvme0.setfeatures(1, cdw11=0x07030103).waitdone()
51        cdw0 = nvme0.getfeatures(1, cdw11=0x7313).waitdone()
52        assert cdw0 == 0x07030103
53
54        nvme0n1 = Namespace(nvme0, 1, 0x10000)
55        nvme0n1.format(512)
56
57        l = []
58        for i in range(3):
59            a = nvme0n1.ioworker(io_size=8,
60                                 read_percentage=100,
61                                 region_end=0x10000,
62                                 qpriorities=i+1,
63                                 time=10)
64            l.append(a)
```

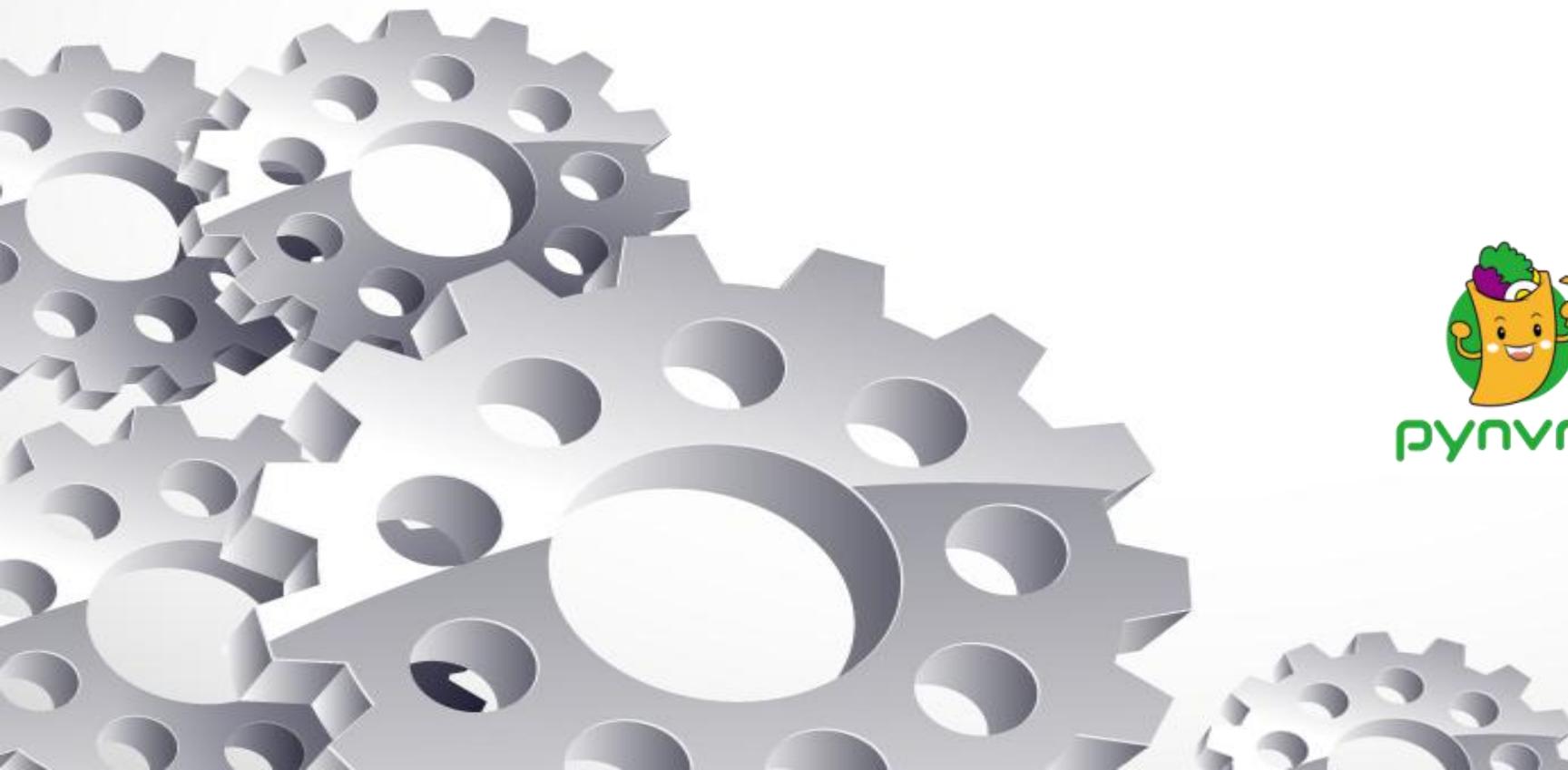


# Test Scripts: error code



```
93 def test_write_in_sanitize_operations(nvme0, nvme0n1, buf, qpairs):
94     if nvme0.id_data(331, 328) == 0: #L9
95         pytest.skip("sanitize operation is not supported") #L10
96
97     logging.info("supported sanitize operation: %d" % nvme0.id_data(331, 328))
98     nvme0.sanitize().waitdone() #L13
99
100    with pytest.warns(UserWarning, match="ERROR status: 00/1d"):
101        nvme0n1.write(qpair, buf, 0).waitdone()
102
103    # check sanitize status in log page
104    with pytest.warns(UserWarning, match="AER notification is triggered"):
105        nvme0.getlogpage(0x81, buf, 20).waitdone() #L17
106        while buf.data(3, 2) & 0x7 != 1: #L18
107            time.sleep(1)
108            nvme0.getlogpage(0x81, buf, 20).waitdone() #L20
109            progress = buf.data(1, 0)*100//0xffff
110            logging.info("%d%%" % progress)
111
112    # check sanitize status
113    nvme0.getlogpage(0x81, buf, 20).waitdone()
114    assert buf.data(3, 2) & 0x7 == 1
115
```

# ioworker



pynvme builds your own tests.

# ioworker: Parameters



## Input Parameters:

- lba\_start, lba\_step, lba\_align
- lba\_random
- region\_start, region\_end
- distribution
- io\_size (int, range, list, dict)
- read\_percentage, **op\_percentage**
- time, io\_count
- qdepth, qprio
- pvalue, ptype
- **iops**
- ...

## Output Parameters:

- io\_count\_read
- io\_count\_write, io\_count\_nonread
- mseconds
- latency\_max\_us
- latency\_average\_us
- error
- cpu\_usage
- output\_io\_per\_second (optional)
- output\_percentile\_latency (optional)
- output\_cmdlog\_list (optional)
- ...

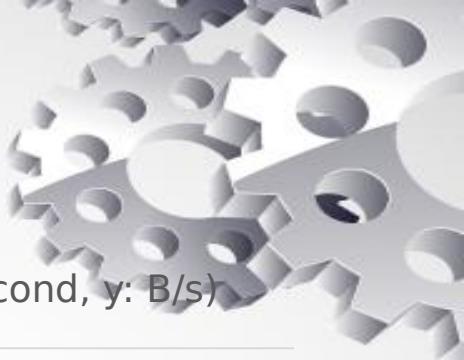
API document: <https://pynvme.readthedocs.io/api.html>

# ioworker: Python API

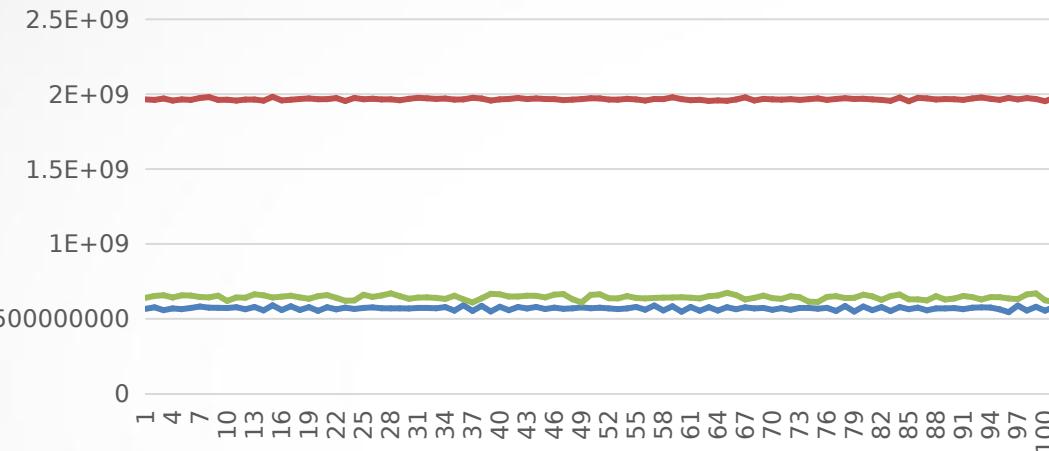


```
774 def test_ioworker_with_temperature(nvme0, nvme0n1, buf):
775     with nvme0n1.ioworker(io_size=256,
776                           time=30,
777                           op_percentage={0:10, # flush
778                                         2:60, # read
779                                         9:30}), \
780         nvme0n1.ioworker(io_size=8,
781                           time=30,
782                           op_percentage={0:10, # flush
783                                         9:10, # trim
784                                         1:80}):# write
785     for i in range(40):
786         time.sleep(1)
787         nvme0.getlogpage(0x02, buf, 512).waitdone()
788         ktemp = buf.data(2, 1)
789         from pytemperature import k2c
790         logging.info("temperature: %0.2f degreeC" %
791                      k2c(ktemp))
792
```

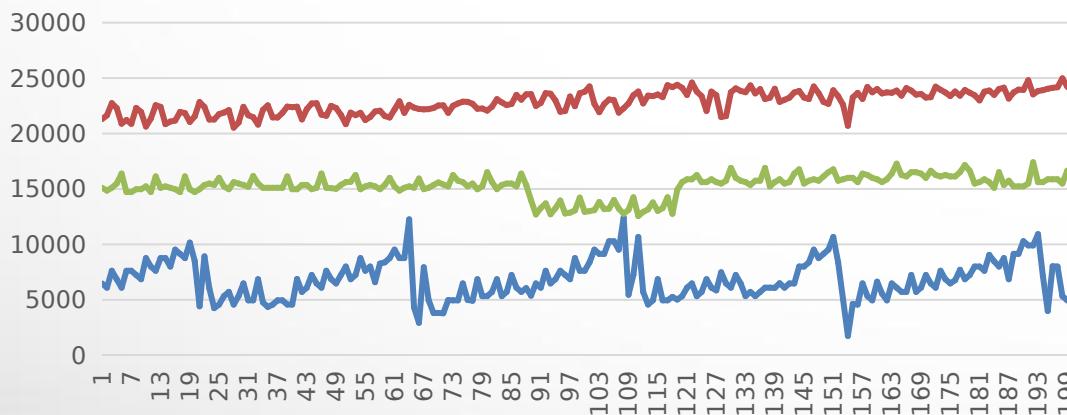
# ioworker: Gallery



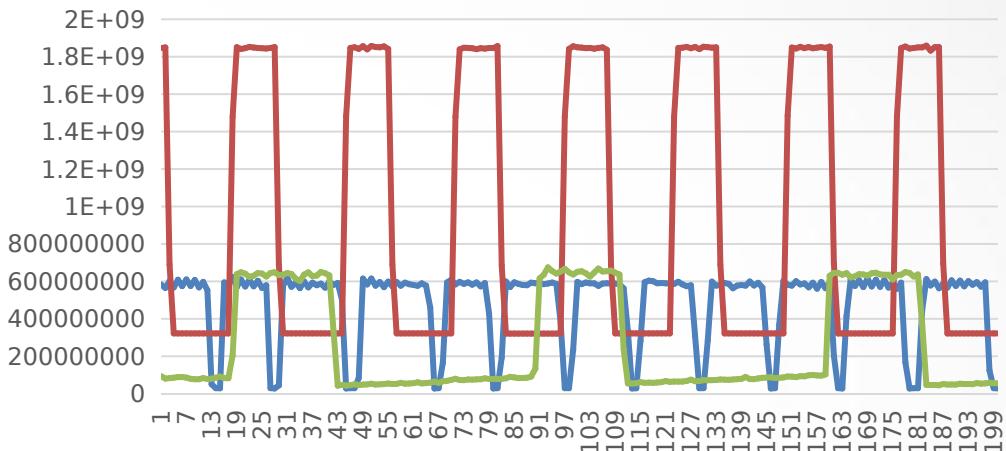
sequential write 1st pass (x: second, y: B/s)



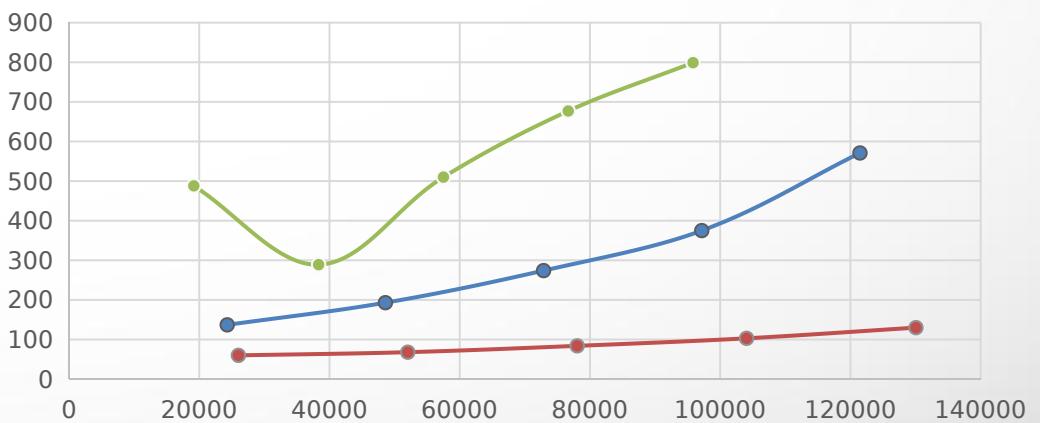
4K random write (x: second, y: IOPS)



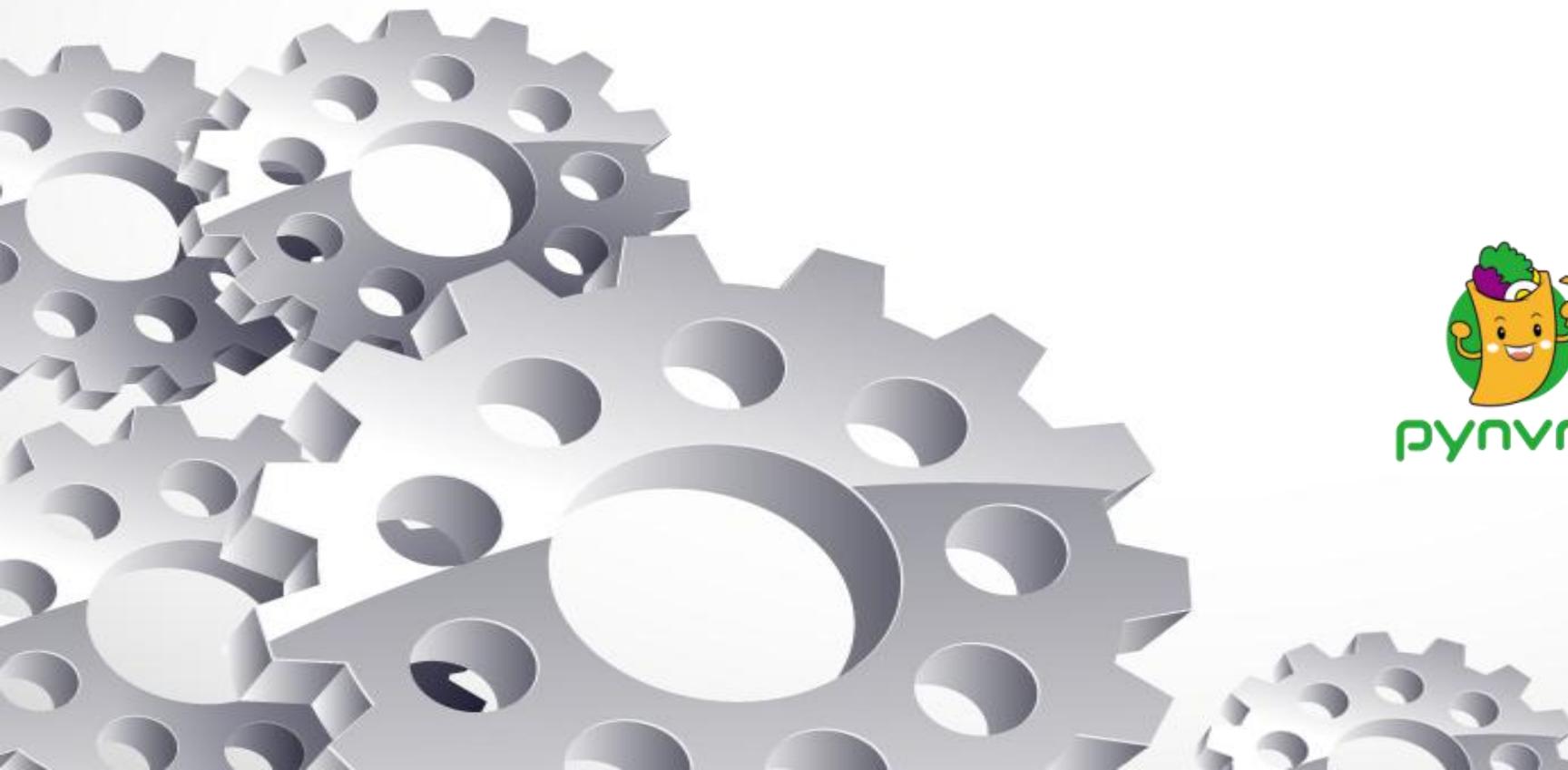
sequential write 3rd pass (x: second, y: B/s)



latency against IOPS, 2R1W (x: IOPS, y: us)

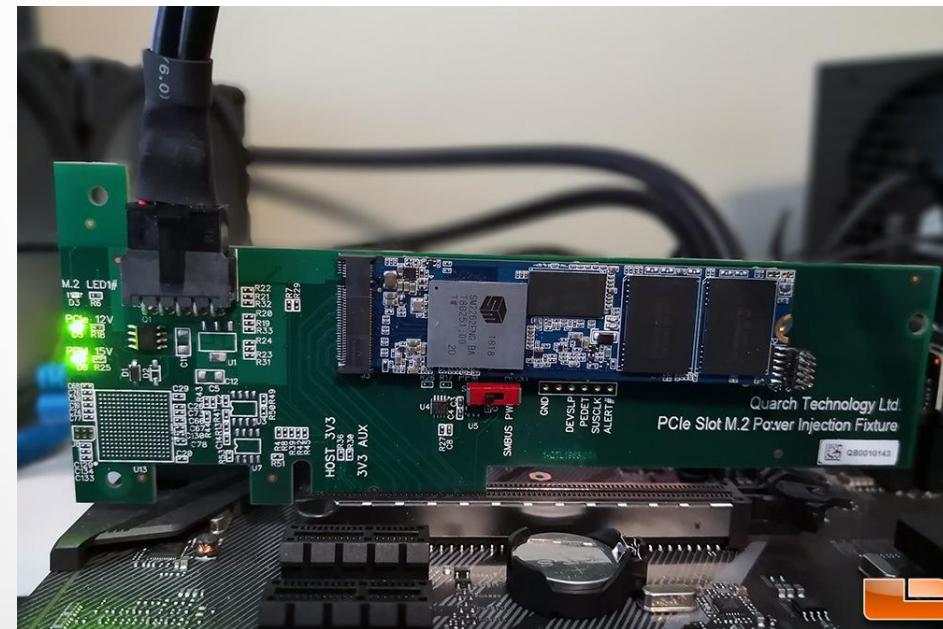


# Features



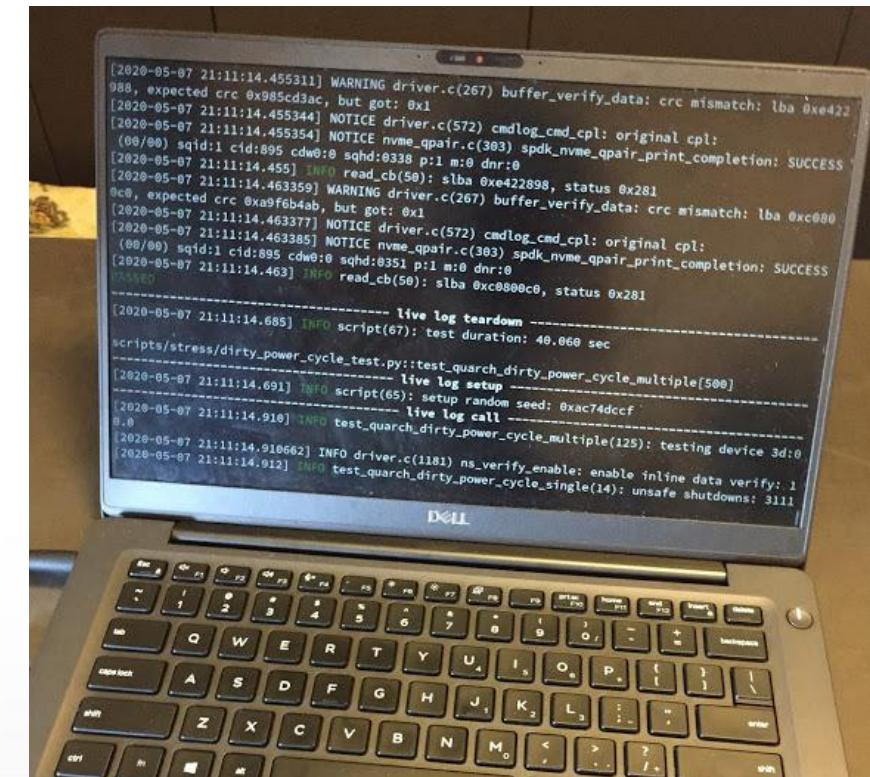
pynvme builds your own tests.

# vPower to ON and OFF



- Usually we need a special hardware box to control the power of SSD

- vPower controls the power of SSD:
    - power off: enter S3/sleep mode
    - power on: wake up by RTC



# vAnalyzer

TEST

PYNVME QPAIRS

0000:3d:00.0 Q00: >>

0000:3d:00.0 Q01: >>

0000:3d:00.0 Q02: >>

0000:3d:00.0 Q03: >>

0000:3d:00.0 Q04: >>

0000:3d:00.0 Q05: >>

0000:3d:00.0 Q06: >>

0000:3d:00.0 Q07: >>

0000:3d:00.0 Q08: >>

0000:3d:00.0 Q09: >> **selected**

0000:3d:00.0 Q10: >>

0000:3d:00.0 Q11: >>

0000:3d:00.0 Q12: >>

0000:3d:00.0 Q13: >>

0000:3d:00.0 Q14: >>

0000:3d:00.0 Q15: >>

0000:3d:00.0 Q16: >>

PYTHON

scripts

conformance

ftl

performance

snia

stress

tcg

trace

test\_examples.py

test\_utilities.py

LOG 0000:3d:00.0 Q02

CMDLOG 0000:3d:00.0 Q05

G 0000:3d:00.0 Q02

CMDLOG 0000:3d:00.0 Q13

CMDLOG 0000:3d:00.0 Q00

Performance Gauge

1353.80 MB/s

330.52 K/s

1 2020-04-15 13:33:21.463617 [cmd001: Read]

2 0x00050002, 0x00000001, 0x00000000, 0x00000000

3 0x00000000, 0x00000000, 0x0c7d3000, 0x00000000

4 0x00000000, 0x00000000, 0x213d9b90, 0x00000000

5 0x00000007, 0x00000000, 0x00000000, 0x00000000

6 not completed

7 ...

9 2020-04-15 13:33:21.463613 [cmd002: Read]

10 0x00010002, 0x00000001, 0x00000000, 0x00000000

11 0x00000000, 0x00000000, 0x0c7d7000, 0x00000000

12 0x00000000, 0x00000000, 0x16b26aa0, 0x00000000

13 0x00000007, 0x00000000, 0x00000000, 0x00000000

14 not completed

15 ...

17 2020-04-15 13:33:21.463607 [cmd003: Read]

18 0x00030002, 0x00000001, 0x00000000, 0x00000000

19 0x00000000, 0x00000000, 0x0c7db000, 0x00000000

20 0x00000000, 0x00000000, 0x151c50c0, 0x00000000

21 0x00000007, 0x00000000, 0x00000000, 0x00000000

22 not completed

1 2020-04-15 13:32:39.104405 [cmd001: Create I/O Submission Queue]

2 0x005a0001, 0x00000000, 0x00000000, 0x00000000

3 0x00000000, 0x00000000, 0x0ea0000, 0x00000001

4 0x00000000, 0x00000000, 0x00070010, 0x00100001

5 0x00000000, 0x00000000, 0x00000000, 0x00000000

6 2020-04-15 13:32:39.104519: [cpl: SUCCESS]

7 0x00000000, 0x00000000, 0x00000056, 0x0000005a

8

9 2020-04-15 13:32:39.103458 [cmd002: Create I/O Completion Queue]

10 0x005a0005, 0x00000000, 0x00000000, 0x00000000

11 0x00000000, 0x00000000, 0x0e800000, 0x00000001

12 0x00000000, 0x00000000, 0x00070010, 0x00100003

13 0x00000000, 0x00000000, 0x00000000, 0x00000000

14 2020-04-15 13:32:39.104403: [cpl: SUCCESS]

15 0x00000000, 0x00000000, 0x00000055, 0x0000005a

16

17 2020-04-15 13:32:38.533985 [cmd003: Create I/O Submission Queue]

18 0x005a0001, 0x00000000, 0x00000000, 0x00000000

19 0x00000000, 0x00000000, 0x0e600000, 0x00000001

20 0x00000000, 0x00000000, 0x0007000f, 0x000f0001

21 0x00000000, 0x00000000, 0x00000000, 0x00000000

22 2020-04-15 13:32:38.534648: [cpl: SUCCESS]

23 0x00000000, 0x00000000, 0x00000054, 0x0000005a

24

25 2020-04-15 13:32:38.533838 [cmd004: Create I/O Completion Queue]

26 0x005a0005, 0x00000000, 0x00000000, 0x00000000

27 0x00000000, 0x00000000, 0x0e400000, 0x00000001

28 0x00000000, 0x00000000, 0x0007000f, 0x000f0003

29 0x00000000, 0x00000000, 0x00000000, 0x00000000

30 2020-04-15 13:32:38.533979: [cpl: SUCCESS]

31 0x00000000, 0x00000000, 0x00000053, 0x0000005a

32

33 2020-04-15 13:32:38.313247 [cmd005: Create I/O Submission Queue]

34 0x005a0001, 0x00000000, 0x00000000, 0x00000000

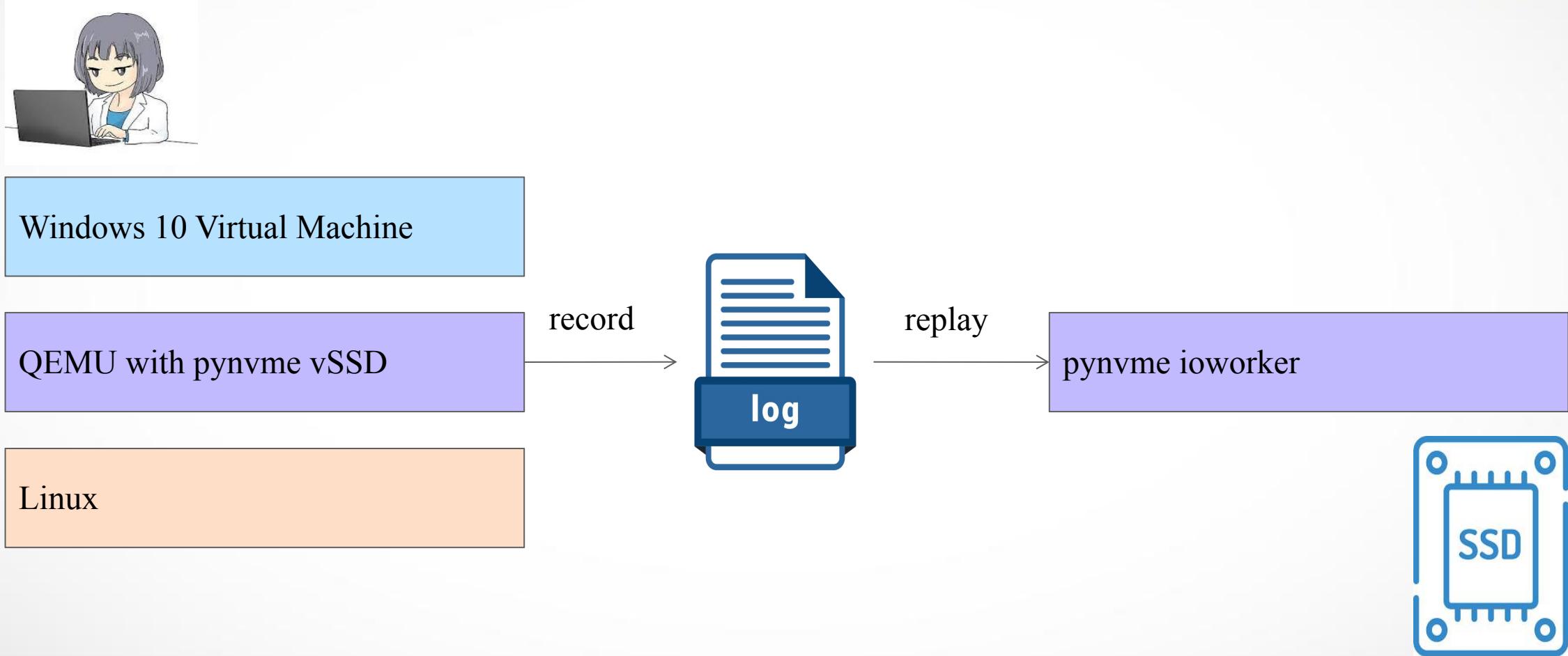
35 0x00000000, 0x00000000, 0x0e200000, 0x00000001

36 0x00000000, 0x00000000, 0x0007000e, 0x000e0001

37 0x00000000, 0x00000000, 0x00000000, 0x00000000

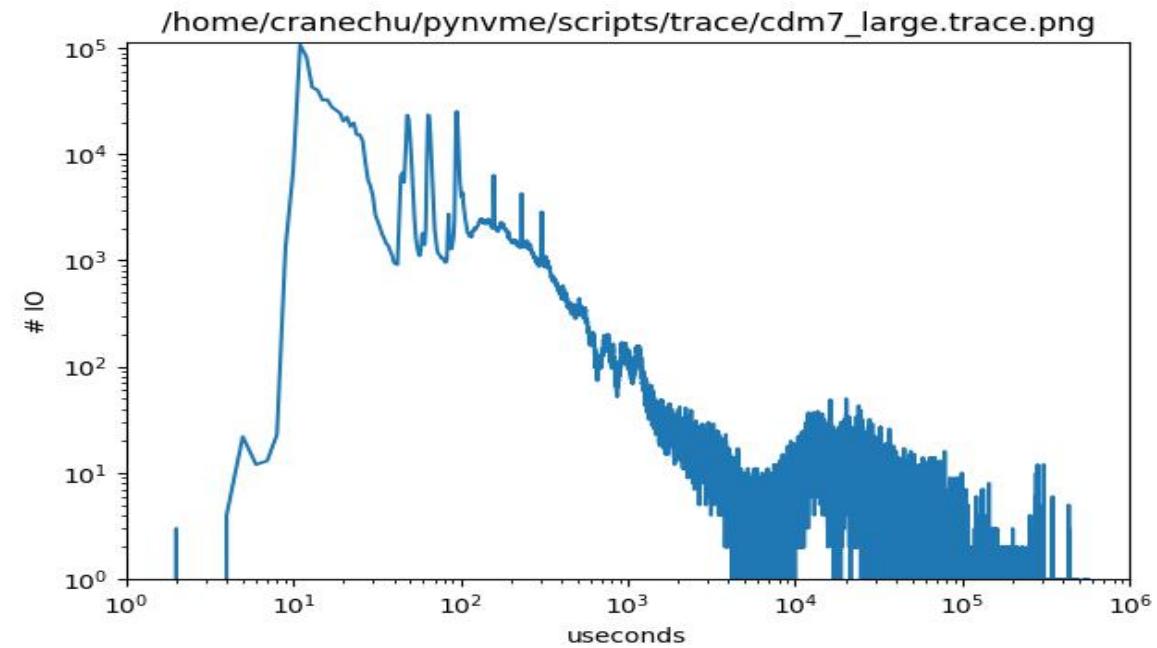
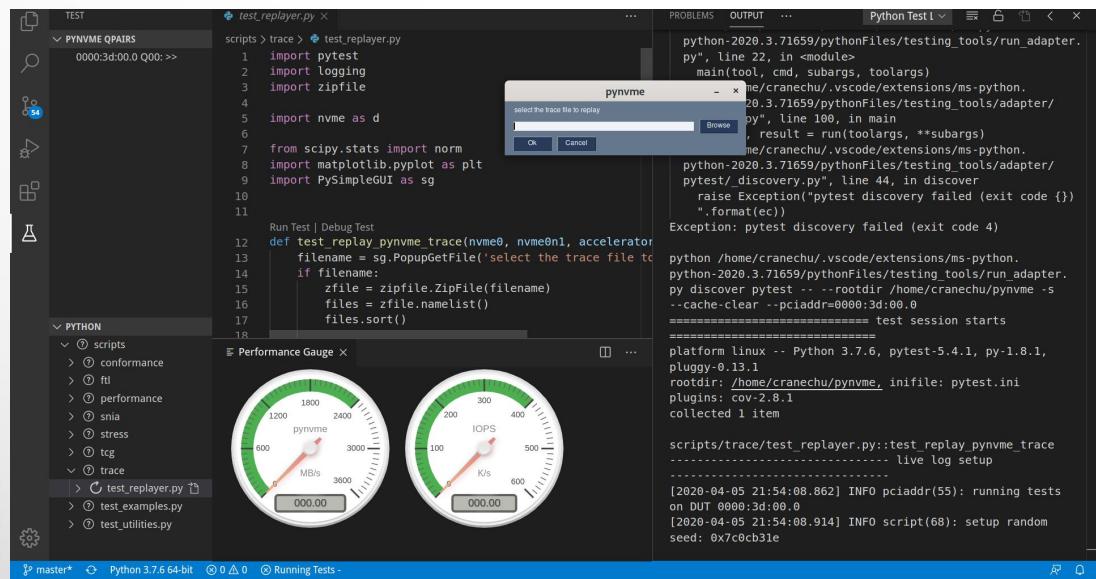
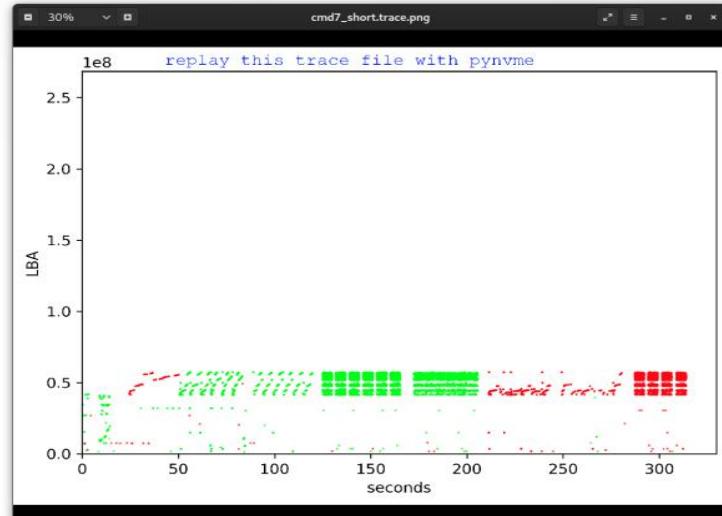
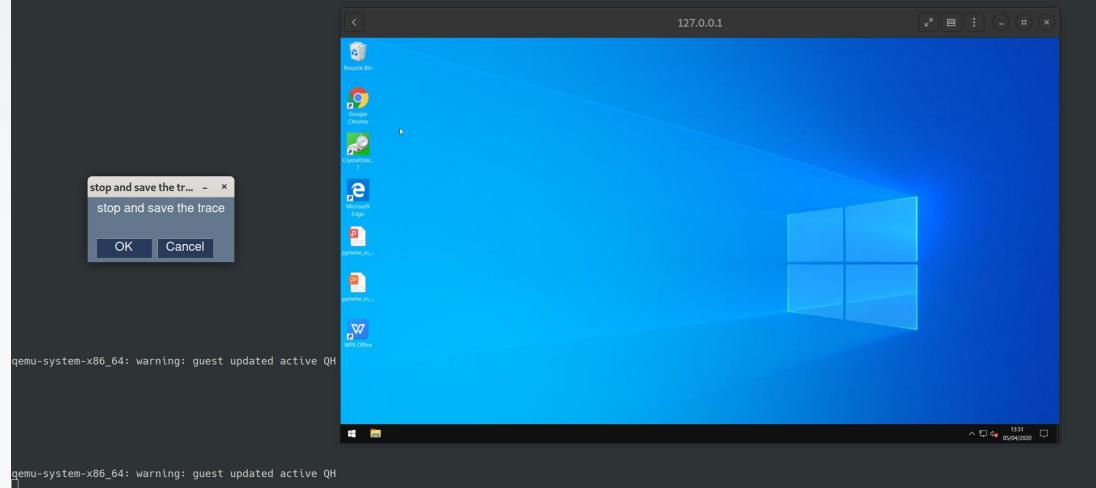
Ln 1, Col 1 Spaces: 4 Plain Text

# vTracer: IO Recorder and Replayer

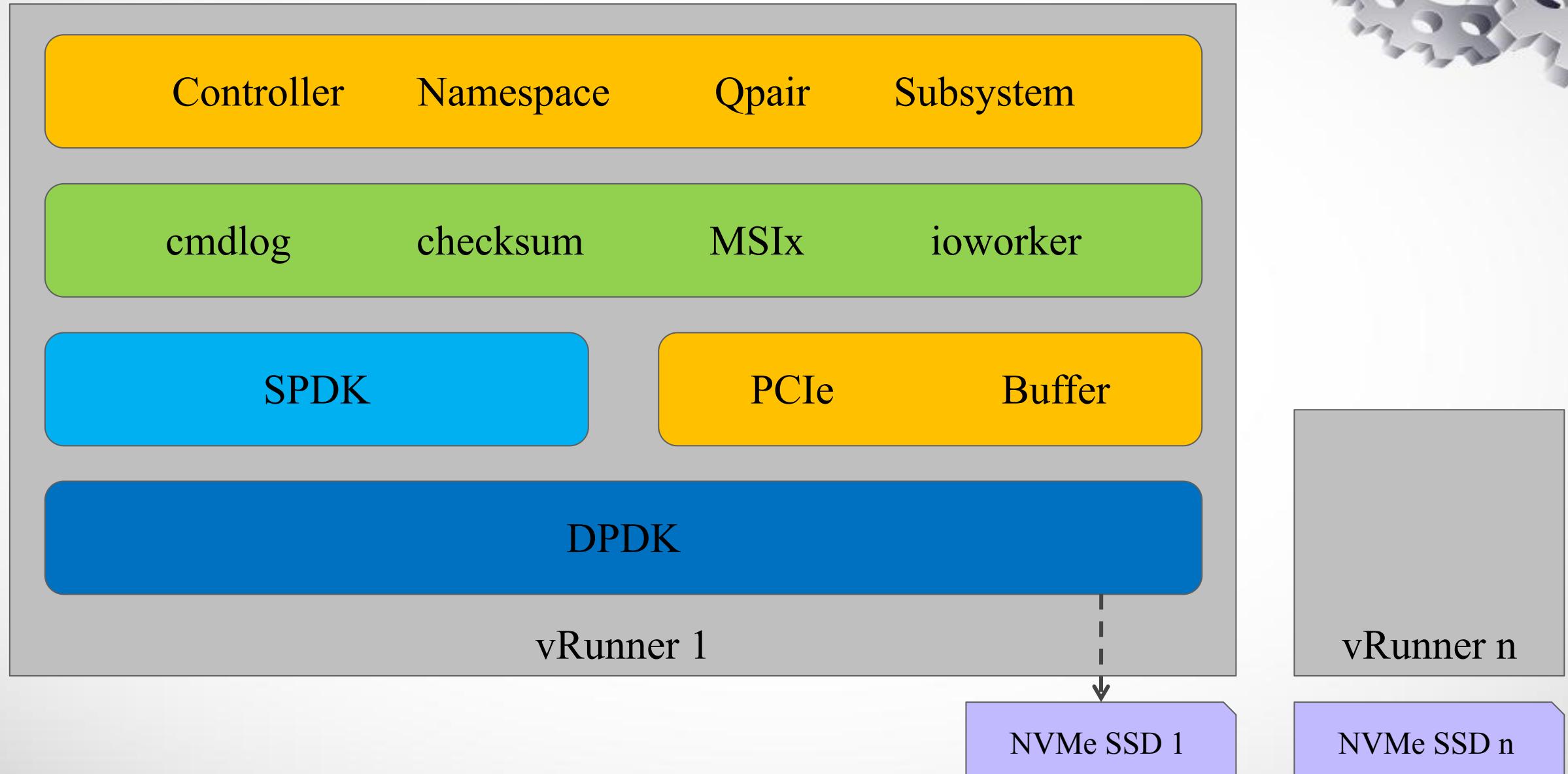


# vTracer: Demo

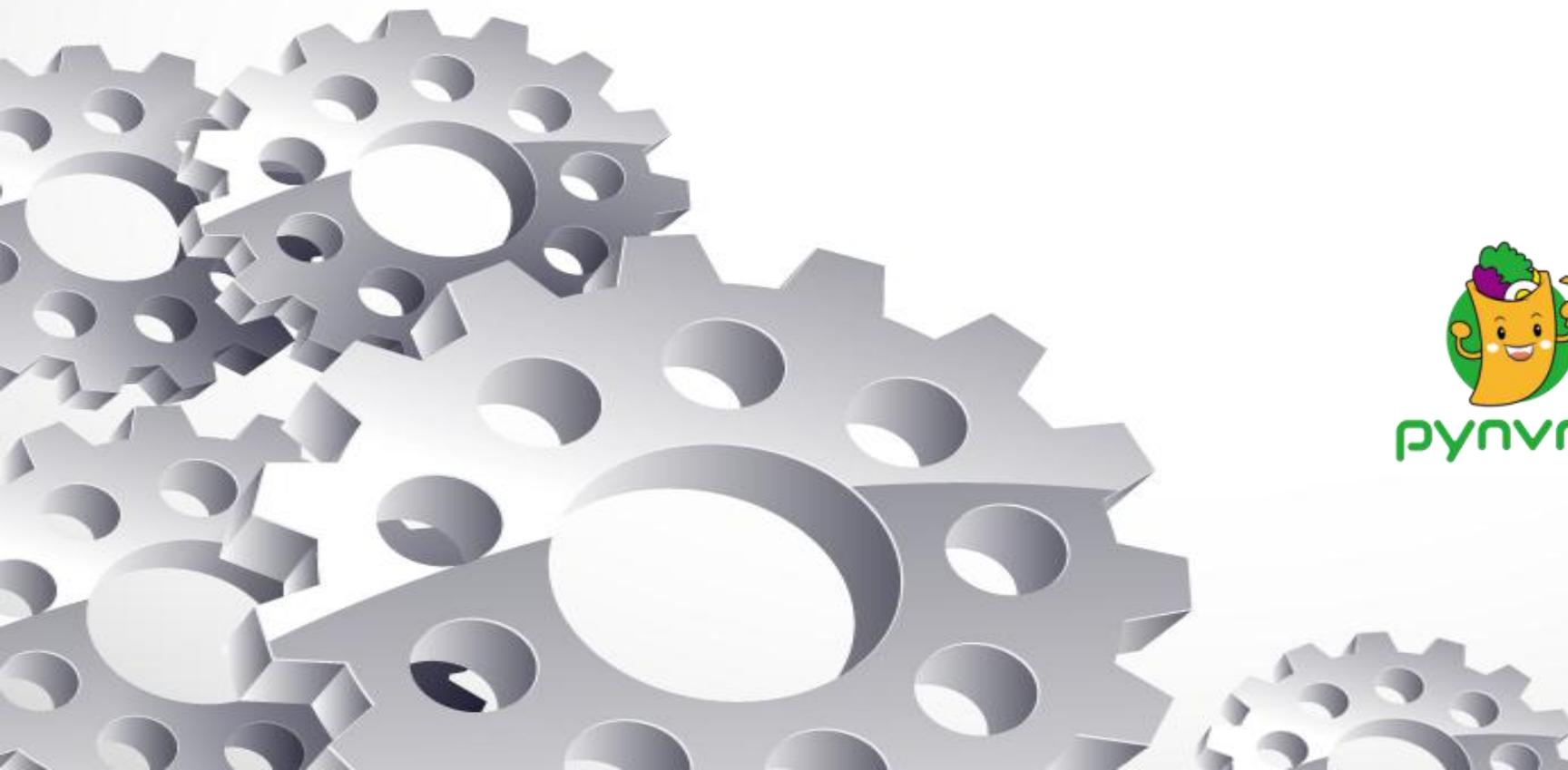
```
laptop:~/pyname$ ./pts/trace ~/home/cranechi/qemu/build/x86_64-safemu/qemu-system-x86_64 -m 4096 -drive file=/home/cranechi/vm/wln10.100.qcow2,lf=none,id=drv0,discard=on -device nvme,drive=drv0,serial=foo -device usb-ehci,id=ehci -device usb-tablet,bus=ehci.0 -enable-kvm -cpu host -smp 4,sockets=1,cores=4,threads=1 | ./recorder.py
VNC server running on ::1:5900
trace time base 0
create minute trace file /tmp/pyname_trace/0/1
create minute trace file /tmp/pyname_trace/0/2
create minute trace file /tmp/pyname_trace/0/3
create minute trace file /tmp/pyname_trace/0/4
```



# vRunner: Mass Deploy



# Services



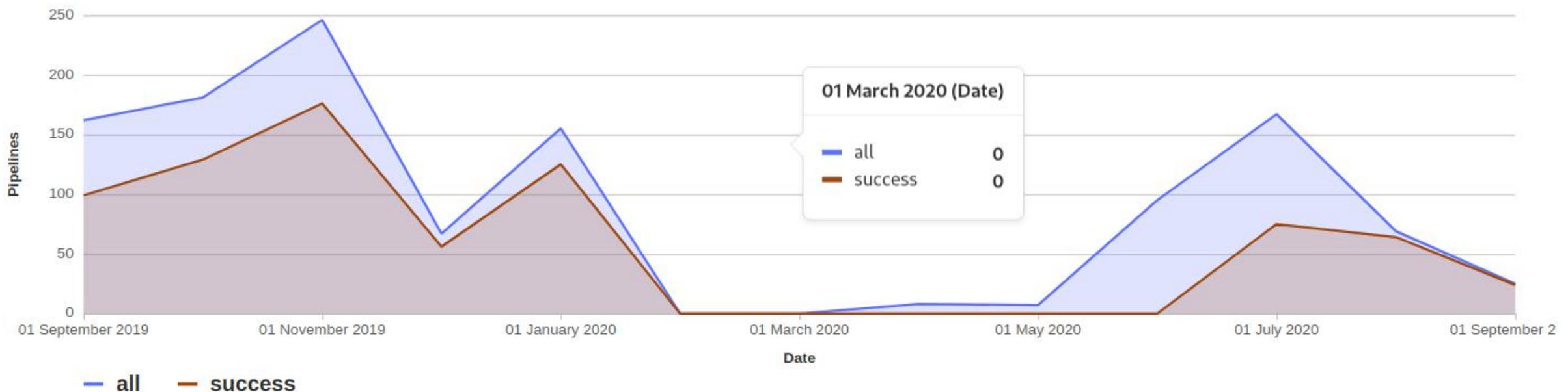
pynvme builds your own tests.

# Quality: test of the test infrastructure



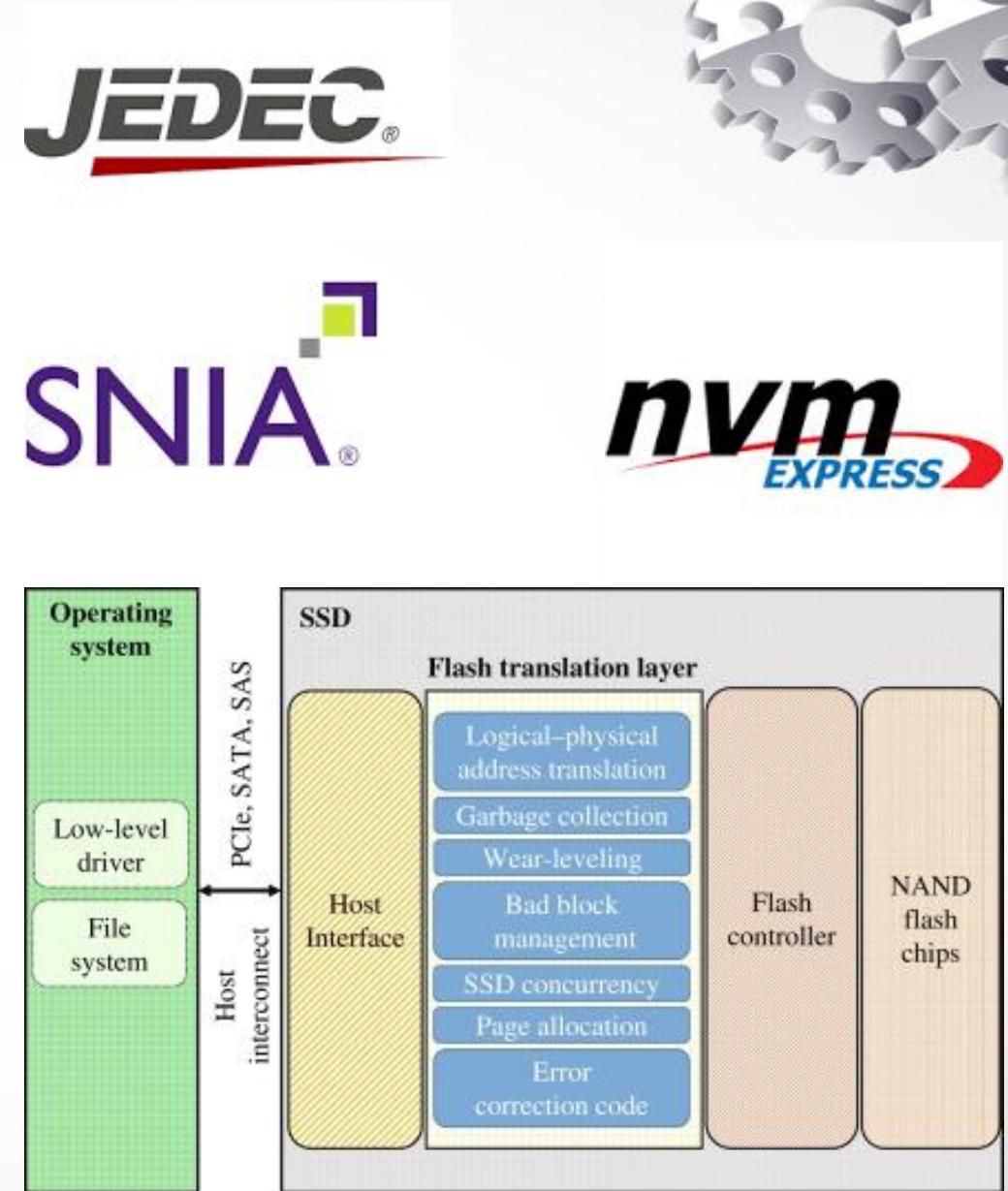
- CI in gitlab.com
- ~600 test items

Pipelines for last year



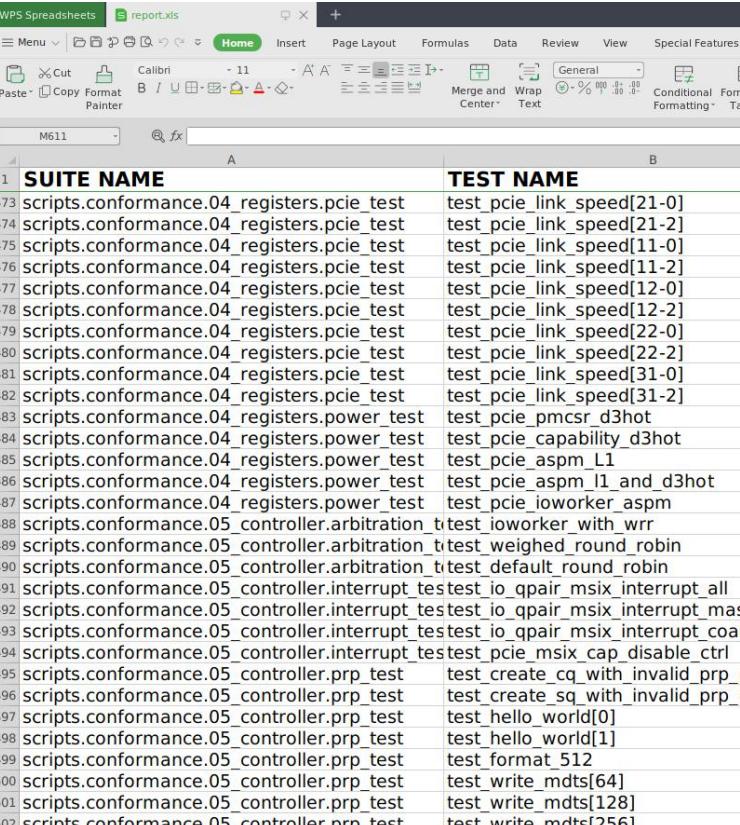
# Services

```
5 def test_ioworker_jedec_workload(nvme0n1):
6     distribution = [1000]*5 + [200]*15 + [25]*80
7     iosz_distribution = {1: 4,
8                           2: 1,
9                           3: 1,
10                          4: 1,
11                          5: 1,
12                          6: 1,
13                          7: 1,
14                          8: 67,
15                          16: 10,
16                          32: 7,
17                          64: 3,
18                          128: 3}
19
20     nvme0n1.ioworker(io_size=iosz_distribution,
21                       lba_random=True,
22                       qdepth=128,
23                       distribution = distribution,
24                       read_percentage=0,
25                       ptype=0xbeef, pvalue=100,
26                       time=12*3600).start().close()
```



# Conformance Test Scripts



- <https://github.com/pynvme/conformance>
  - GPL-3.0
  - suites
    - registers
    - admin
    - nvm
    - features
    - controller
    - TCG
    - ZNS

The screenshot shows a spreadsheet titled "report.xls" in WPS Spreadsheets. The table has three columns: "SUITE NAME" (A), "TEST NAME" (B), and a third column that is mostly cut off but includes "PASSE" and "SKIPPED". The "SUITE NAME" column contains entries like "scripts.conformance.04\_registers.pcie\_test", "scripts.conformance.04\_registers.power\_test", and "scripts.conformance.05\_controller.arbitration\_t". The "TEST NAME" column contains various test names such as "test\_PCIE\_Link\_Speed[21-0]", "test\_PCIE\_Link\_Speed[21-2]", and "test\_PCIE\_Link\_Speed[22-0]". The third column shows results for each test, with many entries showing "PASSE" and some showing "SKIPPED".

SUITE NAME	TEST NAME	
scripts.conformance.04_registers.pcie_test	test_PCIE_Link_Speed[21-0]	PASSE
scripts.conformance.04_registers.pcie_test	test_PCIE_Link_Speed[21-2]	PASSE
scripts.conformance.04_registers.pcie_test	test_PCIE_Link_Speed[11-0]	PASSE
scripts.conformance.04_registers.pcie_test	test_PCIE_Link_Speed[11-2]	PASSE
scripts.conformance.04_registers.pcie_test	test_PCIE_Link_Speed[12-0]	PASSE
scripts.conformance.04_registers.pcie_test	test_PCIE_Link_Speed[12-2]	PASSE
scripts.conformance.04_registers.pcie_test	test_PCIE_Link_Speed[22-0]	PASSE
scripts.conformance.04_registers.pcie_test	test_PCIE_Link_Speed[22-2]	PASSE
scripts.conformance.04_registers.pcie_test	test_PCIE_Link_Speed[31-0]	PASSE
scripts.conformance.04_registers.pcie_test	test_PCIE_Link_Speed[31-2]	PASSE
scripts.conformance.04_registers.power_test	test_PCIE_PMCSCR_D3Hot	PASSE
scripts.conformance.04_registers.power_test	test_PCIE_Capability_D3Hot	PASSE
scripts.conformance.04_registers.power_test	test_PCIE_ASPM_L1	PASSE
scripts.conformance.04_registers.power_test	test_PCIE_ASPM_L1_and_D3Hot	PASSE
scripts.conformance.04_registers.power_test	test_PCIE_IOWORKER_ASPM	PASSE
scripts.conformance.05_controller.arbitration_t	test_IOWORKER_With_WRR	SKIPPE
scripts.conformance.05_controller.arbitration_t	test_Weighted_Round_Robin	SKIPPE
scripts.conformance.05_controller.arbitration_t	test_Default_Round_Robin	PASSE
scripts.conformance.05_controller.interrupt_t	test_IO_QPAIR_MSIX_Interrupt_All	PASSE
scripts.conformance.05_controller.interrupt_t	test_IO_QPAIR_MSIX_Interrupt_Mask	PASSE
scripts.conformance.05_controller.interrupt_t	test_IO_QPAIR_MSIX_Interrupt_Coalescing	PASSE
scripts.conformance.05_controller.interrupt_t	test_PCIE_MSIX_CAP_Disable_CTRL	PASSE
scripts.conformance.05_controller.prp_test	test_Create_CQ_With_Invalid_PRP_Offset	PASSE
scripts.conformance.05_controller.prp_test	test_Create_SQ_With_Invalid_PRP_Offset	PASSE
scripts.conformance.05_controller.prp_test	test_Hello_World[0]	PASSE
scripts.conformance.05_controller.prp_test	test_Hello_World[1]	PASSE
scripts.conformance.05_controller.prp_test	test_Format_512	PASSE
scripts.conformance.05_controller.prp_test	test_Write_MDTS[64]	PASSE
scripts.conformance.05_controller.prp_test	test_Write_MDTS[128]	PASSE
scripts.conformance.05_controller.prp_test	test_Write_MDTS[256]	PASSE
scripts.conformance.05_controller.prp_test	test_Write_MDTS[512]	PASSE
scripts.conformance.05_controller.prp_test	test_Write_MDTS[800]	PASSE
scripts.conformance.05_controller.prp_test	test_Write_MDTS[1024]	PASSE
scripts.conformance.05_controller.prp_test	test_Write_MDTS[16384]	PASSE
scripts.conformance.05_controller.prp_test	test_Write_MDTS[32768]	PASSE
scripts.conformance.05_controller.prp_test	test_Write_MDTS[65536]	PASSE

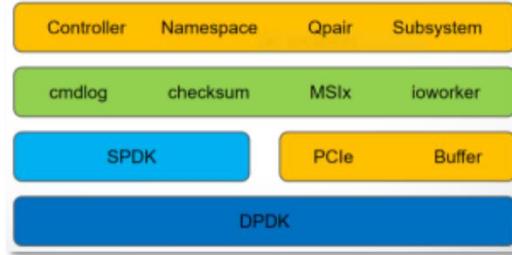
# Values



Ecosystem



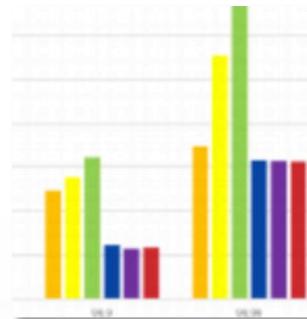
Scripts



Expendability



Hardware



Performance



Service





**pynvme** builds your own tests.



<https://github.com/pynvme/pynvme>

**Thanks!**