
OPEN SOURCE SUMMIT
China 2019

SPDK BASED USER SPACE NVME OVER TCP TRANSPORT SOLUTION

Presenters: Ziye Yang

Company: Intel

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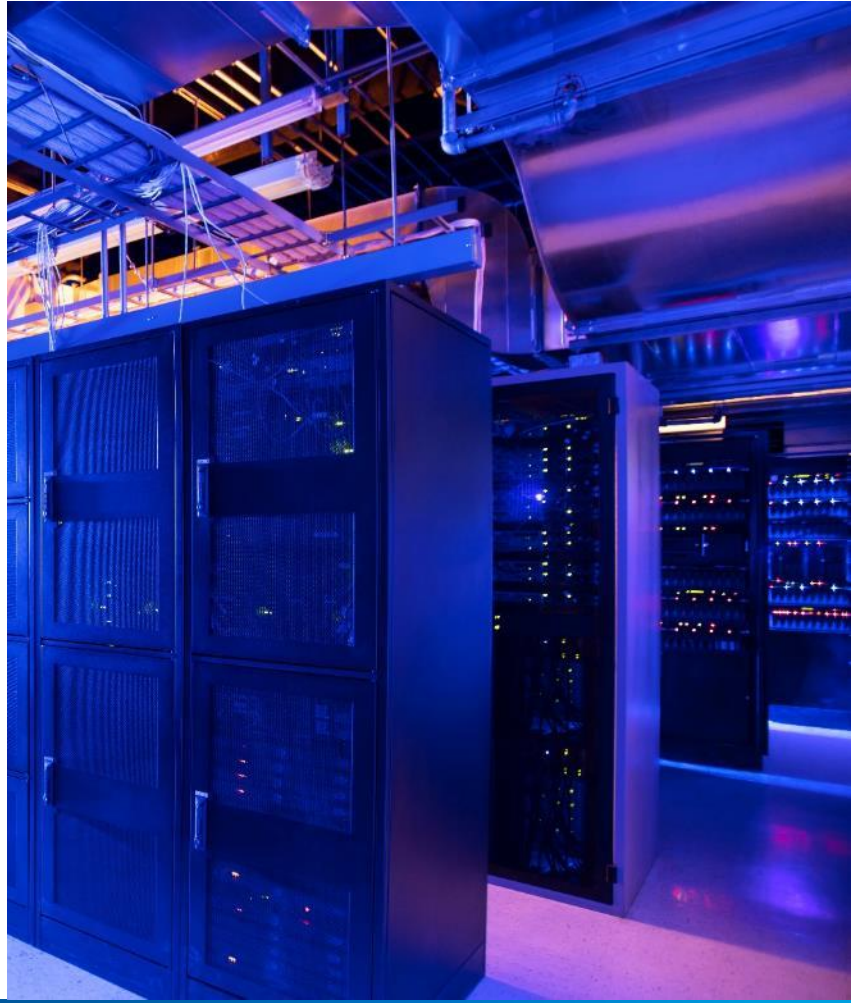
AGENDA

- SPDK NVMe-oF development history & status
- SPDK TCP transport introduction
- Conclusion



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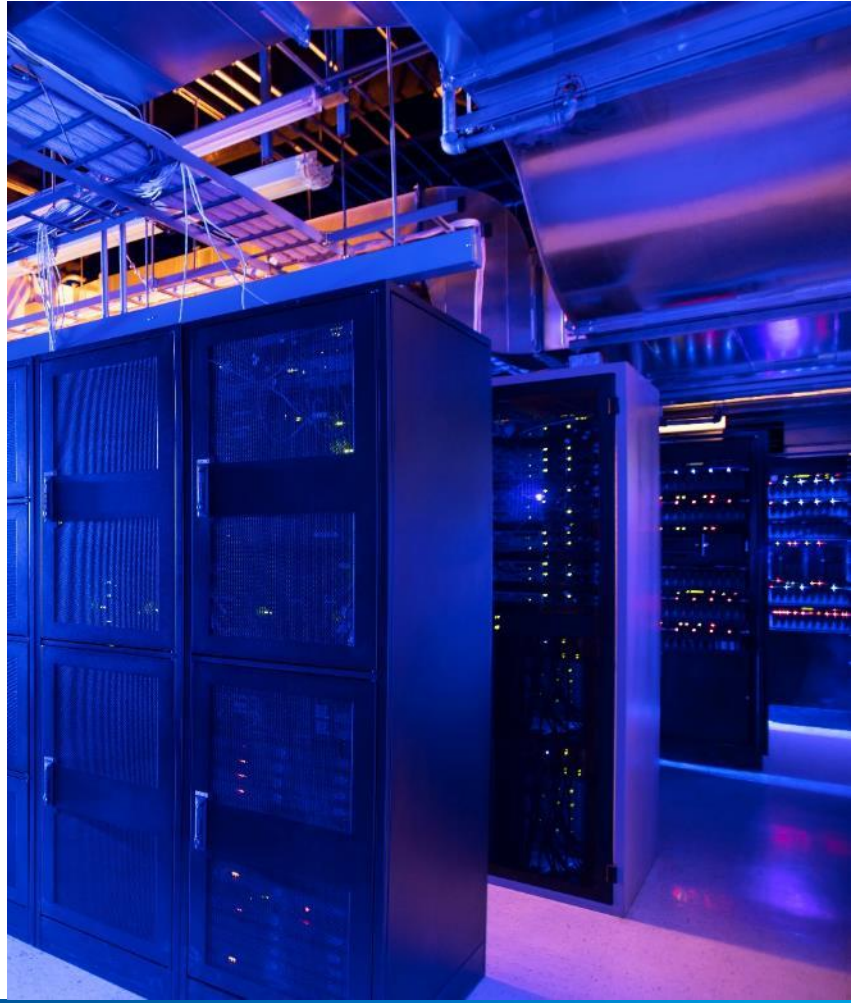
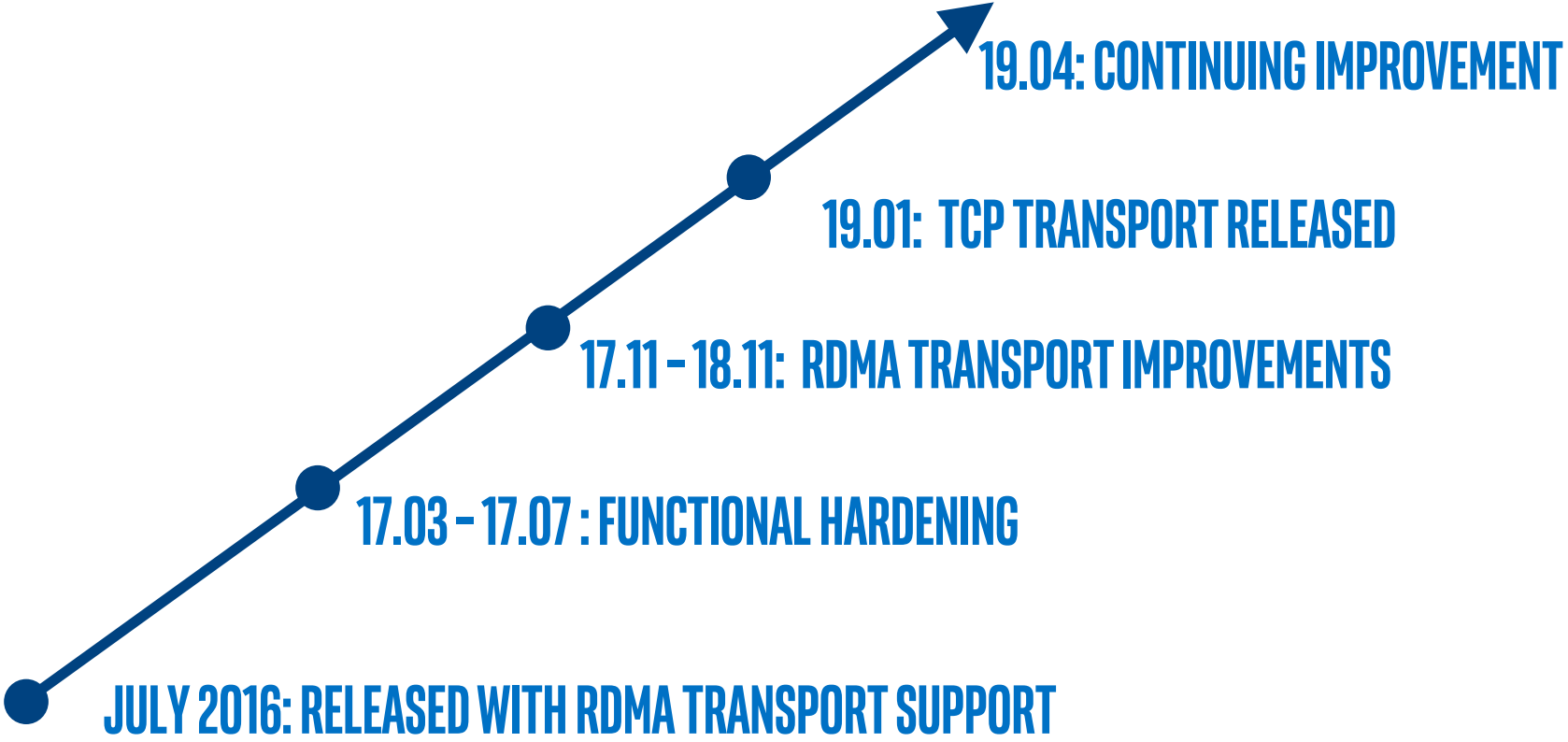
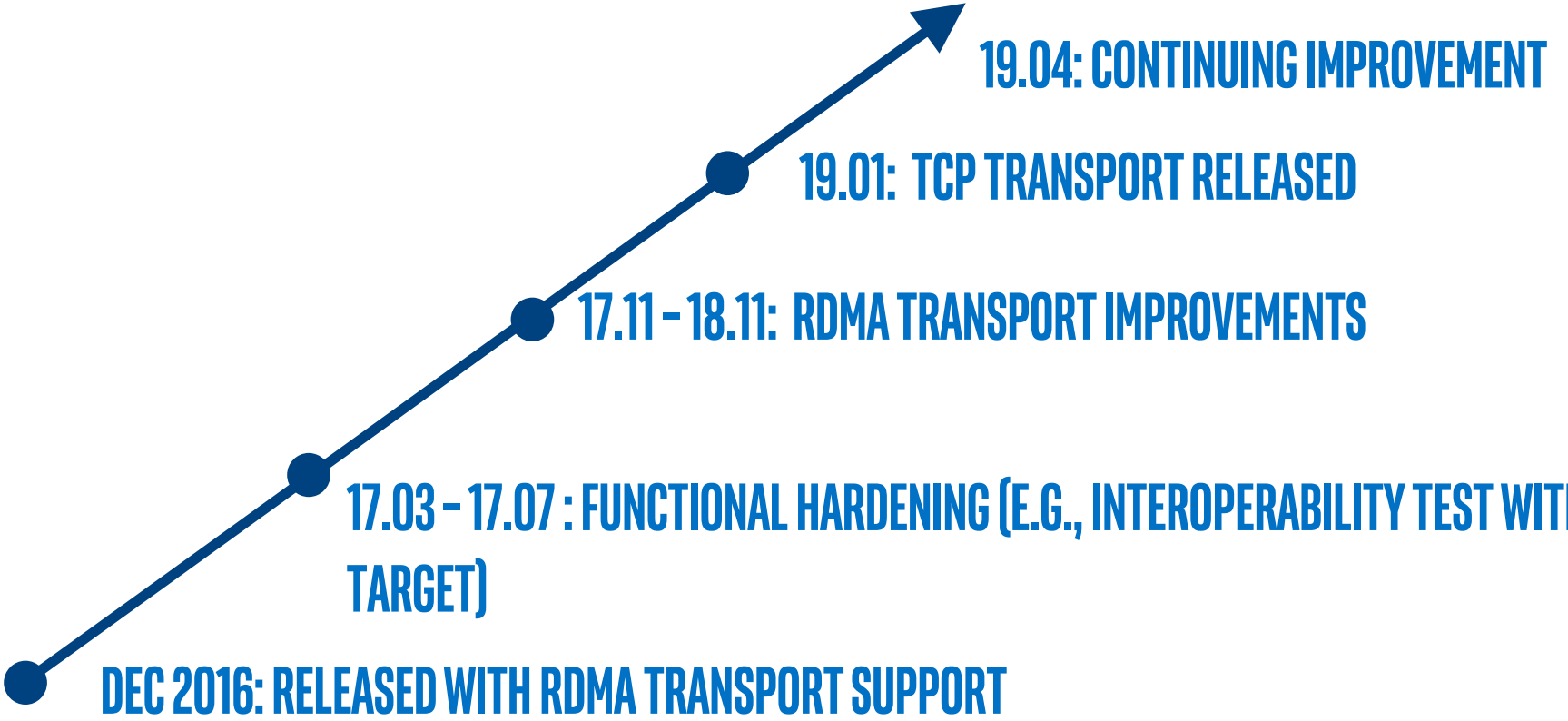


SPDK NVMe-oF Target Timeline



SPDK NVMe-oF Host Timeline



SPDK NVMe-oF target design highlights

NVMe* over Fabrics Target Features	Performance Benefit
Utilizes user space NVM Express* (NVMe) Polled Mode Driver	Reduced overhead per NVMe I/O
Group polling on each SPDK thread (binding on CPU core) for multiple transports	No interrupt overhead
Connections pinned to dedicated SPDK thread	No synchronization overhead
Asynchronous NVMe CMD handling in whole life cycle	No locks in NVMe CMD data handling path

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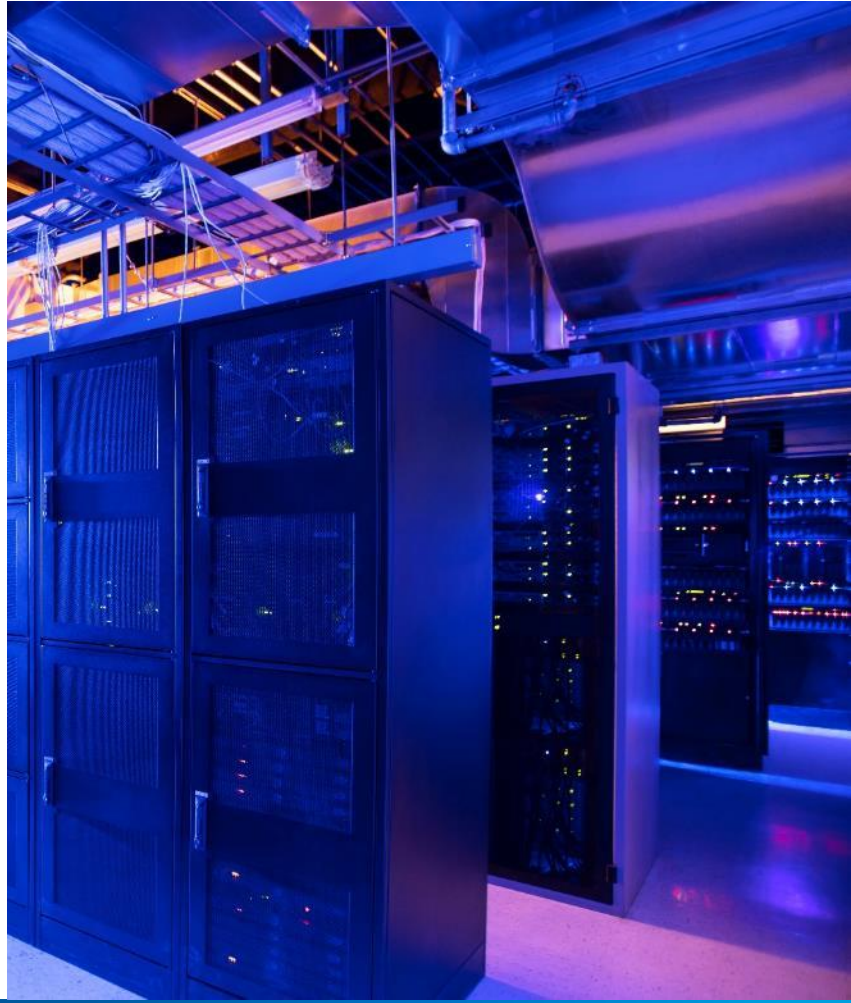
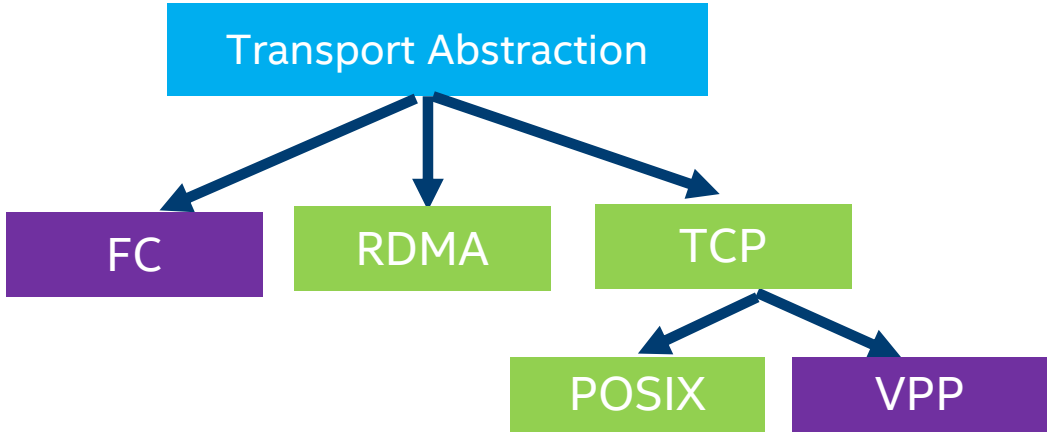


General design and implementation



- Follow the SPDK transport abstraction:
  - Host side code: lib/nvme/nvme_tcp.c
  - Target side code: lib/nvmf/tcp.c

Already released

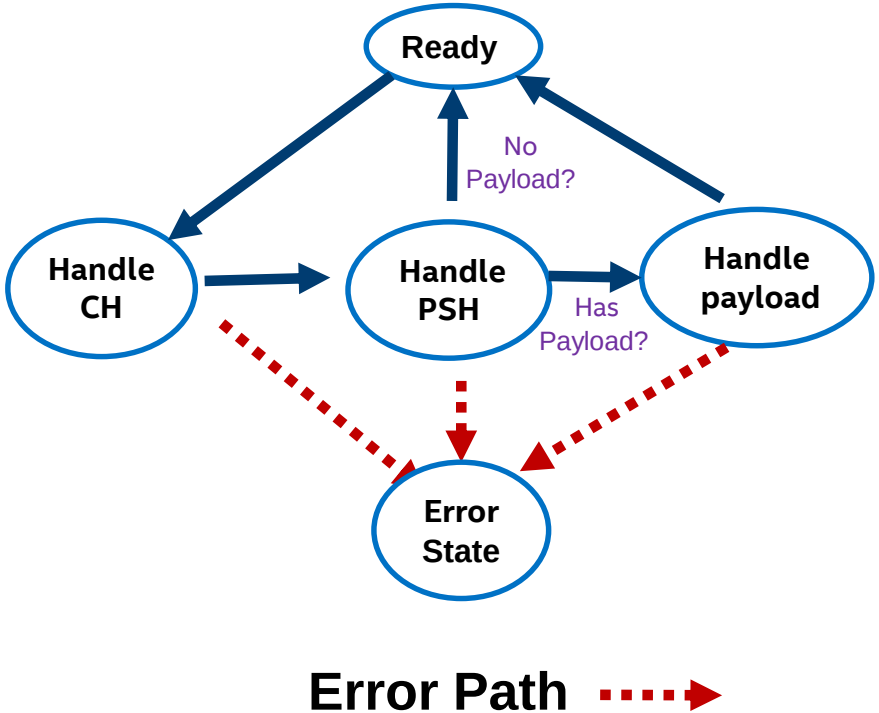
Inprogress

Performance design consideration for TCP transport in target side

Ingredients	Methodology
Design framework	Follow the general SPDK NVMe-oF framework (e.g., polling group)
TCP connection optimization	Use the SPDK encapsulated Socket API (preparing for integrating other stack, e.g., VPP)
NVMe/TCP PDU handling	Use state machine to track
NVMe/TCP request life time cycle	Use state machine to track (Purpose: Easy to debug and good for further performance improvement)

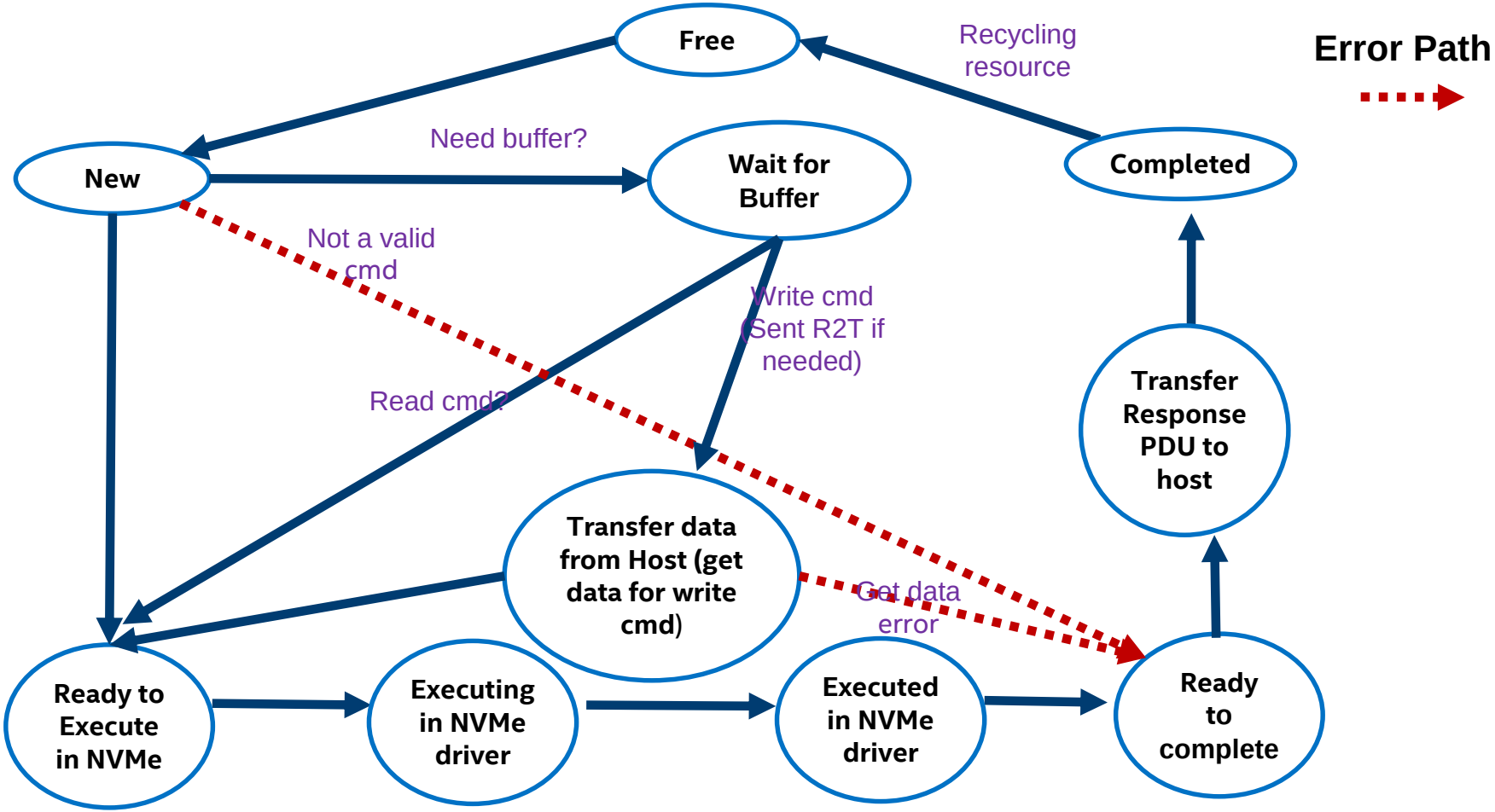
TCP PDU Receiving handling for each connection

```
enum nvme_tcp_pdu_recv_state {
        /* Ready to wait PDU */
        NVME_TCP_PDU_RECV_STATE_AWAIT_PDU_READY,

        /* Active tqpair waiting for any PDU common header */
        NVME_TCP_PDU_RECV_STATE_AWAIT_PDU_CH,

        /* Active tqpair waiting for any PDU specific header */
        NVME_TCP_PDU_RECV_STATE_AWAIT_PDU_PSH,

        /* Active tqpair waiting for payload */
        NVME_TCP_PDU_RECV_STATE_AWAIT_PDU_PAYLOAD,

        /* Active tqpair does not wait for payload */
        NVME_TCP_PDU_RECV_STATE_ERROR,
};
```

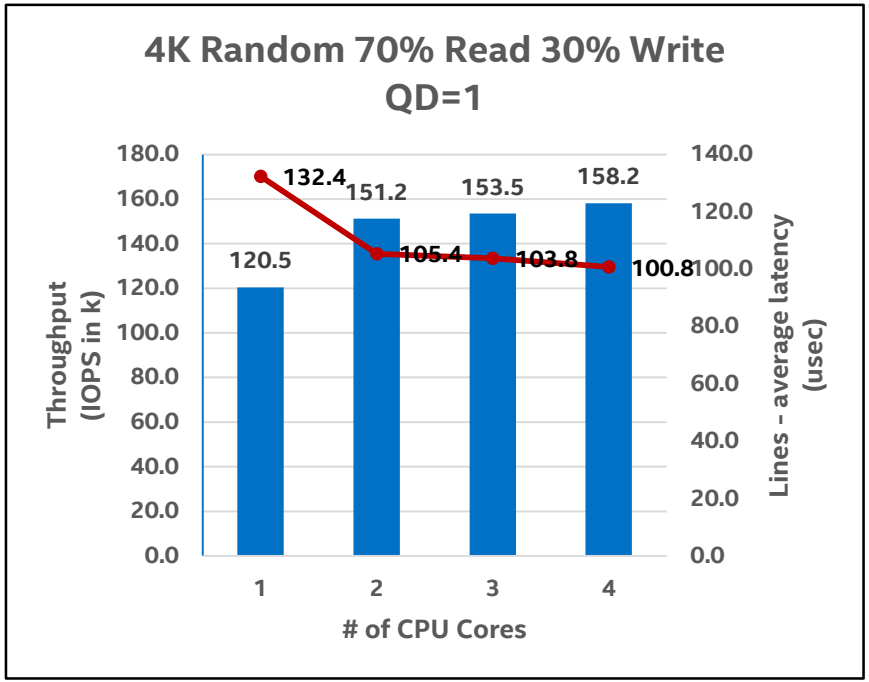


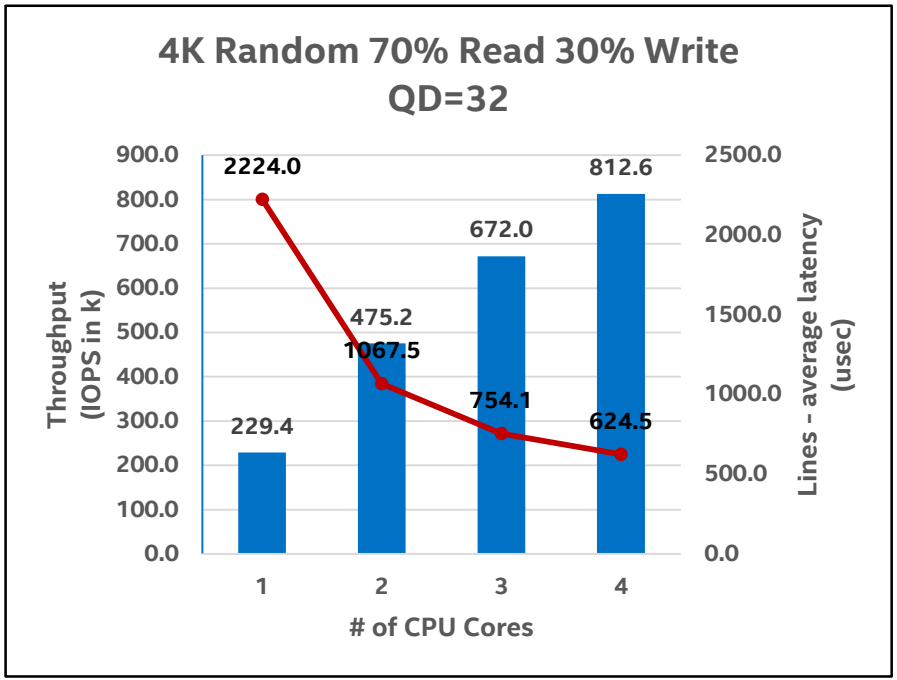
SPDK NVMe-oF TCP request life cycle of each connection in target side

```
/* spdk nvmf related structure */
enum spdk_nvmf_tcp_req_state {

        /* The request is not currently in use */
        TCP_REQUEST_STATE_FREE = 0,

        /* Initial state when request first received */
        TCP_REQUEST_STATE_NEW,

        /* The request is queued until a data buffer is available. */
        TCP_REQUEST_STATE_NEED_BUFFER,

        /* The request is currently transferring data from the host to the controller. */
        TCP_REQUEST_STATE_TRANSFERRING_HOST_TO_CONTROLLER,

        /* The request is ready to execute at the block device */
        TCP_REQUEST_STATE_READY_TO_EXECUTE,

        /* The request is currently executing at the block device */
        TCP_REQUEST_STATE_EXECUTING,

        /* The request finished executing at the block device */
        TCP_REQUEST_STATE_EXECUTED,

        /* The request is ready to send a completion */
        TCP_REQUEST_STATE_READY_TO_COMPLETE,

        /* The request is currently transferring final pdus from the controller to the host. */
        TCP_REQUEST_STATE_TRANSFERRING_CONTROLLER_TO_HOST,

        /* The request completed and can be marked free. */
        TCP_REQUEST_STATE_COMPLETED,

        /* Terminator */
        TCP_REQUEST_NUM_STATES,
};
```


Free
Recycling resource
Error Path
Need buffer?
New
Wait for Buffer
Completed
Not a valid cmd
Write cmd (Sent R2T if needed)
Read cmd?
Transfer Response PDU to host
Transfer data from Host (get data for write cmd)
Get data error
Ready to Execute in NVMe
Executing in NVMe driver
Executed in NVMe driver
Ready to complete

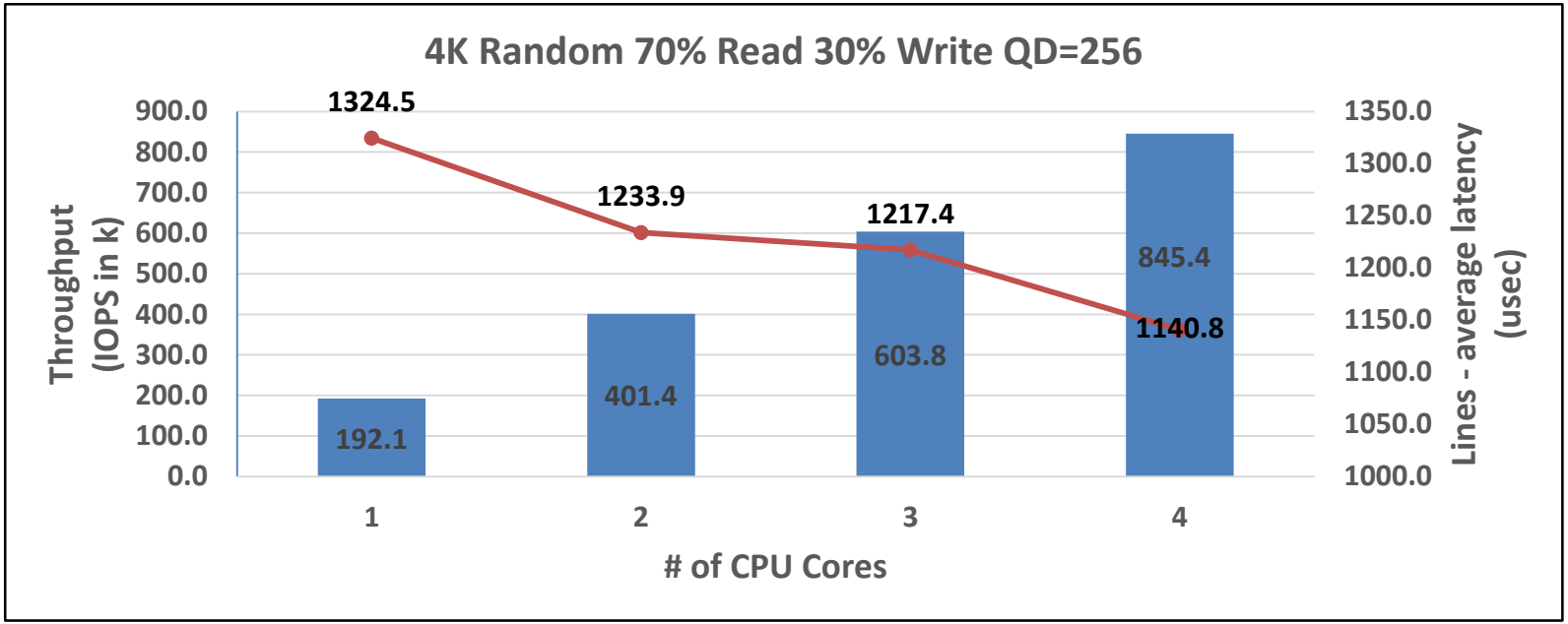
SPDK TARGET SIDE (TCP TRANSPORT): I/O SCALING





System configuration: (1) Target: server platform: SuperMicro SYS2029U-TN24R4T; 2x Intel® Xeon® Platinum 8180 CPU @ 2.50 GHz, Intel® Speed Step enabled, Intel® Turbo Boost Technology enabled, 4x 2GB DDR4 2666 MT/s, 1 DIMM per channel; 2x 100GbE Mellanox ConnectX-5 NICs; Fedora 28, Linux kernel 5.05, SPDK 19.01.1; 6x Intel® P4600TM P4600x 2.0TB; (2) initiator: Server platform: SuperMicro SYS-2028U TN24R4T+; 44x Intel(R) Xeon(R) CPU E5-2699 v4 @ 2.20GHz (HT off); 1x 100GbE Mellanox ConnectX-4 NIC; Fedora 28, Linux kernel 5.05, SPDK 19.0.1. (3) : Fio ver: fio-3.3; Fio workload: blocksize=4k, iodepth=1, iodepth_batch=128, iodepth_low=256, ioengine=libaio or SPDK bdev engine, size=10G, ramp_time=0, run_time=300, group_reporting, thread, direct=1, rw=read/write/rw/randread/randwrite/randrw

SPDK HOST SIDE (TCP TRANSPORT): I/O SCALING



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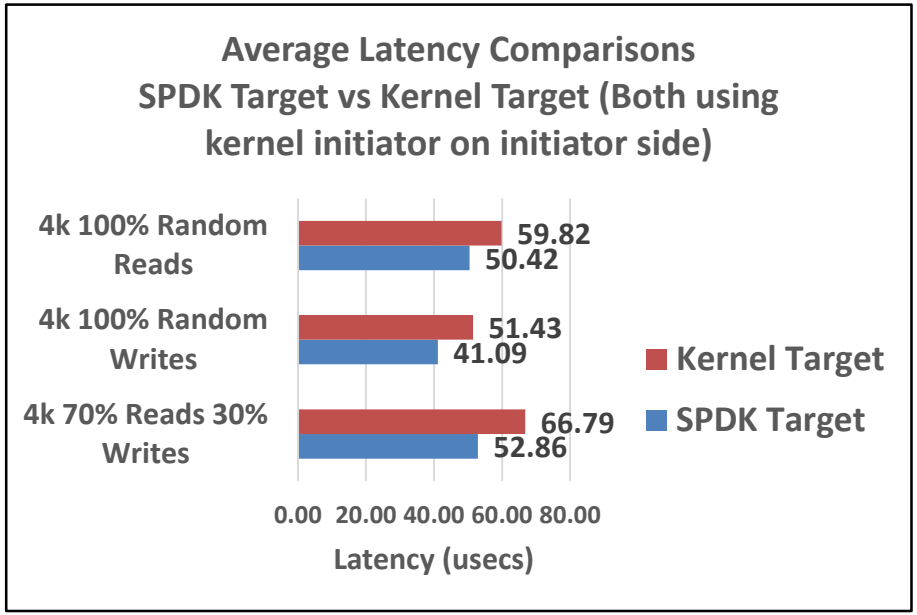
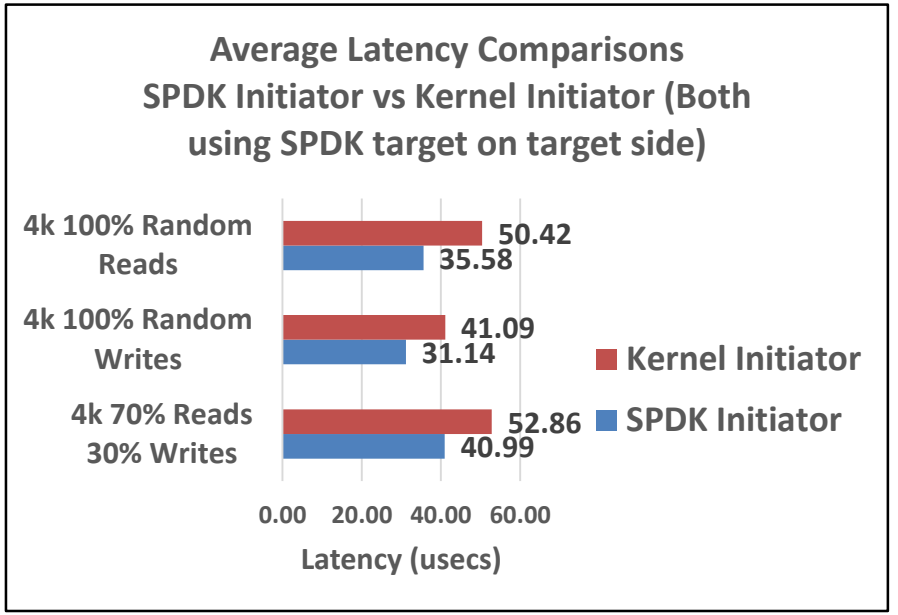
LATENCY COMPARISON BETWEEN SPDK AND KERNEL (NULL BDEV IS USED)





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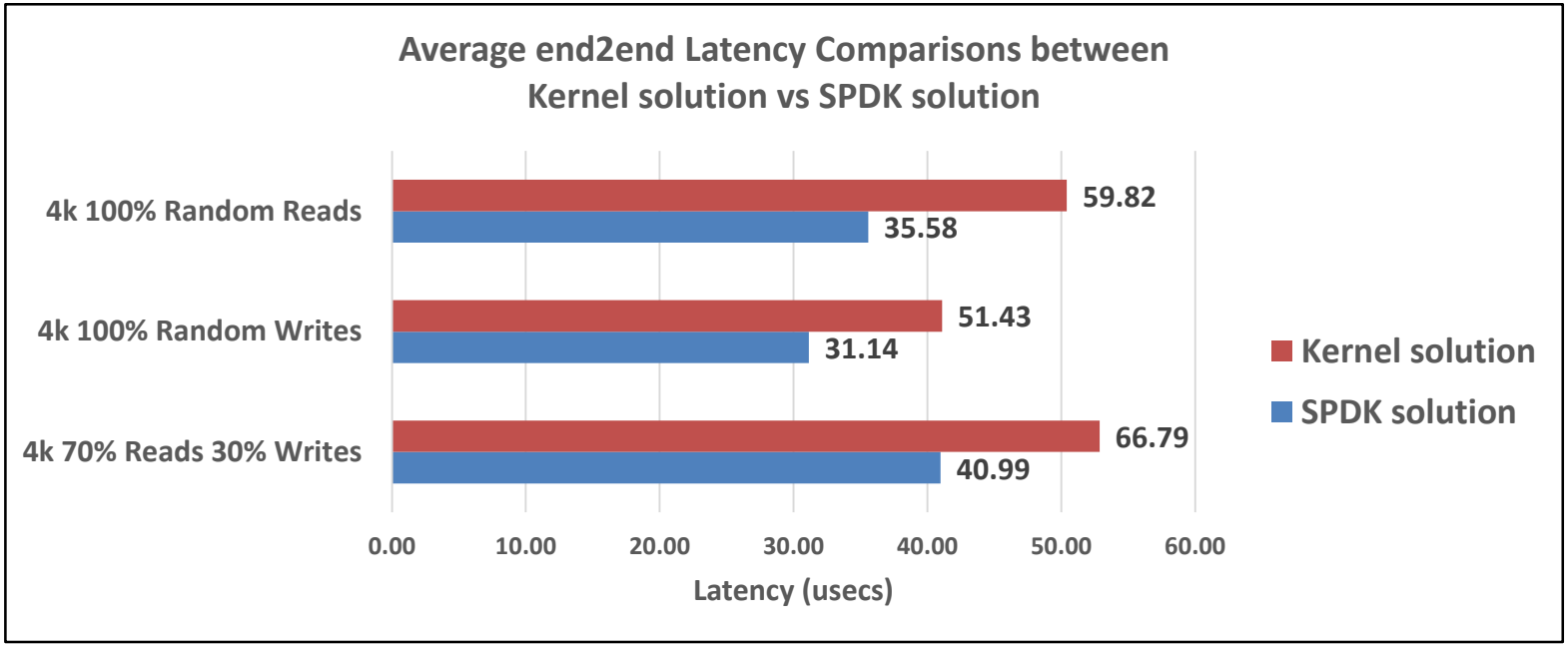

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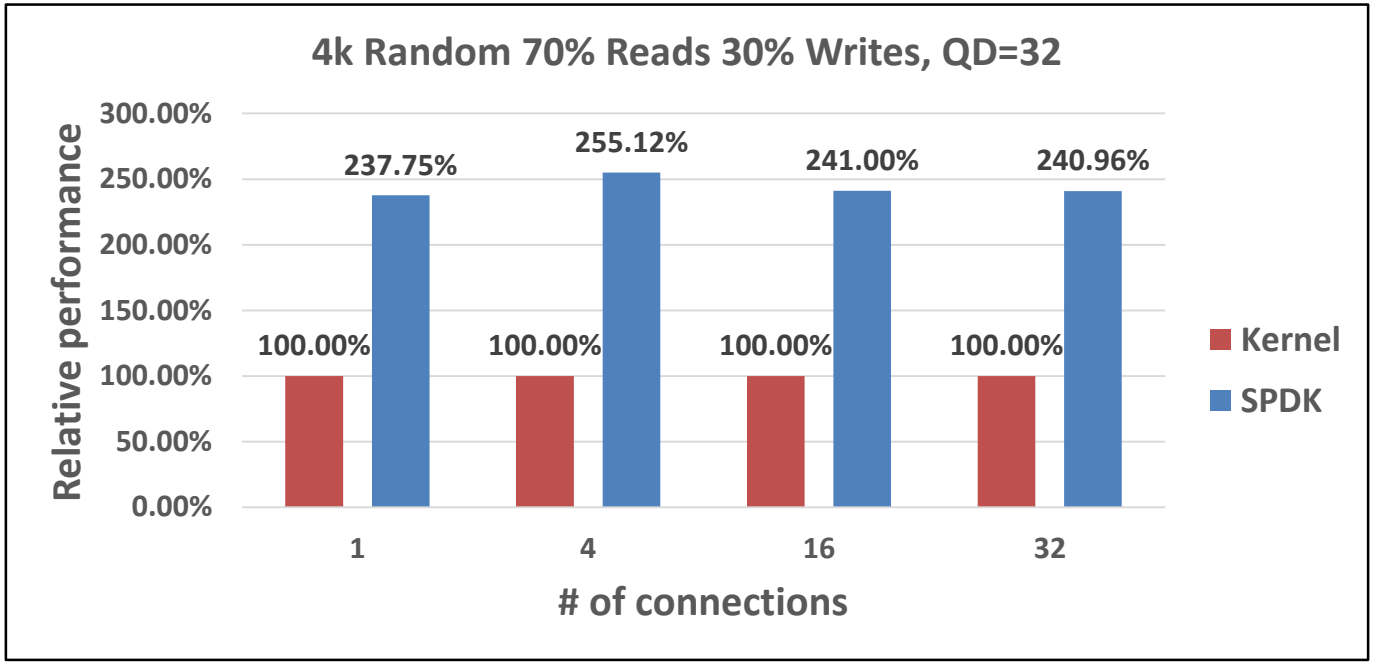
IOPS/CORE COMPARISON BETWEEN SPDK AND KERNEL ON TARGET SIDE



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Further development plan

- Continue enhancing the functionality
  - Including the compatible test with Linux kernel solution.
- Performance tuning
- Integration with third party software
  - Deep integration with user space stack: VPP + DPDK
- Leveraging hardware features
  - Use existing hardware features of NICs for performance improvement, e.g., VMA from Mellanox's NIC; load balance features (ADQ) from Intel's 100Gbit NIC.
  - Figuring out offloading methods with hardware, e.g., FPGA, Smart NIC, and etc.

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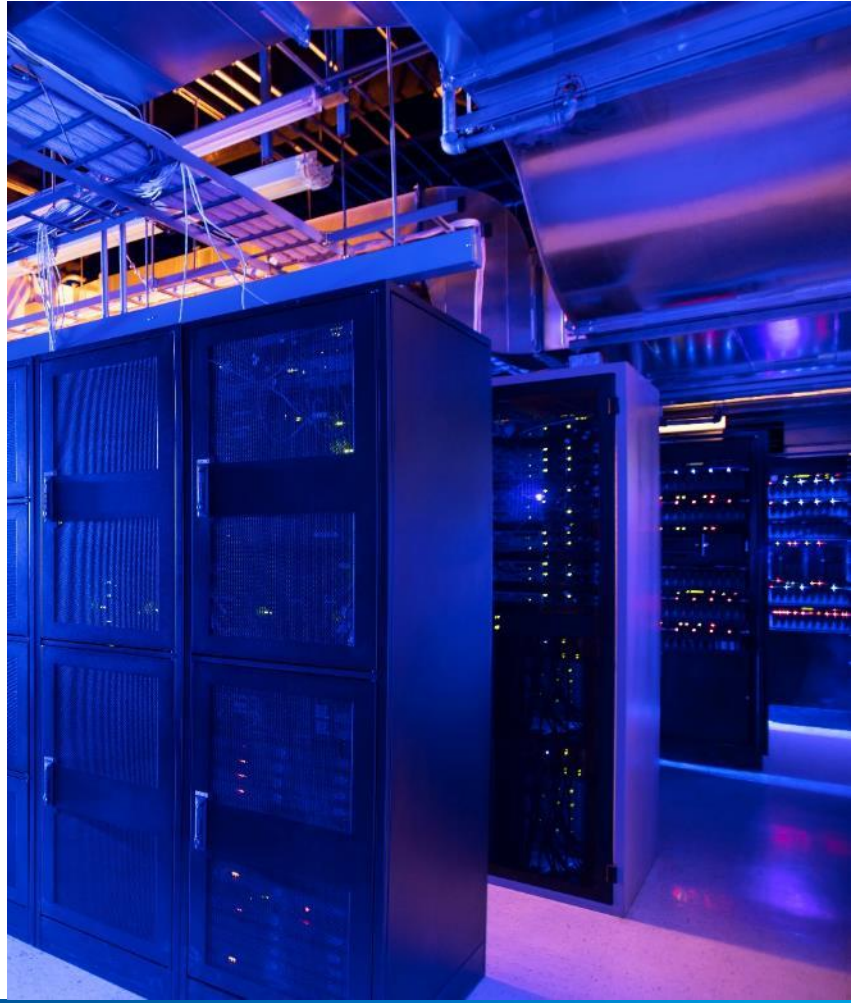
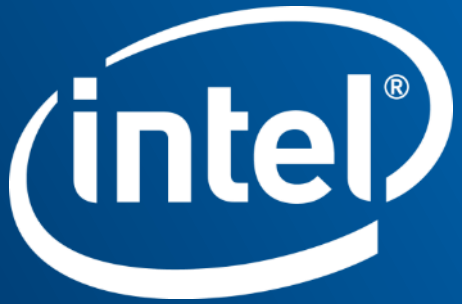


Conclusion

- SPDK NVMe-oF solution is well adopted by the industry. In this presentation, followings are introduced, i.e.,
  - The development status of SPDK NVMe-oF solution
  - SPDK TCP transport development status.
- Further development
  - Continue following the NVMe-oF spec and adding more features.
  - Continue performance enhancements and integration with other solutions.
- Call for activity in community
  - Welcome to bug submission, idea discussion and patch submission for NVMe-oF

Q&A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