Where Does SPDK Fit in the NVMe-oF™ Landscape?

Live Webcast
January 9, 2020
10:00 am PT
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Agenda

- Overview of the SPDK Project
- Key NVMe-oF Use Cases with SPDK
- SPDK NVMe-oF Architecture and Design
- Performance Data
- Q&A
Overview of the SPDK Project
What is SPDK?

Storage Performance Development Kit

- Open source project
- Framework for highly performant and efficient storage software
- Userspace and polled mode programming model
- Special focus on NVM Express (and NVMe over Fabrics!)
- Includes storage networking and storage virtualization
- Discrete libraries and fully-functional applications
What is SPDK?

Project History
- 2013: SPDK starts as an internal project at Intel
- 2015: NVMe driver released on GitHub
- 2016: First contributor outside of Intel
- 2017: First core maintainer outside of Intel
- 2018: NVMe/TCP support released in-step with specification
- 2019: 700+ patches from 50+ contributors outside of Intel
Architecture Diagram

Block Storage Protocols
Networking: NVMe-oF (RDMA, TCP, FC), iSCSI
Virtualization: vhost-scsi, vhost-blk

File Storage Services
Filesystems: BlobFS

Integration
Orchestration: Cinder
Database: RocksDB
Scale-out Storage: Ceph

Block Storage Services
Partitioning: Logical Volumes, GPT
Caching: OCF
Host FTL: Open Channel
Pooling: RAID-0
Transforms: Crypto, Compression

Block Storage Providers
NVMe, io_uring, Linux AI0, virtio, iSCSI, Ceph RBD

Drivers
NVMe (PCIe, RDMA, TCP), virtio (scsi, blk)

Tools
Benchmarking: fio
Management: nvme-cli, spdk-cli
Key NVMe-oF Use Cases with SPDK
Determining Factors

- Performance and efficiency requirements
  - SPDK capable of up to millions of IOPs per CPU core

- Integration with existing software
  - SPDK provides well-defined APIs for integrating custom modules

- Customization
  - SPDK enables use of optional or vendor-specific NVMe features with little or no performance impact

- Licensing
  - SPDK is BSD licensed
Use Cases

- NVMe-oF target
- Basic block services
- Custom block services
  - Including integrating existing block storage stacks
- Custom transports
- Polled mode access to remote storage
Where is SPDK not suited?

- Reduced performance requirements
  - Kernel-based interrupt-driven storage software is typically sufficient for lower IOPs workloads

- Integration with legacy software
  - SPDK APIs designed for asynchronous operation with relatively fixed number of threads

- Support requirements
  - Kernel-based solutions may provide paid support options that are not available with SPDK

- General purpose filesystem requirements
SPDK NVMe-oF Architecture and Design
NVMe-oF Target Architecture
NVMe-oF Primitives

- spdk_nvmf_tgt
  - spdk_nvmfSubsystem
  - spdk_nvmf_transport

Diagram:
- Target
- Subsystem
- TCP
- FC
- RDMA
NVMe-oF Subsystems

- Subsystems are **global**
- Controller – Network session
- Namespace – Set of logical blocks

- Subsystems are **access control lists**
NVMe-oF Primitives

- spdk_nvmf_poll_group
  - spdk_nvmf_subsystem_poll_group
  - spdk_nvmf_transport_poll_group

Per-thread Scope
NVMe-oF Transport Poll Groups

- Per-thread collection of transport data
- TCP: NVMe-oF queue pair is a socket
- Uses a transport-specific mechanism to efficiently poll the group
  - TCP: epoll/kqueue
- The queue pairs are not necessarily for the same controller/subsystem/host
NVMe-oF Subsystem Poll Groups

- Per-thread collection of subsystem data
  - Contains thread-unique I/O channels for each namespace in the subsystem.
  - Think of an I/O channel as an NVMe queue pair for the local device.
Accepting a New Connection

```
spdk_nvmf_tgt_accept()
new_qpair_fn(qpair)
spdk_nvmf_poll_group_add(qpair)
```
Performing an I/O

- No Locks!
- Touches only thread-local data (cache friendly)!
- Lookups are all array math!

Poll group checks for incoming requests associated with a subsystem and targets a namespace. Look up I/O channel for subsystem + namespace in subsystem poll group. Use I/O channel to submit I/O to bdev layer.
NVMe-oF Host Architecture

- Same library/API as local PCIe NVMe driver
- Pluggable Transports
- No poll groups
  - Doing a `spdk_nvme_connect()` creates an `spdk_nvme_ctrlr` (network session) which includes the admin qpair.
  - I/O qpairs are polled directly
Performance Data
NVMe-oF Performance: TCP

Random read/write 70/30 @ 4K QD=64

NVMe-oF Performance: RDMA

Random read/write 70/30 @ 4K QD=64

I/Ops

Latency


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Q&A
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- A full Q&A from this webcast, including answers to questions we couldn't get to today, will be posted to the SNIA-NSF blog: sniansfblog.org
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More Resources

- Let’s Talk Fabrics – NVMe over Fabrics
  SNIAVideo YouTube: https://youtu.be/HfcZwkPzj4w

- What NVMe/TCP Means for Networked Storage
  On-Demand Webcast: https://www.brighttalk.com/webcast/663/344698

- Under the Hood with NVMe over Fabrics
  On-Demand Webcast: https://www.brighttalk.com/webcast/663/175515

- What’s New in NVM Express:
  SNIAVideo YouTube: https://youtu.be/m8ng2BzawNk

- The Performance Impact of NVMe and NVMe over Fabrics
  On-Demand Webcast: https://www.brighttalk.com/webcast/663/132761

- SPDK Performance Reports
  - https://spdk.io/doc

- Links to SPDK Summit presentations not covered today
  - https://spdk.io/blog
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