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A Performance Study for Ceph NVMe-over-Fabrics Gateway

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Why NVMe-over-Fabrics?

RADOS **B**lock **D**evice (RBD)

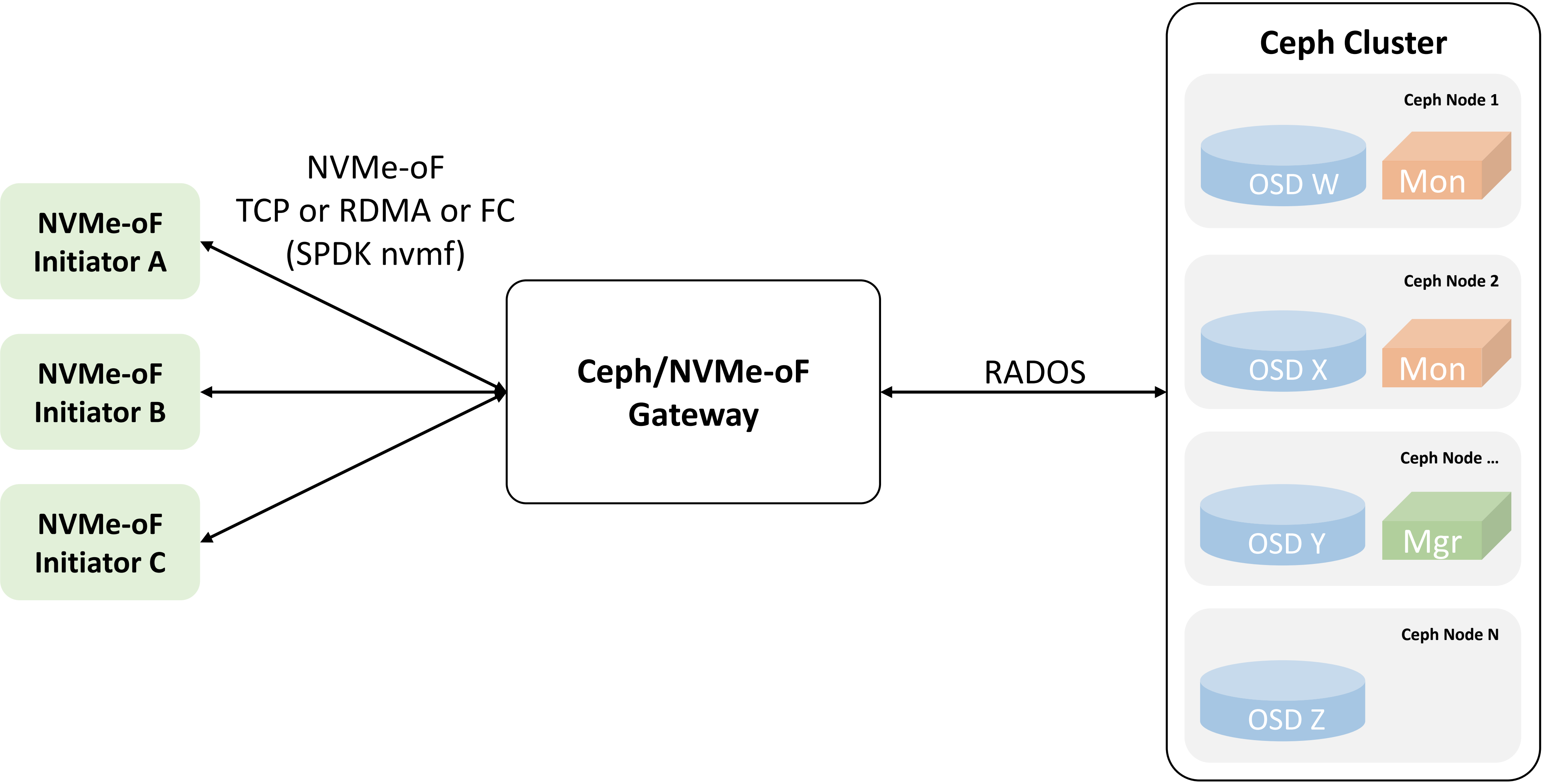
- RADOS protocol
- Distributed n-to-m protocol
- Reliable object access to sharded and replicated/erasure coded storage

Why do we need another protocol to access block storage in Ceph?

NVMe-over-Fabrics (NVMe-oF)

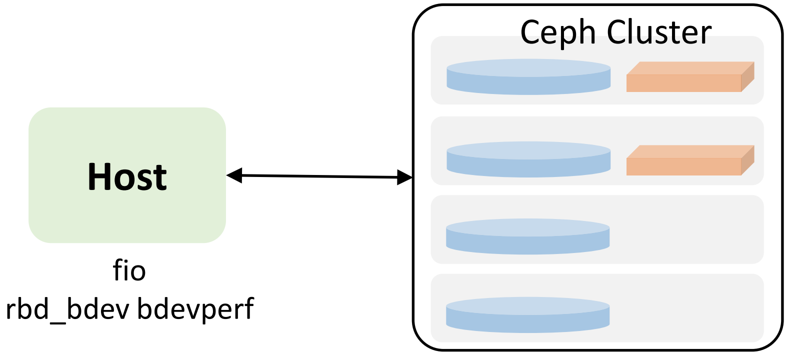
- Open, widely adopted ***industry standard***
- Enable use-cases where NVMe-oF is already part of ***ecosystem***
- Take advantage of NVMe-oF ***offloading*** in DPUs

Ceph NVMeoF Gateway Overview

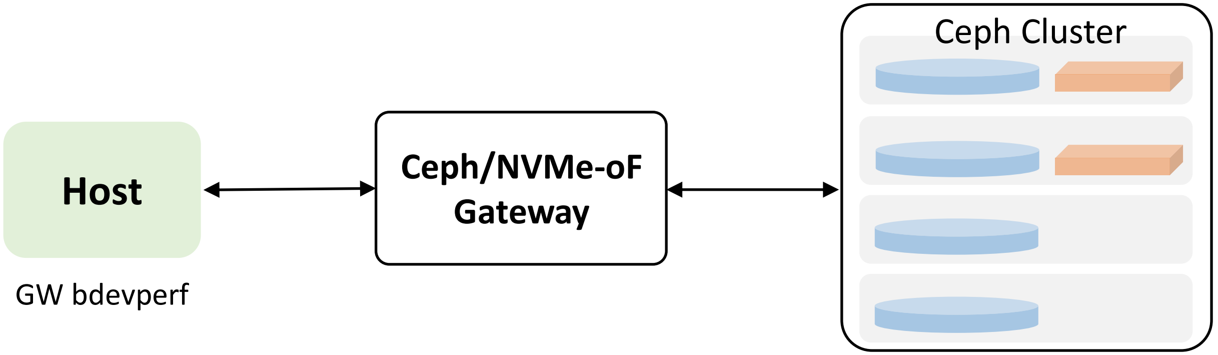


Our Performance Goal

- Target 5~10% performance loss compared to the non-GW solution
  - Non-GW solution: librbd (host ←→ Ceph)
  - Our solution: NVMeoF GW (host ←→ GW ←→ Ceph)



Non-GW Solution



Our GW Solution

- IO benchmarks
  - fio: reports max RBD volume performance with librbd
  - SPDK bdevperf:
    - rbd_bdev: reports SPDK librbd-based rbd_bdev performance (librbd + SPDK)
    - GW: reports SPDK rbd_bdev w/ NVMe-oF performance (our GW solution)

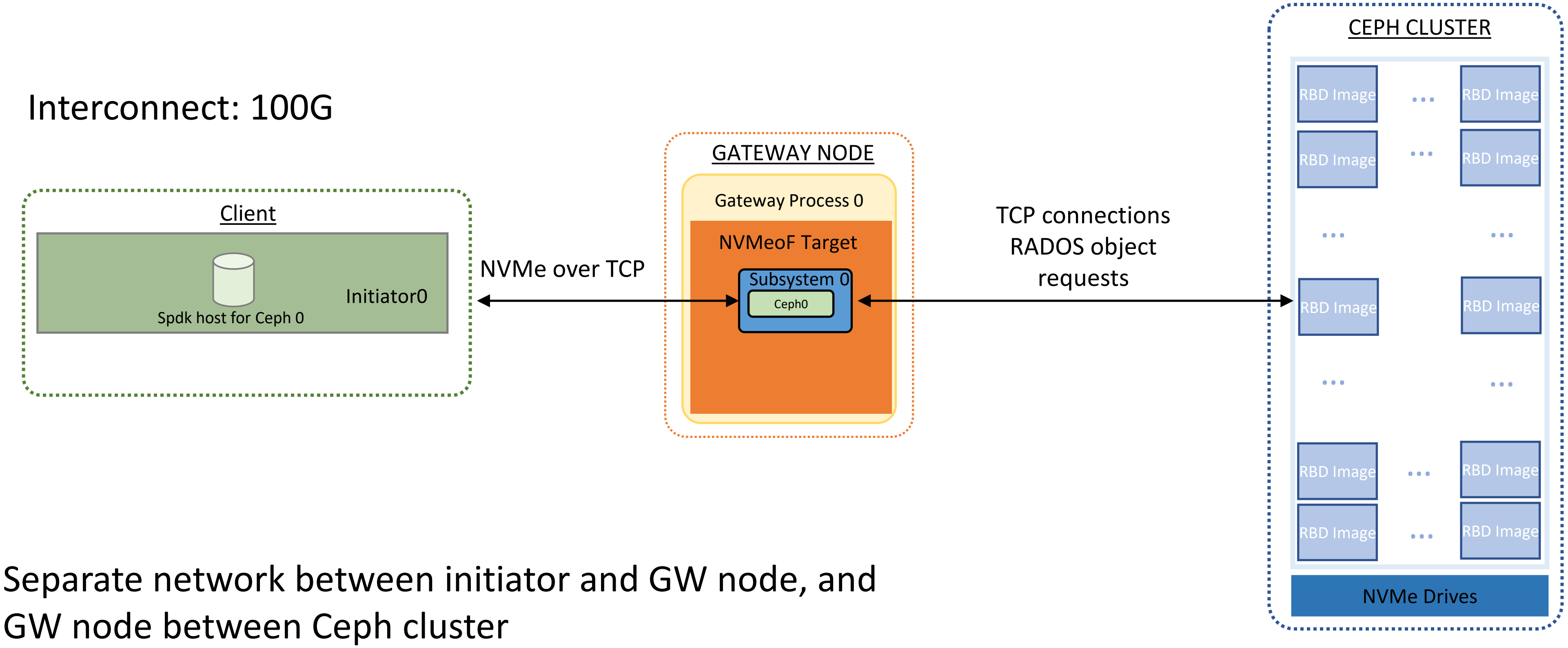
Our Test Setup

- Test environment
  - Intel(R) Xeon(R) Gold 6258R CPU @ 2.70GHz (**28 cores**)
  - **100 Gbit/s** Mellanox Technologies MT28800 Family [ConnectX-5 Ex] connected via PCIe Gen3
  - Samsung PM1725a NVMe SSD
  - Client: 1 node; Ceph cluster: 3 nodes; GW: 1 node

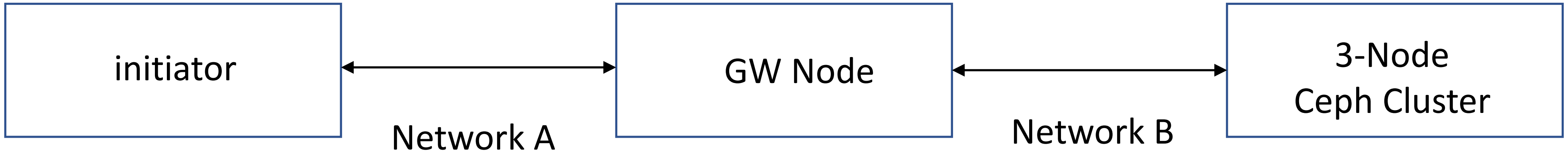
- Test setup
  - Ceph Pacific & Quincy w/ rbd_cache=FALSE
  - Block size = 16KiB, total QD=256, total volume size = 512GiB

SPDK Initiator w/ Ceph Gateway Test System

Interconnect: 100G

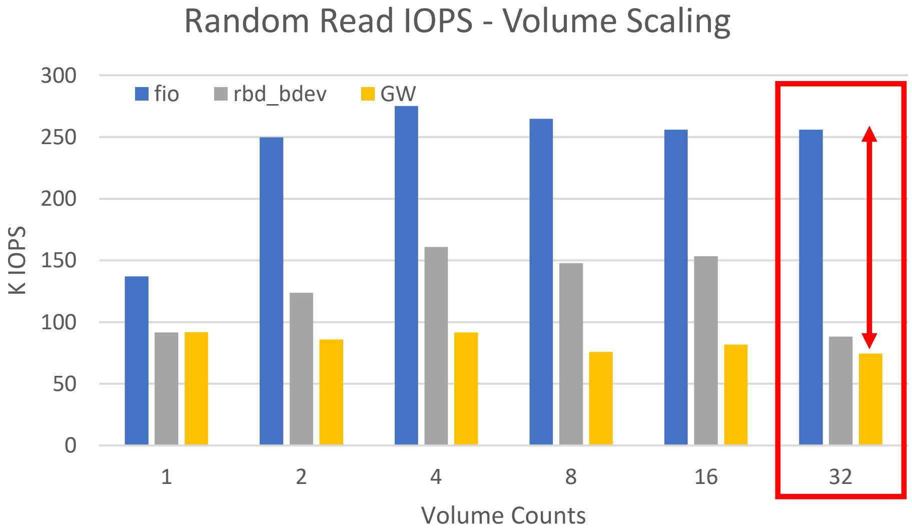


Separate network between initiator and GW node, and GW node between Ceph cluster

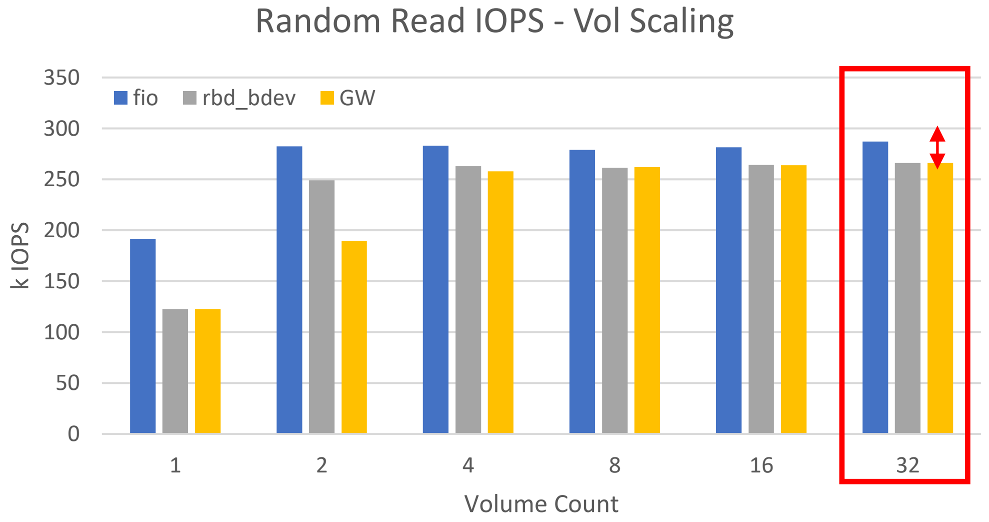


Random Read IOPS on Volume Scaling (SSD)

- Spdk bdev (bdevperf w/ rbd_bdev) and GW (bdevperf w/ nvmf) performance cannot match librbd's (left)
- In most cases, GW's performance is very close to expected performance (fio) (right)



Initial Performance



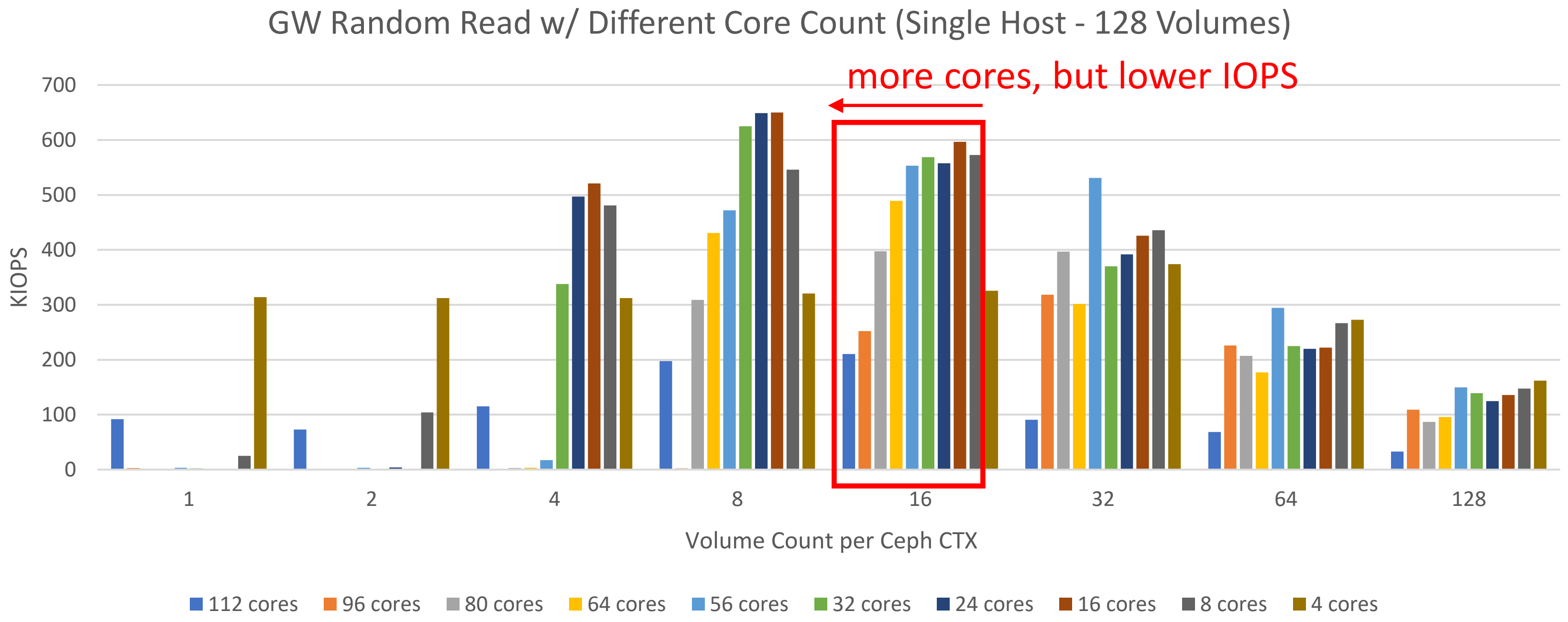
Current Performance

Keys to Performance

- NUMA affinity for cores and NIC
- rbd_bdev IO loadshare between CPU cores
  - https://review.spdk.io/gerrit/c/spdk/spdk/+/10416
  - We helped identify the importance of this patch
- Ceph client instantiations sharing between RBD volumes
  - On slide 6 , every rbd_bdev has its own Ceph client instantiations for right figure, but all rbd_bdev share one Ceph client instantiation for left figure
  - We are identifying the performance effect of sharing Ceph context (see next slide)
- Ceph version
  - We switched from Octopus to Pacific (we are now on Qunicy)
- tcmalloc instead of jmalloc

How do Core Count and Ceph CTX Count Affect IOPS?

- Performance numbers are gathered on RAMDisk based OSD (on Ceph Quincy)
- **The overall performance does not always benefit from high core count and Ceph CTX count**



Current Things To Do for Performance

- Support specified core mask for librbd when creating rbd_bdev.
    - We are going to submit a patch to enable this via bdev_rbd_create
- Find the “optimal” setup for the ratio of core count and Ceph CTX for given RBD volume count
- Understand the relationship between performance and SPDK_DEFAULT_MSG_MEMPOOL_SIZE
    - We submitted a patch to enable configurable SPDK_DEFAULT_MSG_MEMPOOL_SIZE via cmd line
        - https://review.spdk.io/gerrit/c/spdk/spdk/+/15552
- Volume scaling tests for volume count beyond 128

Thank you!

https://github.com/ceph/ceph-NVMeoF
https://pad.ceph.com/p/rbd_NVMeoF