Performance Evaluation of Stream Batch Queuing (SBQ) Linux I/O Scheduler

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1 Evaluation Setup

We use a testbed with two servers (host and target), each with 100Gbps links, directly connected without any intervening switches. Both servers have the same hardware/software configurations as shown in Table 1.

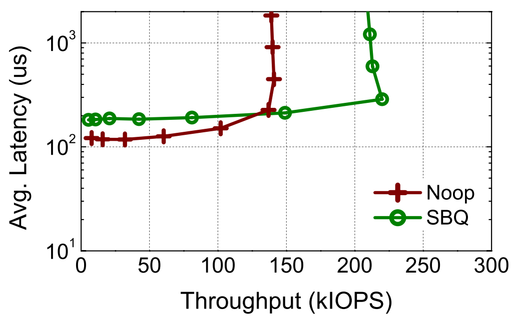
Table 1: Experimental setup used in our evaluation.

H/W configurations	
CPU	4-socket Intel Xeon Gold 6128 CPU @ 3.4GHz 6 cores per socket, NUMA enabled (4 nodes)
Memory	256GB of DRAM
NIC	Mellanox ConnectX-5 EX (100G) TSO/GRO=on, LRO=off, DIM disabled Jumbo frame enabled (9000B)
NVMe SSD	1.6TB of Samsung PM1725a
S/W configurations	
OS	Ubuntu 16.04 (Linux kernel 5.8.0)
Applied patches	Batching dispatch [1] nvme-tcp optimzations [2–4]
IRQ	`irqbalance` enabled
FIO	Block size=4KB, Direct I/O=on I/O engine=`libaio`, gtod_reduce=off CPU affinity enabled

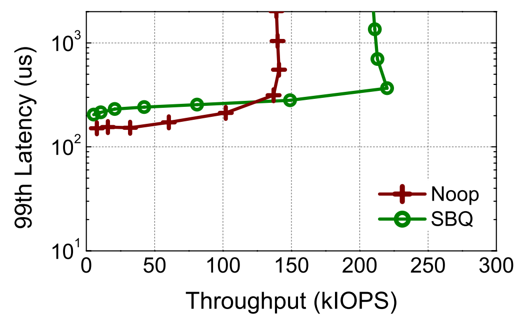
2 Experimental Results

In all experiments, the host-side applications (FIO) access the target-side storage devices (NVMe SSD or RAM block device) over NVMe-over-TCP. We compare our SBQ I/O scheduler with "Noop" I/O scheduler. (An early version of the SBQ idea is described and evaluated in [5].)

Single core performance:

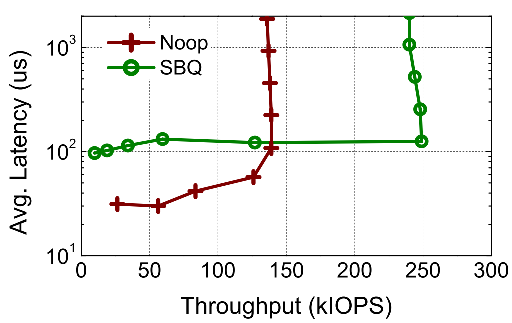


(a) Average Latency

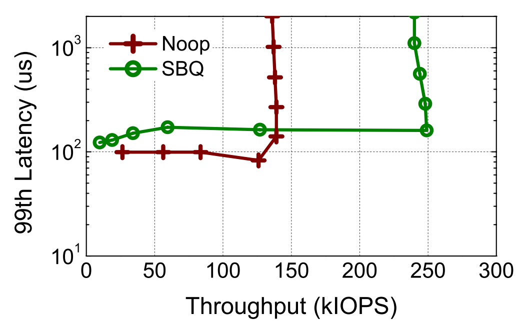


(b) Tail Latency

Figure 1: Target device: NVMe SSD (4KB random read)



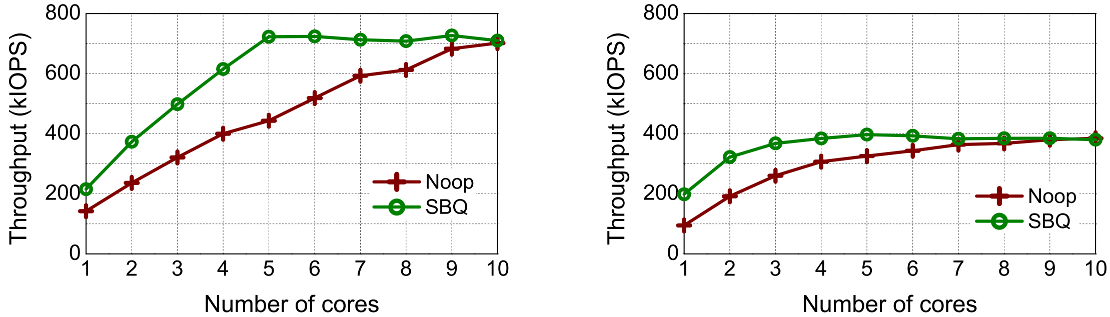
(a) Average Latency



(b) Tail Latency

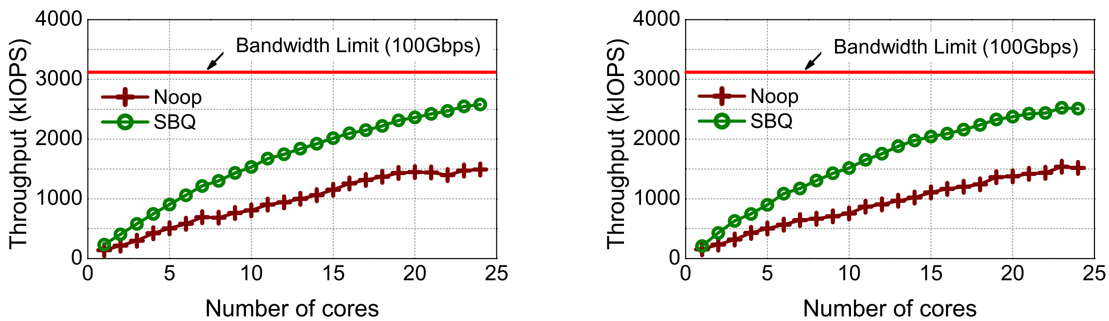
Figure 2: Target device: RAM block device (4KB random read)

Scalability with number of CPU cores:



(a) Random read (b) Random write

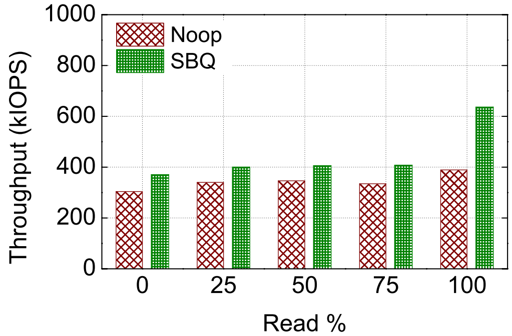
Figure 3: Target device: NVMe SSD (4KB random read/write, I/O depth $= 64$**)**



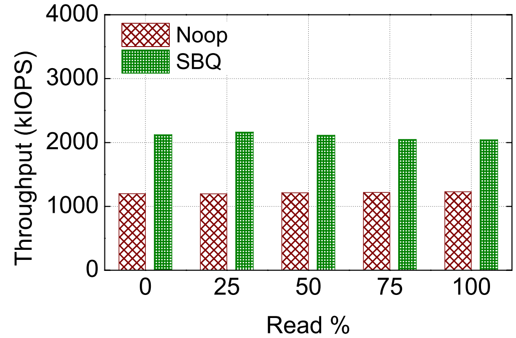
(a) Random read (b) Random write

Figure 4: Target device: RAM block device (4KB random read/write, I/O depth $= 64$**)**

Performance with varying read/write ratios:



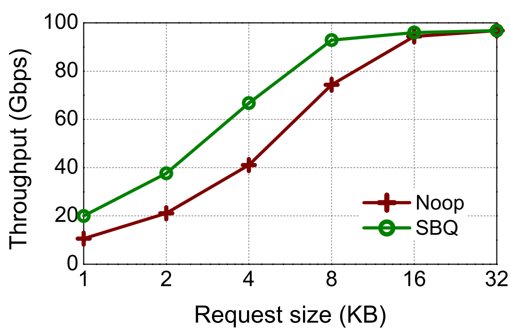
(a) NVMe SSD (4 cores)



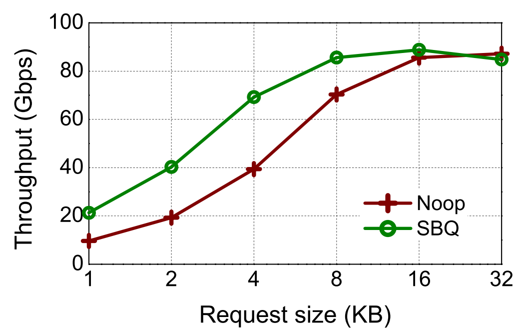
(b) RAM block device (16 cores)

Figure 5: 4KB mixed random read/write (I/O depth $= 64$)

Performance with varying request sizes:



(a) Random read



(b) Random write

Figure 6: Target device: RAM block device (I/O depth $= 64$, 16 cores)

References

[1] https://www.spinics.net/lists/linux-block/msg55860.html.

[2] http://git.infradead.org/nvme.git/commit/122e5b9f3d370ae11e1502d14ff5c7ea9b144a76.

[3] http://git.infradead.org/nvme.git/commit/86f0348ace1510d7ac25124b096fb88a6ab45270.

[4] http://git.infradead.org/nvme.git/commit/15ec928a65e0528ef4999e2947b4802b772f0891.

[5] J. Hwang, Q. Cai, A. Tang, and R. Agarwal. TCP ≈ RDMA: CPU-efficient Remote Storage Access with i10. In *USENIX NSDI*, 2020.