Performance Evaluation of i10 Linux I/O Scheduler

Jaehyun Hwang, Qizhe Cai, Midhul Vuppalapati, Rachit Agarwal
Cornell University

November 12, 2020

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.

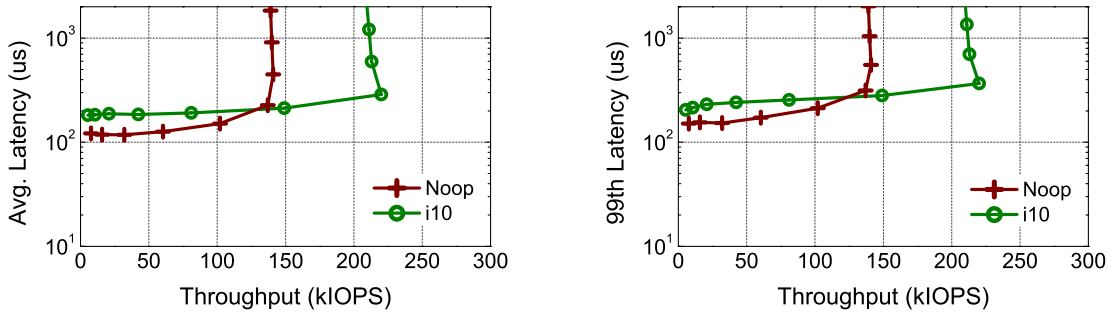
H/W configurations	
CPU	4-socket Intel Xeon Gold 6128 CPU @ 3.4GHz 6 cores per socket, NUMA enabled (4 nodes)
Memory	256GB DRAM
NIC	Mellanox ConnectX-5 Ex VPI (100G) TSO/GRO=on, LRO=off, DIM disabled Jumbo frame enabled (9000B)
NVMe SSD	1.6TB Samsung PM1725a
S/W configurations	
OS	Ubuntu 16.04 (Linux 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

2.1 Remote Storage Access

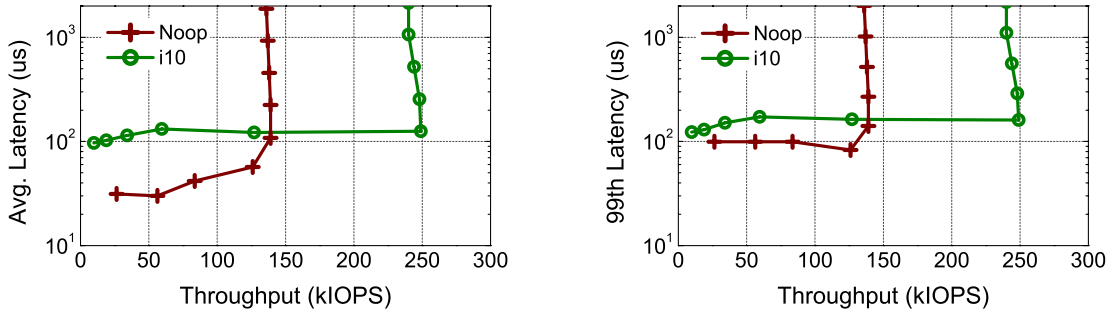
In this subsection, we measure the performance of remote storage access; the host-side applications (FIO) access the target-side storage devices (NVMe SSD or RAM block device) over NVMe-over-TCP. We compare our i10 I/O Scheduler with "Noop" I/O scheduler. We use the default batching thresholds for i10 (i.e., 16 for the number of requests and 50μs for timeout). An early version of the i10 idea is described and evaluated in [5].

Single core performance:



(a) Average Latency (b) Tail Latency

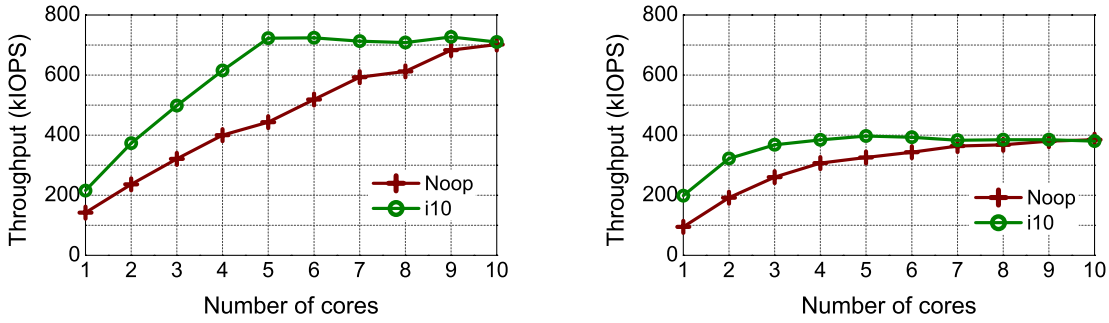
Figure 1: Target device: NVMe SSD (4KB random read)



(a) Average Latency (b) Tail Latency

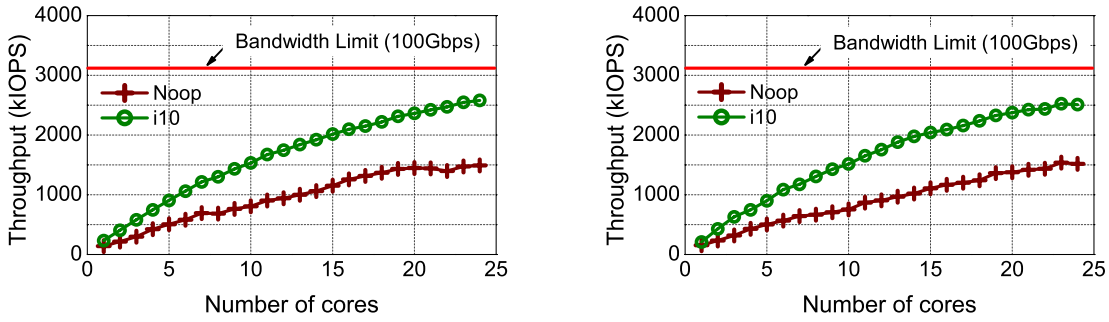
Figure 2: Target device: RAM block device (4KB random read)

Scalability with number of CPU cores:



(a) Random read (b) Random write

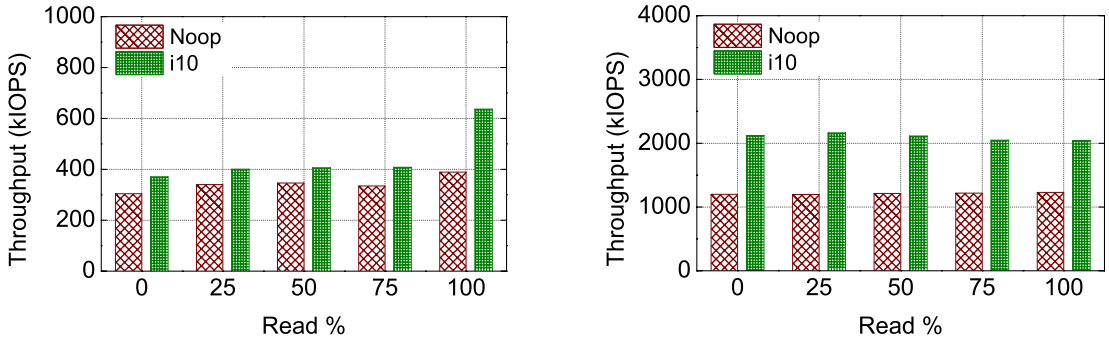
Figure 3: Target device: NVMe SSD (4KB random read/write, I/O depth = 64)



(a) Random read (b) Random write

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

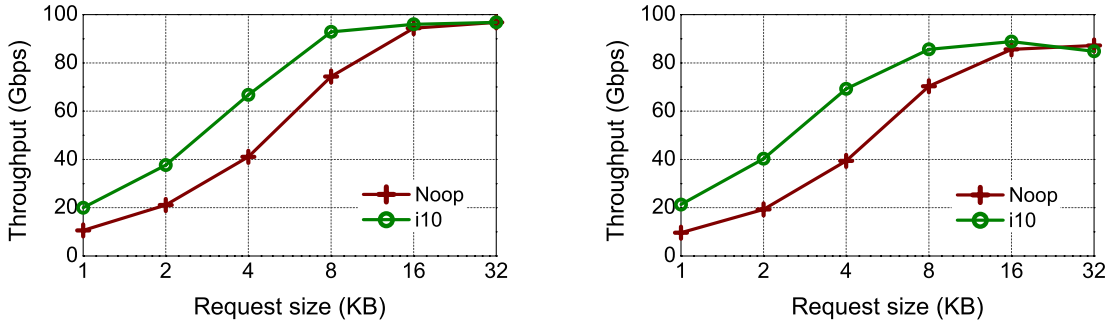
Performance with varying read/write ratios:



(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)

2.2 Local Storage Access

We also measure the i10 performance with a local NVMe SSD to see how it works with a device that does not benefit from batching. We vary the number of requests for batching from 1 to 16. We note that Linux I/O scheduler introduces an additional kernel worker thread at the I/O dispatching stage; thus, with batching size of 1, there will be per-request context switching between "application-context thread" and "I/O dispatching worker thread". This leads to 13% throughput drops compared to the "Noop" scheduler.

Single core performance:

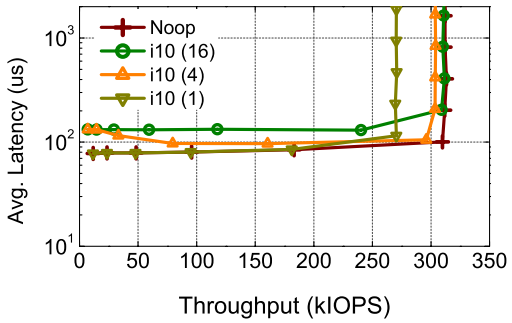


Figure 7: Target device: Local NVMe SSD (4KB random read)

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 $\approx$ RDMA: CPU-efficient Remote Storage Access with i10. In *USENIX NSDI*, 2020.