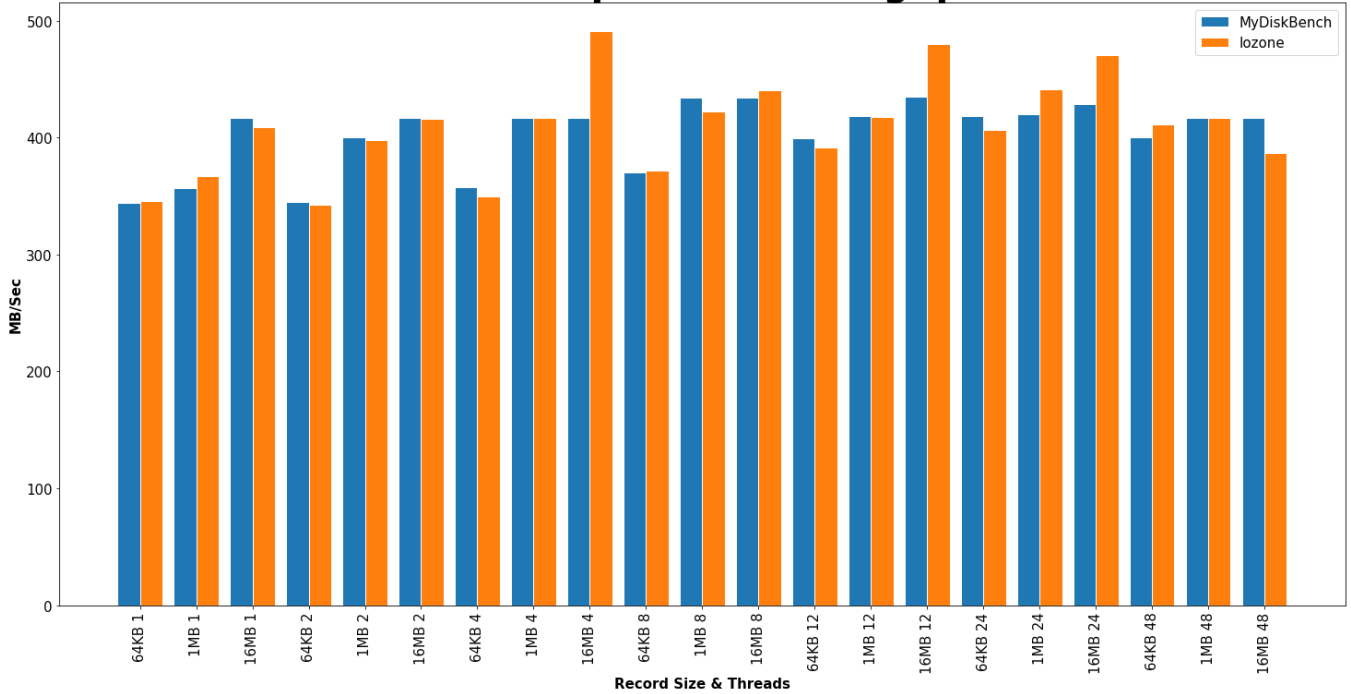# Benchmark Results

Table 1a Write Sequential

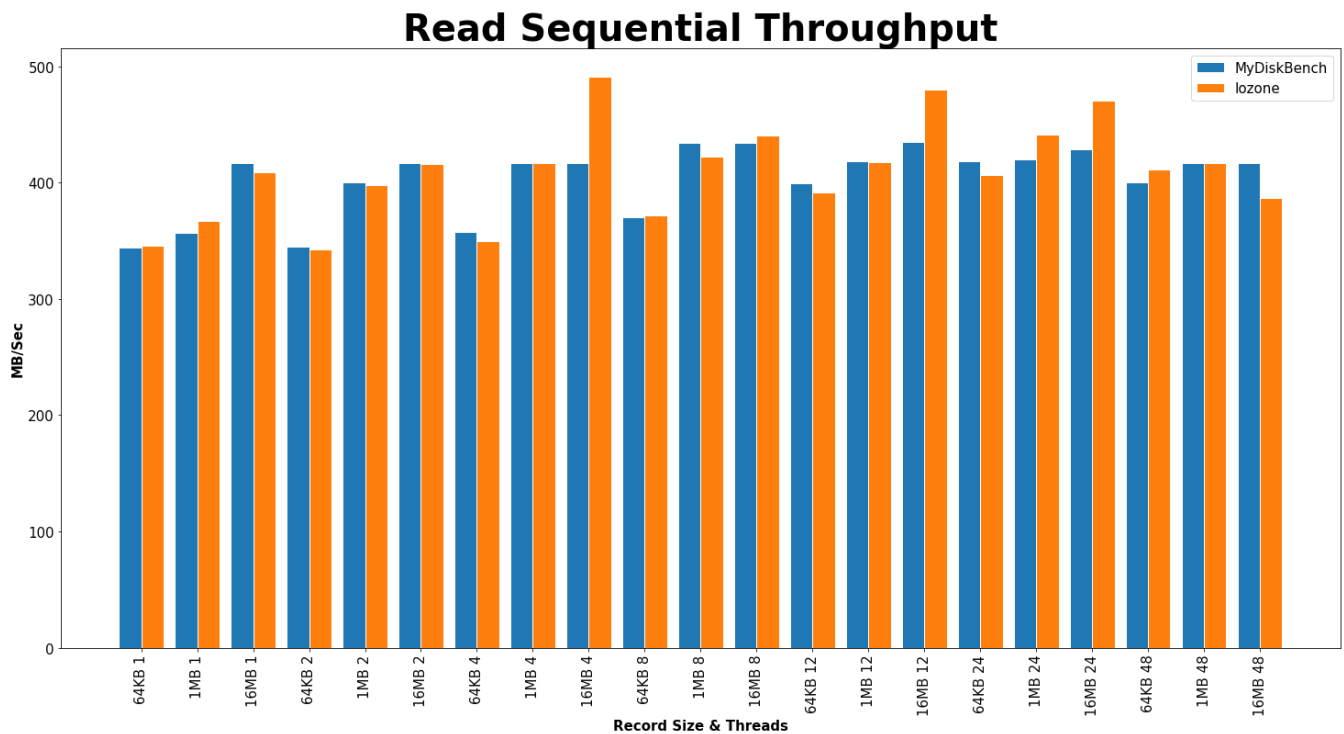| Concurrency	Record size	MyDiskBench Throughput(MB/sec)	IOZone Throughput(MB/sec)	Theoretical Throughput(MB/sec)	MyDiskBench Efficiency(%)	IOZone Efficiency(%)
1	64KB	370.37	367.11	450	82.30	81.58
1	1MB	454.00	471	450	100.89	104.67
1	16MB	454.55	459.92	450	101.01	102.20
2	64KB	454.54	450.66	450	101.01	100.15
2	1MB	454.54	465.65	450	101.01	103.48
2	16MB	454.54	451.8	450	101.01	100.40
4	64KB	476.19	466.109	450	105.82	103.58
4	1MB	476.19	463.54	450	105.82	103.01
4	16MB	474.53	461.51	450	105.45	102.56
8	64KB	476.19	470.31	450	105.82	104.51
8	1MB	474.24	455.24	450	105.39	101.16
8	16MB	473.33	460.71	450	105.18	102.38
12	64KB	475.75	468.84	450	105.72	104.19
12	1MB	481.46	461.56	450	106.99	102.57
12	16MB	471.77	466.95	450	104.84	103.77
24	64KB	478.74	470.61	450	106.39	104.58
24	1MB	479.67	450.43	450	106.59	100.10
24	16MB	469.25	472.89	450	104.28	105.09
48	64KB	390.81	460	450	86.85	102.22
48	1MB	476.37	464.22	450	105.86	103.16

Write Sequential Throughput

Above graph shows the comparison with MyDiskBench and Iozone about write sequential operation. Y-axis denotes speed in MB/sec and X-axis is record size and thread. We can conclude that our results are always similar to that of Iozone.

Table 1b Read Sequential

Concurrency	Record size	MyDiskBench Throughput(MB/sec)	IOZone Throughput(MB/sec)	Theoretical Throughput(MB/sec)	MyDiskBench Efficiency(%)	IOZone Efficiency(%)
1.00	64KB	344.00	346.00	410.00	83.90	84.39
1.00	1MB	357.00	367.00	410.00	87.07	89.51
1.00	16MB	416.67	409.00	410.00	101.63	99.76
2.00	64KB	344.82	342.25	410.00	84.10	83.48
2.00	1MB	400.00	397.50	410.00	97.56	96.95
2.00	16MB	416.66	416.16	410.00	101.62	101.50
4.00	64KB	357.14	349.86	410.00	87.11	85.33
4.00	1MB	416.67	416.36	410.00	101.63	101.55
4.00	16MB	416.67	490.78	410.00	101.63	119.70

8.00	64KB	370.37	371.87	410.00	90.33	90.70
8.00	1MB	434.38	422.56	410.00	105.95	103.06
8.00	16MB	433.92	440.65	410.00	105.83	107.48
12.00	64KB	399.03	391.24	410.00	97.32	95.42
12.00	1MB	418.00	417.34	410.00	101.95	101.79
12.00	16MB	435.01	480.09	410.00	106.10	117.10
24.00	64KB	418.58	406.34	410.00	102.09	99.11
24.00	1MB	420.03	440.89	410.00	102.45	107.53
24.00	16MB	428.78	470.56	410.00	104.58	114.77
48.00	64KB	400.00	411.21	410.00	97.56	100.29
48.00	1MB	416.66	416.41	410.00	101.62	101.56
48.00	16MB	416.67	386.39	410.00	101.63	94.24

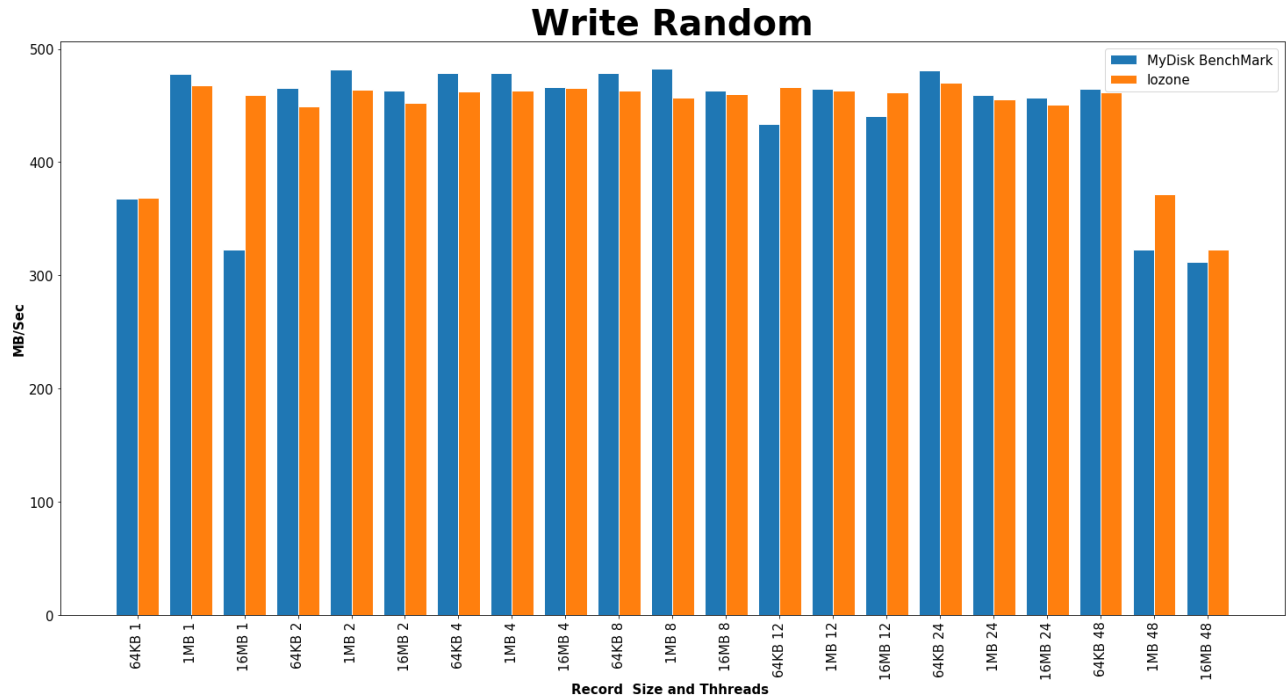

Read Sequential Throughput

Above graph shows the comparison with MyDiskBench and Iozone about read sequential operation. Y-axis denotes speed in MB/sec and X-axis is record size and thread. We can conclude that our results are always similar to that of Iozone.

Table 1c Write Random

| Concurrency	Record size	MyDiskBench Throughput(MB/sec)	IOZone Throughput(MB/sec)	Theoretical Throughput(MB/sec)	MyDiskBench Efficiency(%)	IOZone Efficiency(%)
1.00	64KB	367.62	368.23	450.00	81.69	81.83
1.00	1MB	478.07	461.00	450.00	106.24	102.44
1.00	16MB	322.58	459.23	450.00	71.68	102.05
2.00	64KB	465.12	310.00	450.00	103.36	68.89
2.00	1MB	481.81	463.60	450.00	107.07	103.02
2.00	16MB	463.23	452.35	450.00	102.94	100.52
4.00	64KB	478.35	353.77	450.00	106.30	78.62
4.00	1MB	478.68	419.20	450.00	106.37	93.16
4.00	16MB	466.15	474.66	450.00	103.59	105.48
8.00	64KB	478.97	400.87	450.00	106.44	89.08
8.00	1MB	482.31	436.11	450.00	107.18	96.91
8.00	16MB	463.48	439.22	450.00	103.00	97.60
12.00	64KB	479.99	412.12	450.00	106.66	91.58
12.00	1MB	480.69	415.43	450.00	106.82	92.32
12.00	16MB	495.71	450.25	450.00	110.16	100.06
24.00	64KB	478.78	470.08	450.00	106.40	104.46
24.00	1MB	488.61	414.65	450.00	108.58	92.14
24.00	16MB	555.94	410.67	450.00	123.54	91.26
48.00	64KB	188.68	461.94	450.00	41.93	102.65
48.00	1MB	486.74	371.20	450.00	108.16	82.49
48.00	16MB	601.96	323.00	450.00	133.77	71.78

Plot

Write Random

Above graph shows the comparison with MyDiskBench and Iozone about write random operation. Y-axis denotes speed in MB/sec and X-axis is record size and thread. We can conclude that our results mostly outperform Iozone.

Table 1d Read Random

Concurrency	Record size	MyDiskBench Throughput(MB/sec)	IOZone Throughput(MB/sec)	Theoretical Throughput(MB/sec)	MyDiskBench Efficiency(%)	IOZone Efficiency(%)
1.00	64KB	344.82	243.06	410.00	84.10	59.28
1.00	1MB	357.14	335.00	410.00	87.11	81.71
1.00	16MB	416.66	405.23	410.00	101.62	98.84
2.00	64KB	344.83	323.00	410.00	84.10	78.78
2.00	1MB	400.00	399.10	410.00	97.56	97.34
2.00	16MB	416.66	419.48	410.00	101.62	102.31
4.00	64KB	357.14	412.86	410.00	87.11	100.70

|						
4.00	1MB	416.67	430.72	410.00	101.63	105.05
4.00	16MB	416.67	425.35	410.00	101.63	103.74
8.00	64KB	384.00	309.55	410.00	93.66	75.50
8.00	1MB	437.79	457.89	410.00	106.78	111.68
8.00	16MB	431.23	450.45	410.00	105.18	109.87
12.00	64KB	399.67	446.64	410.00	97.48	108.94
12.00	1MB	422.64	470.87	410.00	103.08	114.85
12.00	16MB	427.10	456.65	410.00	104.17	111.38
24.00	64KB	418.42	440.48	410.00	102.05	107.43
24.00	1MB	418.58	465.04	410.00	102.09	113.42
24.00	16MB	429.65	467.93	410.00	104.79	114.13
48.00	64KB	400.00	408.55	410.00	97.56	99.65
48.00	1MB	416.67	418.07	410.00	101.63	101.97
48.00	16MB	416.67	385.00	410.00	101.63	93.90

Read Random Throughput
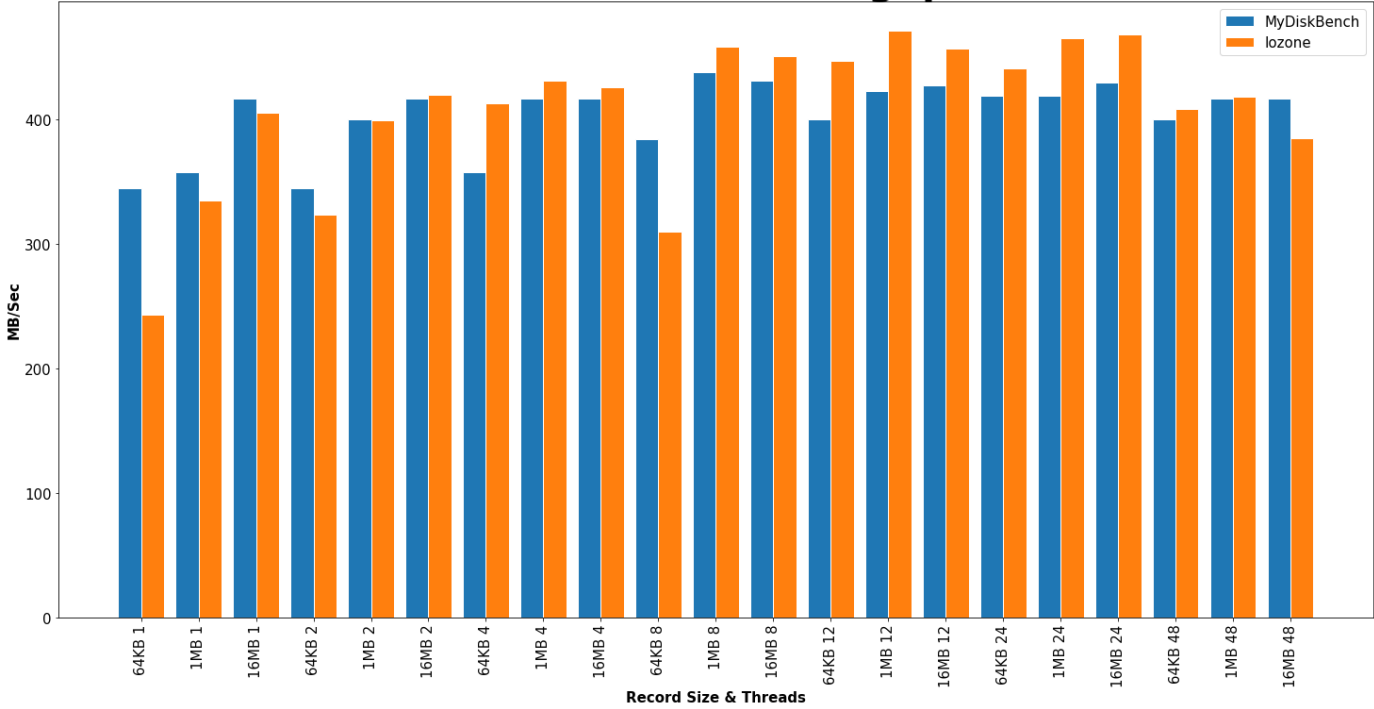
Above graph shows the comparison with MyDiskBench and Iozone about read random operation. Y-axis denotes speed in MB/sec and X-axis is record size and thread. We can conclude that our results are always similar to that of Iozone.

Table 2a Write Random IOPS

Workload	Concurrency	Record Size	MyDiskBench IOPS	IOZone Measured IOPS	Theoretica IOPS	MyDiskBench Effeciency (%)	IOZone Effeciency (%)
10.00	1.00	4096.00	23808.00	23376.81	10000.00	238.08	233.77
10.00	2.00	4096.00	43064.00	44345.00	10000.00	430.64	443.45
10.00	4.00	4096.00	56278.53	56850.92	10000.00	562.79	568.51
10.00	8.00	4096.00	69044.48	67232.50	10000.00	690.44	672.33
10.00	12.00	4096.00	69011.97	48330.16	10000.00	690.12	483.30
10.00	24.00	4096.00	69120.00	65770.79	10000.00	691.20	657.71
10.00	48.00	4096.00	69222.00	66282.32	10000.00	692.22	662.82

Write Random IOPS

Record Size 4KB. Workload 10GB
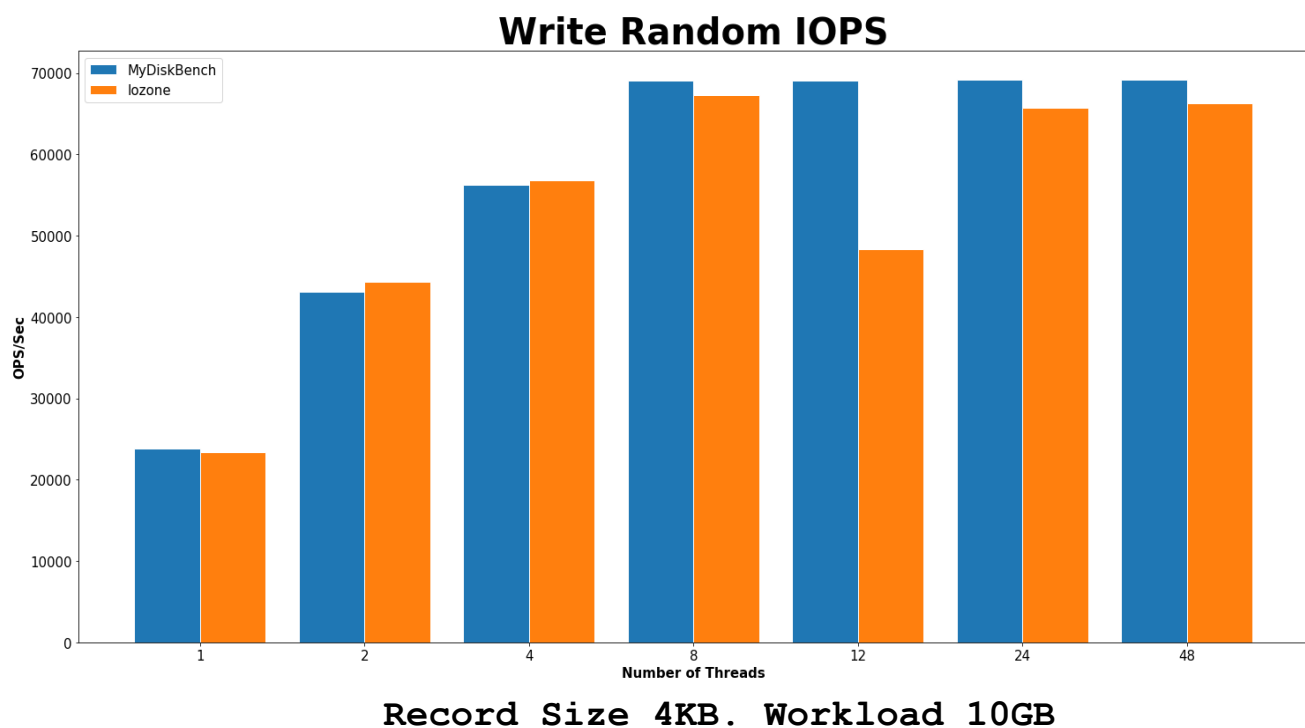
This figure shows the mean of different operations. Until 4th thread performance increases and it is nearly stagnant afterwards.

## Table 2b Read Random IOPS

| Workload	Concurrency	Record Size	MyDiskBench IOPS	IOZone Measured IOPS	Theoretica IOPS	MyDiskBench Effeciency (%)	IOZone Effeciency (%)
10.00	1.00	4096.00	27392.00	8518.00	90000.00	30.44	9.46
10.00	2.00	4096.00	49152.00	16190.00	90000.00	54.61	17.99
10.00	4.00	4096.00	33792.00	29513.60	90000.00	37.55	32.79
10.00	8.00	4096.00	53504.00	50300.50	90000.00	59.45	55.89
10.00	12.00	4096.00	69376.00	57301.00	90000.00	77.08	63.67
10.00	24.00	4096.00	73984.00	65803.38	90000.00	82.20	73.11
10.00	48.00	4096.00	85760.00	81441.30	90000.00	95.29	90.49

Read Random IOPS

Record Size 4KB
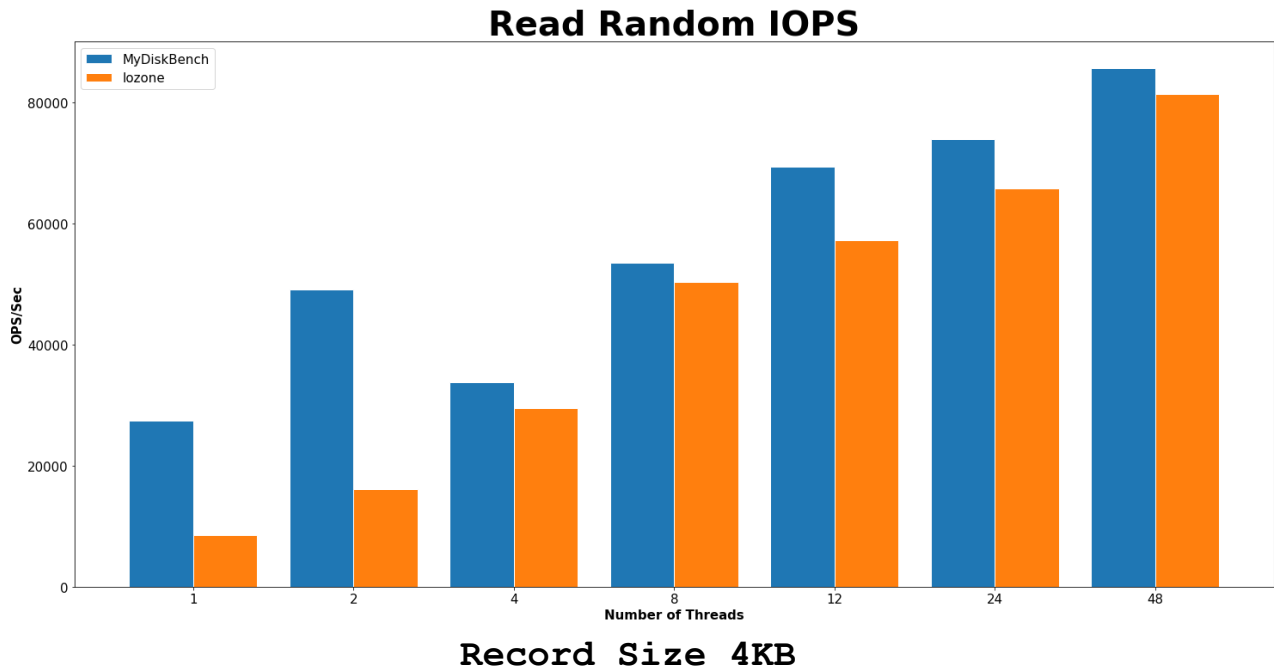
From this plot it is clear that with increase in thread the performance of read random increases.

Additional Plots

Benchmark Plot (Mean)
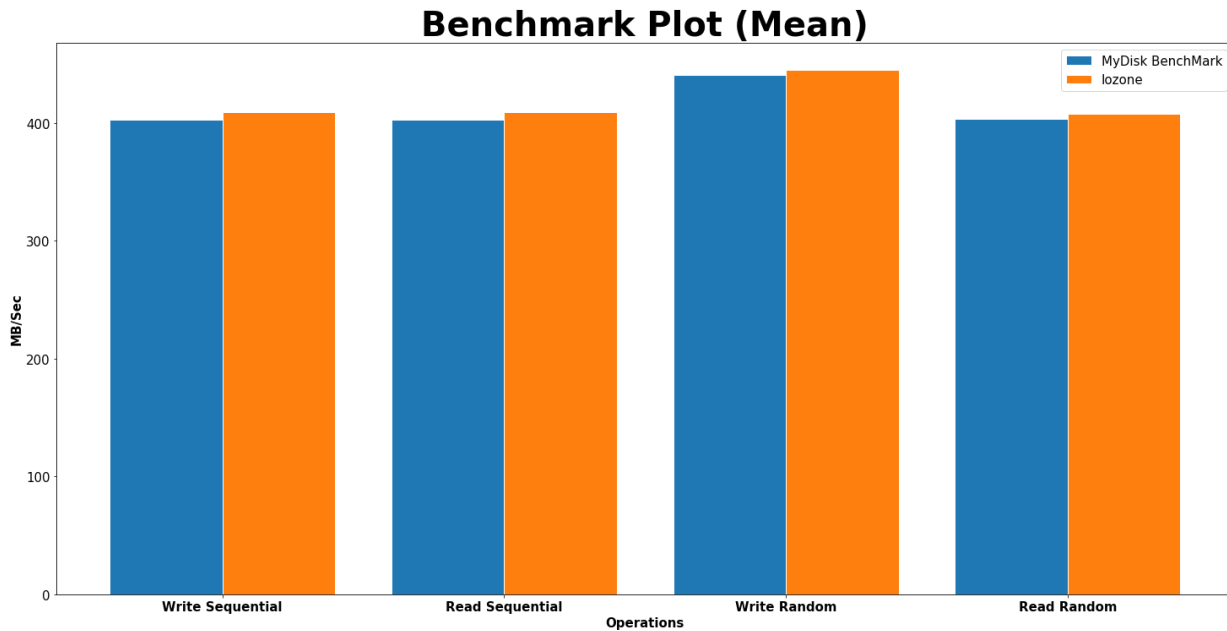
After running multiple test we can conclude that the mean of all the readings in all the categories for MyDiskBench in quite similar to that of Iozone.

Benchmark Plot (Standard Deviation)
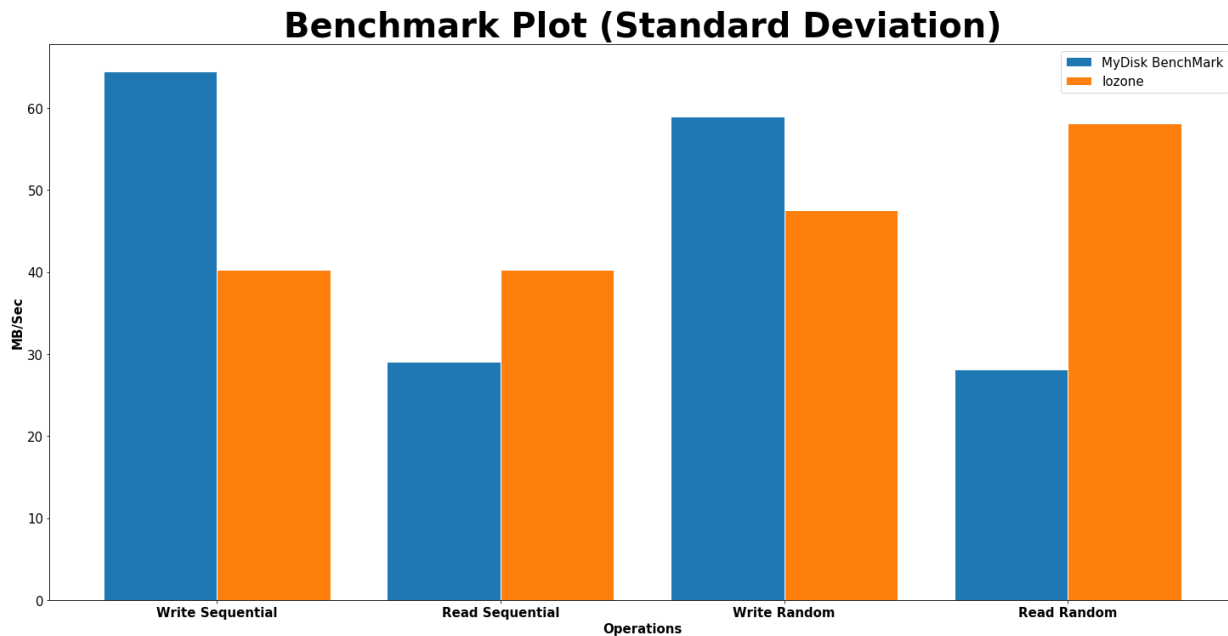
After running multiple test we can conclude that varying standard deviation states that performance of MyDiskBench is varying as compared to Iozone. In write operations MyDiskBench has higher standard deviation than that of Iozone. However, in case of read operations we are more consistent as compared to Iozone.

Theoretical Values

Technical specifications

Specifications

PM863a		MZ7LM240HMHQ	MZ7LM480HMHQ	MZ7LM960HMJP	MZ7LM1T9HMJP	MZ7LM3T8HMLP
Capacity[1]		240 GB	480 GB	960 GB	1,920 GB	3,840 GB
Performance[2]	Seq. read (128 KB)	330 MB/s	520 MB/s	520 MB/s	520 MB/s	520 MB/s
	Seq. write (128 KB)	300 MB/s	480 MB/s	480 MB/s	480 MB/s	480 MB/s
	Rand. read (4KB, QD32)	86K IOPS	97K IOPS	97K IOPS	97K IOPS	97K IOPS
	Rand. write (4KB, QD32)	9K IOPS	16K IOPS	24K IOPS	24K IOPS	24K IOPS
Average power consumption[3] (3,840 GB)		Active Read (Typ.) 3 W, Active Write (Typ.) 4 W, Idle 1.3 W				
TBW (Terabytes written)[4]		341 TB	683 TB	1,366 TB	2,733 TB	5,466 TB
DWPD[5]		1.3 (3 Years)				

SM863a		MZ7KM240HMHQ	MZ7KM480HMHQ	MZ7KM960HMJP	MZ7KM1T9HMJP
Capacity[1]		240 GB	480 GB	960 GB	1,920 GB
Performance[2]	Seq. read (128 KB)	410 MB/s	510 MB/s	510 MB/s	510 MB/s
	Seq. write (128 KB)	450 MB/s	485 MB/s	485 MB/s	485 MB/s
	Rand. read (4KB, QD32)	90K IOPS	95K IOPS	95K IOPS	95K IOPS
	Rand. write (4KB, QD32)	10K IOPS	19K IOPS	25K IOPS	28K IOPS
Average power consumption[3] (1,920 GB)		Active Read (Typ.) 2.5 W, Active Write (Typ.) 3 W, Idle 1.4 W			
TBW (Terabytes written)[4]		1,540 TB	3,080 TB	6,160 TB	12,320 TB
DWPD[5]		3.6 (5 Years)			

Common features		
	Form factor	2.5 inch 7mmT
	Interface	SATA 6.0 Gbps
	Dimension (WxDxH)	Max. 100.2 x 69.85 x 6.8 (mm)
	Weight	Max. 55 g (PM863a) / Max. 60 g (SM863a)
	NAND type	Samsung V-NAND
	Encryption support	AES 256-bit Encryption Engine
	Allowable voltage	5.0 V ± 5%
	MTBF[6]	2,000,000 hours
	UBER[7]	1 sector per 10¹⁷ bits read
	Operating temperature	0 - 70°C
	Shock	1500 G, duration 0.5 ms, Half Sine Wave

1. 1 GB = 1 Billion bytes by IDEMA. Actual usable capacity may be less (due to formatting, partitioning, operating system, applications or otherwise).
2. Actual performance may vary depending on use conditions and environment.
   1) Performance measured using IOMeter 2006 with queue depth 32, C216 Intel® SATA 6G port.
   2) Measurements are performed on whole LBA range.
   3) Write cache enabled.
   4) 1 MB/sec = 1,048,576 bytes/sec was used in sequential performance.
3. Actual power consumption may vary depending on system hardware & configuration. Active write power is measured on 128 KB sequential write and active read power is measured on 4 KB random read.

4. TBW is measured while running 100 % random 4 KB writes across the entire SSD. (TBW = DWPD x 365 x 3 x User capacity).
5. Drive Write Per Day (DWPD)
6. MTBF is Mean Time Between Failure. As same word, annual failure ratio is 0.438%.
7. Uncorrectable Bit Error Rate (UBER) is a metric for the rate of occurrence of data errors, equal to the number of data errors per bits read as specified in the JESD218 document of JEDEC standard. For the enterprise application, JEDEC recommends that UBER shall be below 10-16.

Sequential read (128kB record size): 410 MB/sec
Sequential write (128kB record size): 450 MB/sec
Random read (4kB record size, 32 threads): 90K IOPS
Random write(4kB record size, 32 threads): 10K IOPS

Above mentioned values are based on IO meter reading as mentioned by manufacturer.

Contribution:

CODING	CONTRIBUTORS
Write Sequential	Varun Shanbhag, Tushar Nitave
Read Sequential	Talwinder Singh
Write Random	Varun Shanbhag
Read Random	Talwinder Singh, Varun Shanbhag
BENCHMARKING	
Iozone	Tushar
MydiskBenchMark	Talwinder
REPORT	Talwinder Singh, Varun Shanbhag, Tushar Nitave
GRAPHS	Varun Shanbhag

Execution Environment

Chameleon Cloud
Node type: Compute Skylake
Operating System: Ubuntu 18.04
Storage System: Samsung SATA MZ7KM240HMHQ0D3
RAM Size: 192 GiB