This assignment aims at benchmarking of disk.
The experiments are performed on Chameleon Cloud using bare metal instances having following configuration

```
cc@team-22-instance:~$ sudo fdisk -l
Disk /dev/sda: 232.9 GiB, 250059350016 bytes, 488397168 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x1aa5aa6f

Device     Boot Start       End   Sectors   Size Id Type
/dev/sda1  *     2048 488397134 488395087 232.9G 83 Linux
```

Disk for the cloud configured is SATA ST9250610NS (250GB).

Program Design:

All programs are written in C language. Bash scripts are created to run all possible combinations of the parameters together saving the time to run commands individually for every experiment.

Disk Benchmark:
Disk benchmark is performed to measure the disk speed in terms of throughput and latency. Speed is measured using different types of operations such as read sequential and read random , write sequential and write random with varying block sizes (64KB, 1MB, 16MB) and varying level of concurrency (1 thread, 2 threads, 4 threads, 8 threads, 12 threads , 24 threads and 48 threads). Throughput is measured in MB/sec. Theoretical performance (theoretical throughput, theoretical IOPS) is also calculated for disk assigned to bare metal instance on chameleon cloud. Results from MyDiskBenchmark and IOZone benchmark are compared with theoretical performance to measure efficiency of both MyDiskBenchmark and IOZone benchmark.

We found theoretical throughput from Datasheet on manufacturer website
https://www.seagate.com/www-content/product-content/enterprise-hdd-fam/enterprise-capacity-2-5-hdd/en-us/docs/constellation2-fips-ds1719-4a-1605us.pdf
For Disk ST9250610NS ,

Constellation.2™

SEAGATE

Design Small and Deliver BIG—2.5-Inch, Eco-Friendly Nearline Drive

Specifications	6Gb/s SAS		SATA 6Gb/s		
	1TB[1]	500GB[1]	1TB[1]	500GB[1]	250GB[1]
Standard Model Number	ST91000640SS	ST9500620SS	ST91000640NS	ST9500620NS	ST9250610NS
Features					
Protection Information	Yes	Yes	—	—	—
Low Halogen	Yes	Yes	Yes	Yes	Yes
Reliability/Data Integrity					
Mean Time Between Failures (MTBF, hours)	1.4 million	1.4 million	1.4 million	1.4 million	1.4 million
Reliability Rating @ Full 24x7 Operation (AFR)	0.62%	0.62%	0.62%	0.62%	0.62%
Nonrecoverable Read Errors per Bits Read	1 sector per 10E15	1 sector per 10E15	1 sector per 10E15	1 sector per 10E15	1 sector per 10E15
Power-On Hours per Year	8760	8760	8760	8760	8760
Bytes per Sector	512, 520, 528	512, 520, 528	512	512	512
Limited Warranty (years) [2]	5	5	5	5	5
Performance					
Spindle Speed (RPM)	7200	7200	7200	7200	7200
Cache, Multisegmented (MB)	64	64	64	64	64
Interface Access Speed (Gb/s)	6.0, 3.0, 1.5	6.0, 3.0, 1.5	6.0, 3.0, 1.5	6.0, 3.0, 1.5	6.0, 3.0, 1.5
Max. Sustained Transfer Rate (MB/s)	115	115	115	115	115
Seek Time, Average Read/Write (ms)	8.5/9.5	8.5/9.5	8.5/9.5	8.5/9.5	8.5/9.5
Average Latency (ms)	4.16	4.16	4.16	4.16	4.16
Interface Ports	Dual	Dual	Single	Single	Single
RV Tolerance (rad/s² to 1800Hz)	16	16	16	16	16
Power Management					
Idle Power (W)	3.85	3.27	3.31	2.67	2.52
Typical Operating, Random Read (W)	6.4	5.6	5.21	4.51	4.35
Power Supply Requirements	+12V and +5V	+12V and +5V	+12V and +5V	+12V and +5V	+12V and +5V

Theoretical Throughput:
We have taken theoretical throughput from above sheet as : **115MBps**

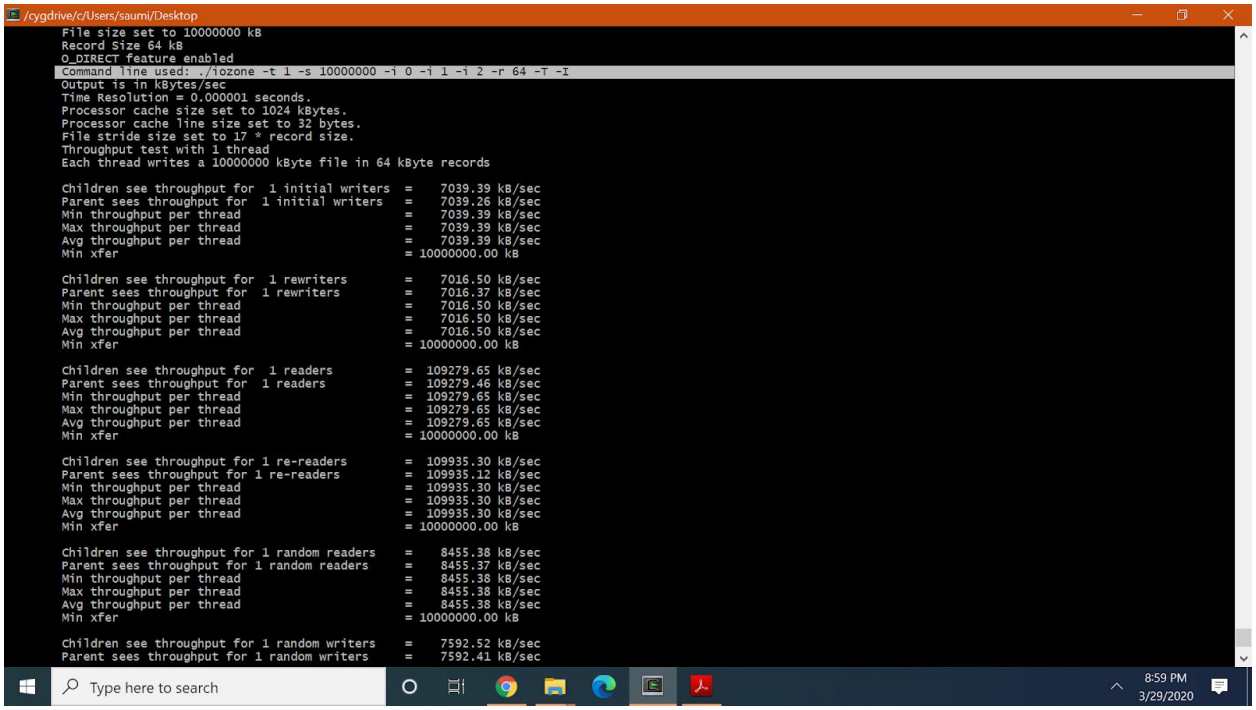
Theoretical IOPS:
IO size x IOPS = Throughput
4KB x IOPS = 115MBps
IOPS=28750

Running MyDiskBenchmark :

gcc -o myDiskBenchmark MyDiskBenchmark.c -lpthread
./myDiskBenchmark WS 1 16MB 10GB

```
cc@team-22-instance:~/hw3/disk$ ./myDiskBenchmark WS 1 16MB 10GB
Throughput is:  40.750471MBps
```

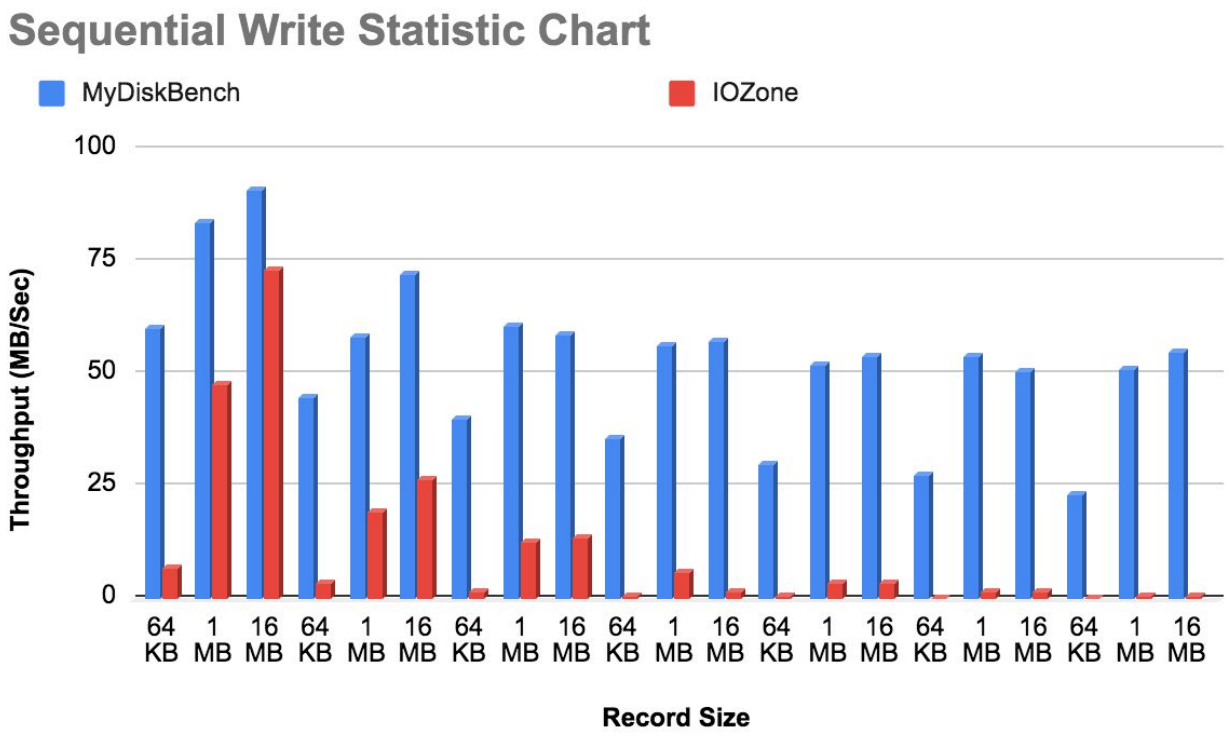
Running IOZone Benchmark:
./iozone -t 1 -s 10000000 -i 0 -i 1 -i 2 -r 64 -T -I



Sequential Write Statistic Table:-

Workload	Concurrency	Record Size	MyDiskBench Measured Throughput (MB/sec)	IOZone Measured Throughput (MB/sec)	Theoretical Throughput (MB/sec)	MyDiskBench Efficiency (%)	IOZone Efficiency (%)
WS	1	64 KB	60.162	7.039	115	52.31478261	6.120869565
WS	1	1 MB	83.74	47.71	115	72.8173913	41.48695652
WS	1	16 MB	91.09	73.029	115	79.20869565	63.50347826
WS	2	64 KB	45.12	3.492	115	39.23478261	3.036521739
WS	2	1 MB	58.45	19.396	115	50.82608696	16.86608696
WS	2	16 MB	72.1	26.77	115	62.69565217	23.27826087
WS	4	64 KB	40.165	1.7175	115	34.92608696	1.493478261
WS	4	1 MB	60.94	12.69404	115	52.99130435	11.03829565

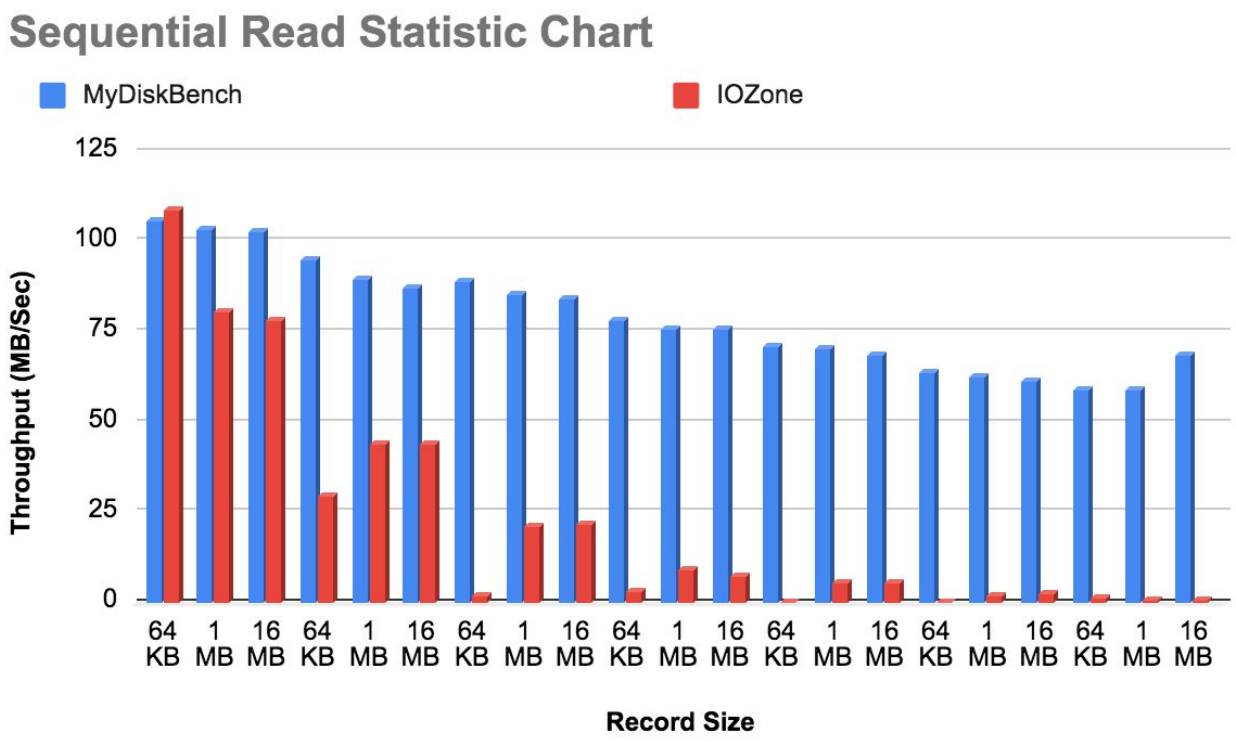
WS	4	16 MB	58.75	13.7133	115	51.08695652	11.9246087
WS	8	64 KB	35.812	0.6139	115	31.14086957	0.53382608 7
WS	8	1 MB	56.35	5.83038	115	49	5.06989565 2
WS	8	16 MB	57.15	1.85573	115	49.69565217	1.61367826 1
WS	12	64 KB	30.1567	0.568	115	26.22321739	0.49391304 35
WS	12	1 MB	51.92	3.717	115	45.14782609	3.23217391 3
WS	12	16 MB	53.99	3.817	115	46.94782609	3.31913043 5
WS	24	64 KB	27.523	0.256	115	23.93304348	0.22260869 57
WS	24	1 MB	53.92	1.728	115	46.88695652	1.50260869 6
WS	24	16 MB	50.66	1.657	115	44.05217391	1.44086956 5
WS	48	64 KB	23.456	0.146	115	20.39652174	0.12695652 17
WS	48	1 MB	51.04	0.926	115	44.3826087	0.80521739 13
WS	48	16 MB	54.87	0.574	115	47.71304348	0.49913043 48



Sequential Read Statistic Table:

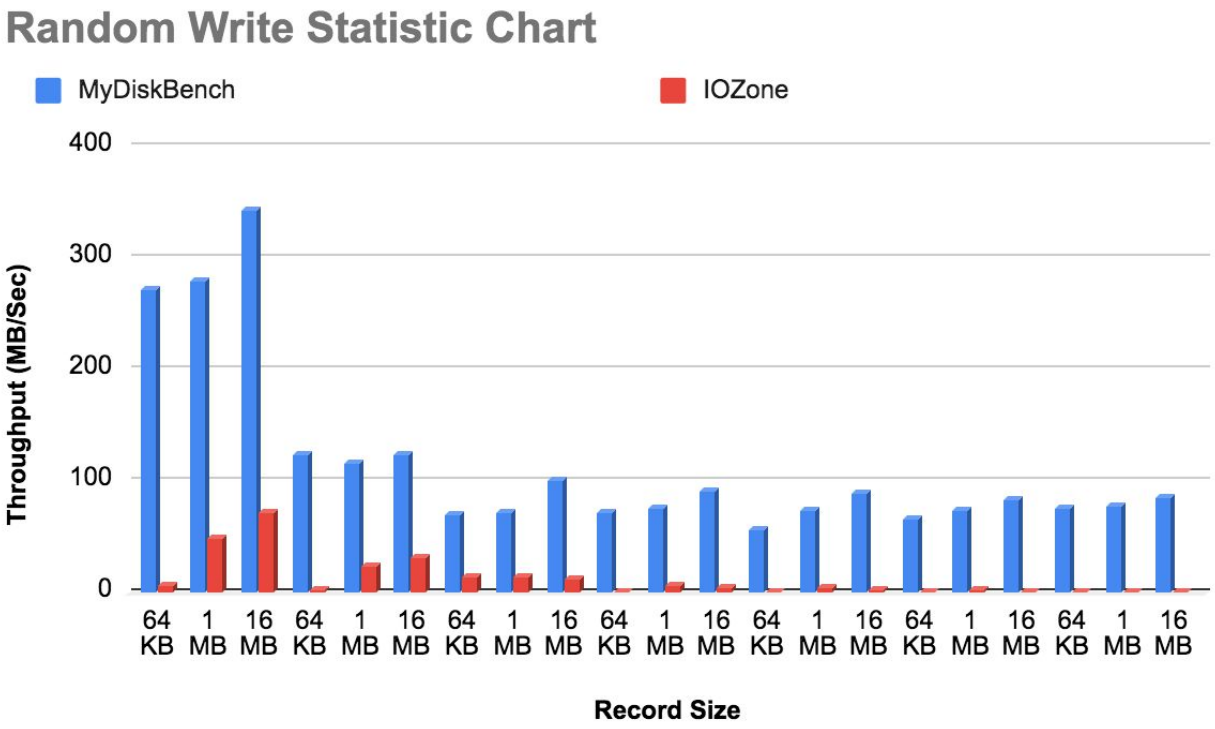
Workload	Concurrency	Record Size	MyDiskBench Measured Throughput (MB/sec)	IOZone Measured Throughput (MB/sec)	Theoretical Throughput (MB/sec)	MyDiskBench Efficiency (%)	IOZone Efficiency (%)
RS	1	64 KB	106.22	109.2	115	92.36521739	94.95652174
RS	1	1 MB	103.47	80.56	115	89.97391304	70.05217391
RS	1	16 MB	102.72	78.472	115	89.32173913	68.23652174
RS	2	64 KB	95.37	29.84	115	82.93043478	25.94782609
RS	2	1 MB	89.62	44.3231	115	77.93043478	38.54182609
RS	2	16 MB	87.53	44.09	115	76.11304348	38.33913043
RS	4	64 KB	88.991	2.016954	115	77.38347826	1.753873043
RS	4	1 MB	85.7	21.42594	115	74.52173913	18.63125217
RS	4	16 MB	84.06	21.97135	115	73.09565217	19.10552174
RS	8	64 KB	78.53	2.99077	115	68.28695652	2.600669565
RS	8	1 MB	76.16	9.03	115	66.22608696	7.852173913
RS	8	16 MB	75.71	7.68052	115	65.83478261	6.678713043

RS	12	64 KB	71.1625	0.424	115	61.88043478	0.3686956522
RS	12	1 MB	70.63	5.673	115	61.4173913	4.933043478
RS	12	16 MB	68.83	5.826	115	59.85217391	5.066086957
RS	24	64 KB	63.887	0.1789	115	55.55391304	0.1555652174
RS	24	1 MB	62.49	2.339	115	54.33913043	2.033913043
RS	24	16 MB	61.76	2.405	115	53.70434783	2.091304348
RS	48	64 KB	59.139	1.198	115	51.42521739	1.04173913
RS	48	1 MB	58.82	0.953	115	51.14782609	0.8286956522
RS	48	16 MB	68.89	0.903	115	59.90434783	0.7852173913



Random Write Statistic Table:

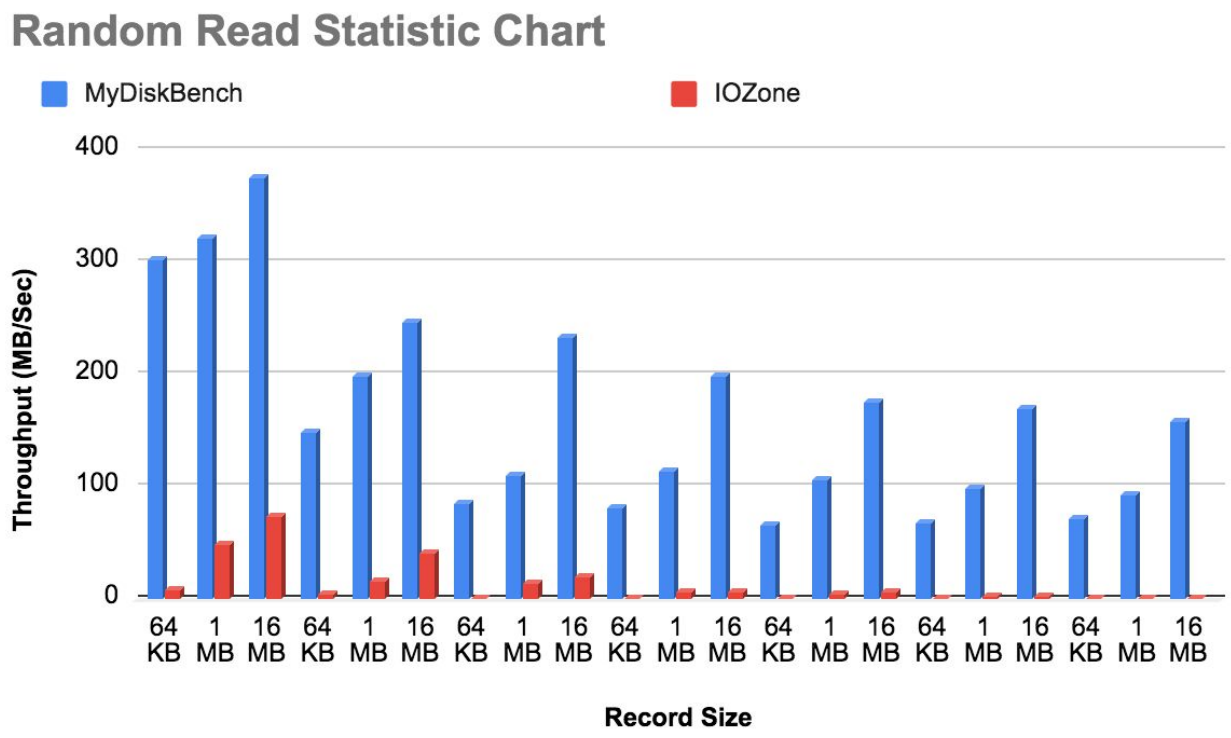
Concurrency	Record Size	MyDiskBench Measured Throughput (MB/sec)	IOZone Measured Throughput (MB/sec)	Theoretical Throughput (MB/sec)	MyDiskBench Efficiency (%)	IOZone Efficiency (%)
1	64 KB	272.7399	7.59	115	237.1651304	6.6
1	1 MB	279.195206	48.72	115	242.77844	42.36521739
1	16 MB	342.895494	72.016	115	298.1699948	62.6226087
2	64 KB	123.8478	2.955	115	107.6937391	2.569565217
2	1 MB	115.242116	23.29732	115	100.2105357	20.25853913
2	16 MB	124.795727	30.75	115	108.5180235	26.73913043
4	64 KB	70.1367	13.5627	115	60.98843478	11.79365217
4	1 MB	71.586507	14.1406	115	62.24913652	12.29617391
4	16 MB	100.03679	12.67245	115	86.98851304	11.01952174
8	64 KB	71.0635	1.24456	115	61.79434783	1.082226087
8	1 MB	75.71454	6.82053	115	65.83873043	5.930895652
8	16 MB	91.838588	5.18507	115	79.85964174	4.508756522
12	64 KB	56.3034	0.833	115	48.95947826	0.7243478261
12	1 MB	74.340225	4.256	115	64.64367391	3.700869565
12	16 MB	89.563545	3.662	115	77.88134348	3.184347826
24	64 KB	66.5217	0.482	115	57.84495652	0.4191304348
24	1 MB	74.649628	1.962	115	64.91272	1.706086957
24	16 MB	83.811998	1.57	115	72.87999826	1.365217391
48	64 KB	74.9205	0.288	115	65.14826087	0.2504347826
48	1 MB	77.363333	0.848	115	67.27246348	0.7373913043
48	16 MB	85.985244	0.573	115	74.76977739	0.4982608696



Random Read Statistic Table:

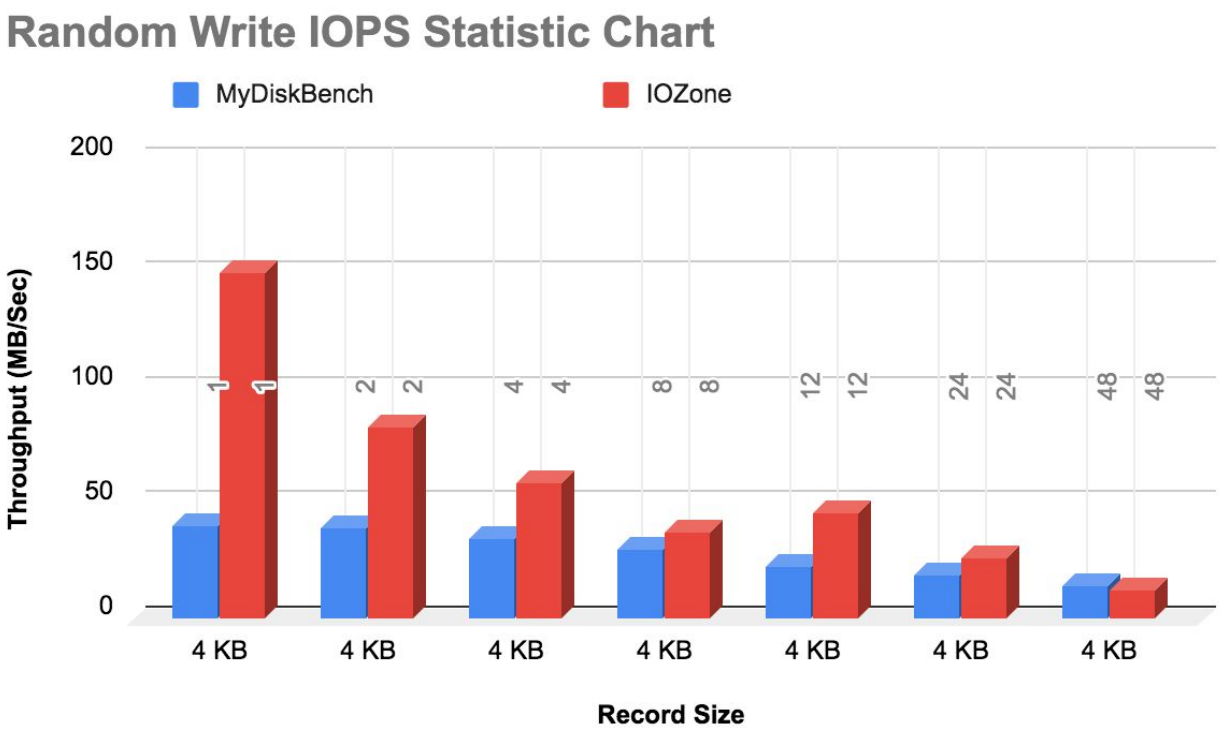
Workload	Concurrency	Record Size	MyDiskBench Measured Throughput (MB/sec)	IOZone Measured Throughput (MB/sec)	Theoretical Throughput (MB/sec)	MyDiskBench Efficiency (%)	IOZone Efficiency (%)
RR	1	64 KB	301.8806	8.45	115	262.5048696	7.347826087
RR	1	1 MB	321.853145	49.24	115	279.8723	42.8173913
RR	1	16 MB	374.831468	73.95	115	325.940407	64.30434783
RR	2	64 KB	148.8788	3.905	115	129.4598261	3.395652174
RR	2	1 MB	198.780926	15.512	115	172.8529791	13.48869565
RR	2	16 MB	247.173342	41.48	115	214.9333409	36.06956522
RR	4	64 KB	85.0955	1.28266	115	73.99608696	1.115356522
RR	4	1 MB	109.702736	14.19587	115	95.39368348	12.3442347

							8
RR	4	16 MB	233.899703	20.66975	115	203.3910461	17.97369565
RR	8	64 KB	81.3204	1.43471	115	70.7133913	1.247573913
RR	8	1 MB	115.081387	6.85234	115	100.0707713	5.958556522
RR	8	16 MB	198.439925	7.43353	115	172.5564565	6.46393913
RR	12	64 KB	67.1352	0.943	115	58.37843478	0.82
RR	12	1 MB	106.30565	4.535	115	92.43969565	3.943478261
RR	12	16 MB	174.893927	5.759	115	152.0816757	5.007826087
RR	24	64 KB	67.731	0.548	115	58.89652174	0.4765217391
RR	24	1 MB	98.790091	2.101	115	85.90442696	1.826956522
RR	24	16 MB	169.550765	2.33	115	147.4354478	2.026086957
RR	48	64 KB	72.6801	0.346	115	63.20008696	0.3008695652
RR	48	1 MB	92.157766	0.912	115	80.13718783	0.7930434783
RR	48	16 MB	158.287443	0.902	115	137.6412548	0.7843478261



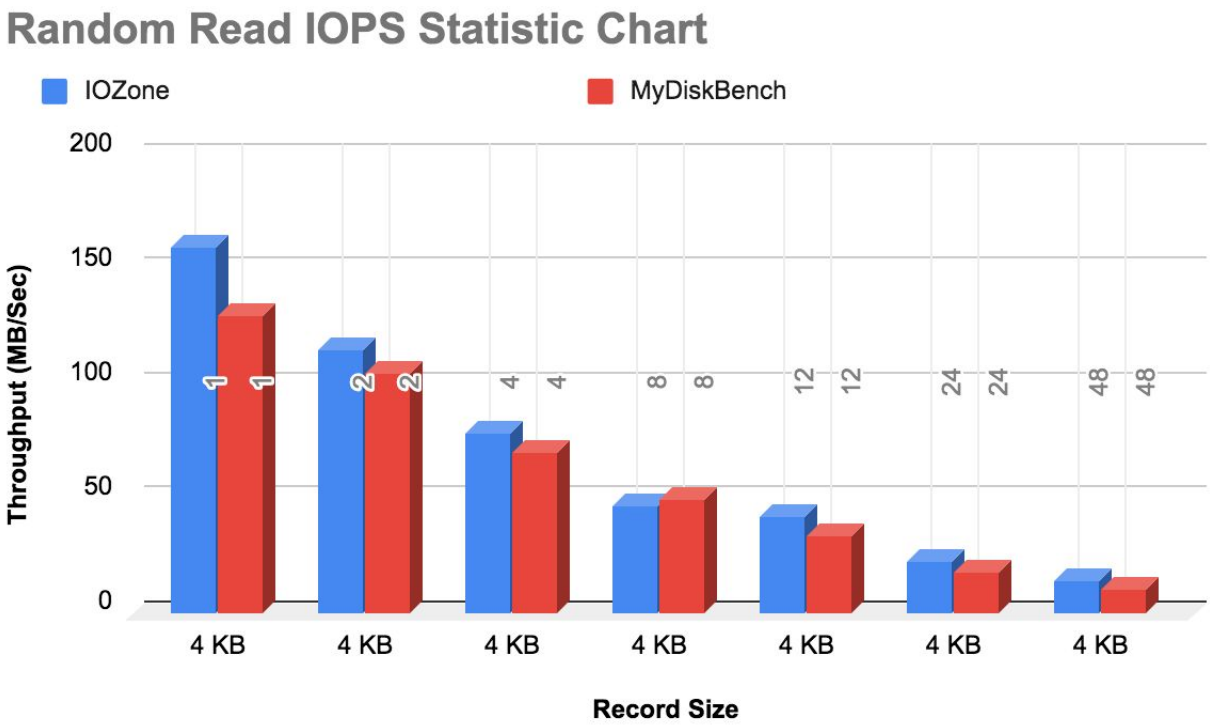
Random Write IOPS Statistics Table:-

Workload	Concurrency	Record Size	MyDiskBench IOPS (OPS/sec)	IOZone Measured IOPS (OPS/sec)	Theoretical IOPS (OPS/sec)	MyDiskBench Efficiency (%)	IOZone Efficiency (%)
WR	1	4 KB	40.37	150.74	28750	0.1404173913	0.5243130435
WR	2	4 KB	40.02	83.65	28750	0.1392	0.2909565217
WR	4	4 KB	35.33	59.43	28750	0.1228869565	0.2067130435
WR	8	4 KB	30.67	37.76	28750	0.1066782609	0.1313391304
WR	12	4 KB	22.57	46.25	28750	0.07850434783	0.1608695652
WR	24	4 KB	18.77	26.54	28750	0.06528695652	0.09231304348
WR	48	4 KB	13.97	12.45	28750	0.04859130435	0.04330434783



Random Read IOPS Statistic Table:-

Workload	Concurrency	Record Size	MyDiskBench Measured Throughput (OPS/sec)	IOZone Measured Throughput (OPS/sec)	Theoretical Throughput (OPS/sec)	MyDiskBench Efficiency (%)	IOZone Efficiency (%)
RR	1	4 KB	130.43	159.72	28750	0.4536695652	0.5555478261
RR	2	4 KB	105.26	115.39	28750	0.3661217391	0.4013565217
RR	4	4 KB	70.55	79.25	28750	0.2453913043	0.2756521739
RR	8	4 KB	49.65	47.38	28750	0.1726956522	0.1648
RR	12	4 KB	33.98	42.63	28750	0.1181913043	0.1482782609
RR	24	4 KB	17.98	22.91	28750	0.06253913043	0.07968695652
RR	48	4 KB	10.46	14.83	28750	0.0363826087	0.0515826087



Work Distribution:

Sirisha worked on C code for Sequential Write and Random Write operation.
Sirisha worked on bash scripts for MyDiskBenchmark code.
Sneha worked on C code for Sequential Read and Random Read.
Sneha worked on Chameleon Cloud setup and IOZONE benchmark setup.
Sneha and Sirisha both ran experiments on the cloud for different combinations and updated tables.