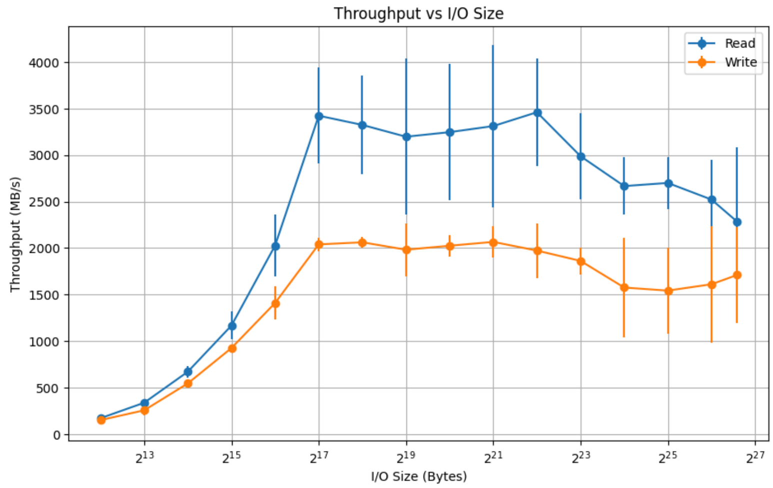
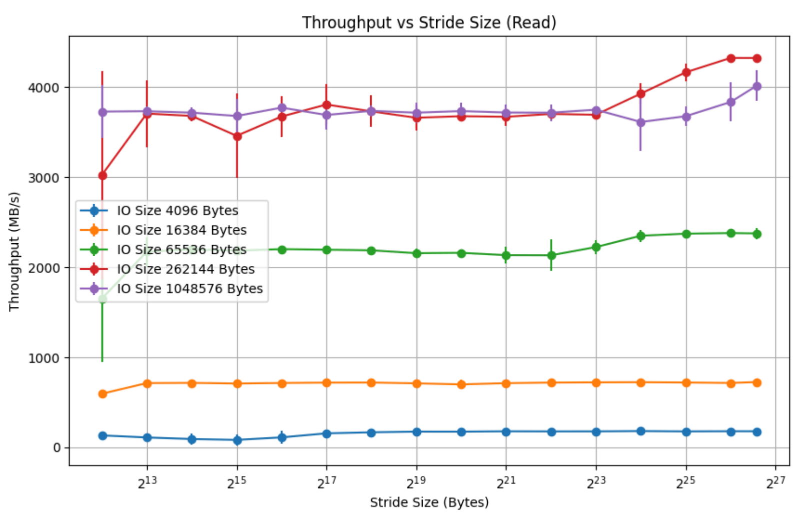
PIDs: 730470219, 730466997, 730411082
Data Collected from running on 1GB test file on Mac (SSD)

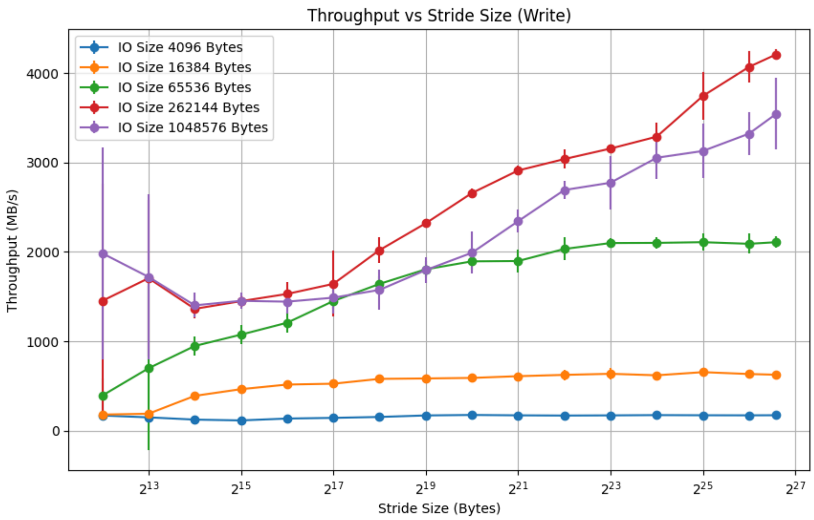


In this experiment, throughput is plotted against the I/O size, ranging from 4 KB to 100 MB, with the graph reporting the mean throughput and 95% confidence intervals for each point. The data shows a significant increase in throughput as the I/O size grows, with a peak performance observed between 256 KB and 1 MB. Reads achieve the highest throughput, hovering at 3500 MB/s, before a slight decline beyond 1 MB, possibly due to system overheads like buffer management or caching inefficiencies. Write throughput follows a slower increase and plateaus around 2000 MB/s. These results indicate that larger I/O sizes, up to 1 MB, are optimal for maximizing throughput in sequential access scenarios, particularly for read-intensive tasks. Beyond this range, the performance gain diminishes. For applications or file systems handling sequential workloads, choosing an I/O size around 256 KB to 1 MB is ideal for balancing performance and overhead.

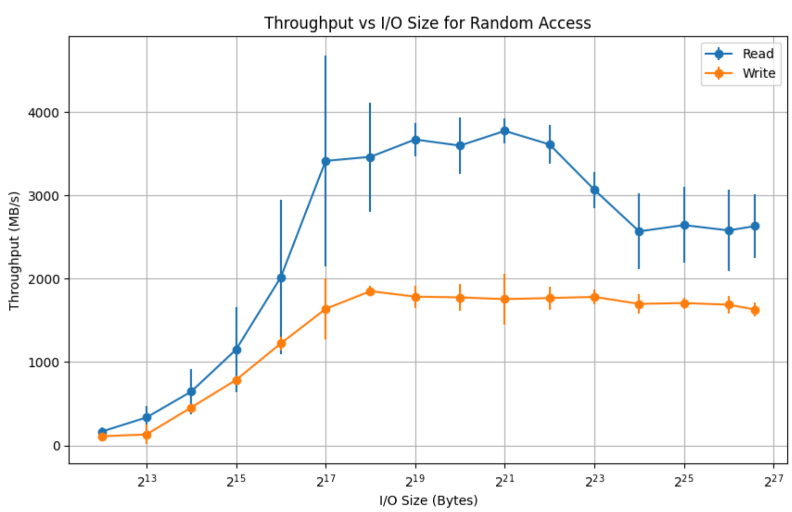


This experiment highlights the relationship between I/O size and stride size. For small I/O sizes (4 KB, 16 KB, and 64 KB), throughput remains consistently low across all stride sizes, indicating that small I/O sizes underutilize system bandwidth regardless of the stride. Medium I/O sizes, such as 256 KB, show a significant improvement, with throughput stabilizing around 3000-4000 MB/s across stride sizes, suggesting that this range strikes a balance between efficiency and system overhead. Larger I/O sizes, like

1 MB, achieve the highest throughput (approximately 4000 MB/s) consistently across all stride sizes, with minimal variability, demonstrating that the system is well-optimized for handling large reads. Overall, read operations are influenced more by I/O size than stride size, with larger I/O sizes (256 KB to 1 MB) ensuring optimal performance.



This experiment of throughput versus stride size for write operations, shows a different trend where both I/O size and stride size play a significant role. Small I/O sizes (4 KB and 16 KB) exhibit low and consistent throughput (below 500 MB/s), regardless of the stride size, as they incur higher overhead per operation. Medium to larger I/O sizes (64 KB, 256 KB, 1MB), show steady improvement as stride size increases, peaking at approximately 3500 - 4000 MB/s and for the largest strides, indicating that reducing overhead through larger strides benefits writes. However it seems that the larger I/O sizes (1 MB) demonstrate the slight worse performance compared to 256 KD. This suggests that excessively large I/O sizes, like 1 MB, may introduce additional overheads such as buffer management inefficiencies, increased synchronization costs, or delays in write flushing. While larger strides help alleviate contention and improve throughput for larger I/O sizes, the marginal difference in performance between 256 KB and 1 MB suggests that 256 KB may strike the best balance between reducing overhead and maximizing throughput.



For random I/O patterns, throughput is again plotted against the I/O size, with granularity ranging from 4 KB to 100 MB over a range of 1 GB addresses. The graph reveals a similar upward trend as I/O size increases, but the peak throughput for random reads is slightly lower compared to sequential reads, reaching around 3750 MB/s at 512 KB to 1 MB before declining. Write throughput is relatively stable, plateauing between 1500 MB/s and 2000 MB/s, and is less sensitive to changes in I/O size. The confidence intervals show higher variability in random access performance, especially for larger I/O sizes, likely due to increased latency, cache misses, or hardware limitations. These results suggest that for applications requiring random access, an I/O size around 512 KB offers the best trade-off between throughput and variability.

Challenge:
Methodology:
Firstly, we reorganized the data by separating each run into test types. Then, we imported the data into a Jupyter notebook. To calculate the sample size needed, firstly we calculated the mean and standard deviation across all 5 runs for each size (or size and stride). Then, we used the means to calculate a hypothetical population mean, which was given a standard conservative value of 0.90*sample mean. Then, we calculated the Cohen's d effect size for each size (or size and stride) for every test type. Using the effect size, and a standard alpha of 0.05 and power of 0.8, we calculated the required sample size n using the formula below.

$$n = \frac{2(Z_{\mathrm{a}} + Z_{1-\beta})^{2\sigma 2,}}{\Delta^2}$$

SIZE READ		
IO_SIZE(Bytes)	Sample Size (n)	# of rounds
4096	2.29	1
8192	296.95	60
16384	9945.4	1990
32768	121128.19	24226
65536	971735.57	194348
131072	2010632.15	402127
262144	2334885.79	466978
524288	16262891.59	3252579
1048576	9035544.29	1807109
2097152	17451606.41	3490322
4194304	3106626.08	621326

8388608	1692891.84	338579
16777216	412682.4	82537
33554432	268545.52	53710
67108864	1737146.67	347430
100663296	26656702.99	5331341

SIZE WRITE		
IO_SIZE(Bytes)	**Sample Size (n)**	**# of rounds**
4096	1589.93	318
8192	52117.95	10424
16384	1287.64	258
32768	332.29	67
65536	168452.23	33691
131072	2415.41	484
262144	976.44	196
524288	539697.84	107940
1048576	13974.33	2795
2097152	61143.29	12229
4194304	642672.99	128535
8388608	41651.31	8331
16777216	10585812.84	2117163
33554432	6135570.73	1227115
67108864	19425719.9	3885144
100663296	7945700.24	1589141

RANDOM READ		
IO_SIZE(Bytes)	**Sample Size (n)**	**# of rounds**
4096	87061.13	17413
8192	1110706.56	222142
16384	4530870.42	906175
32768	16839836.7	3367968
65536	59485600.88	11897121

131072	70077493.03	14015499
262144	5000931.29	1000187
524288	39756.48	7952
1048576	324271.6	64855
2097152	10516.39	2104
4194304	75229.3	15046
8388608	78961.64	15793
16777216	2159808.7	431962
33554432	2036332.32	407267
67108864	2782141.63	556429
100663296	1048910.27	209783

RANDOM WRITE		
IO_SIZE(Bytes)	**Sample Size (n)**	**# of rounds**
4096	295636.88	59128
8192	3425514.02	685103
16384	28.74	6
32768	366.72	74
65536	12296.08	2460
131072	2124341.42	424869
262144	1499.09	300
524288	32081.75	6417
1048576	61239.13	12248
2097152	961033.8	192207
4194304	40445.42	8090
8388608	6708.17	1342
16777216	22520.68	4505
33554432	2234.36	447
67108864	14193.19	2839
100663296	5189.9	1038

STRIDE READ			

IO_SIZE(Bytes)	Stride(Bytes)	Sample Size (n)	# of rounds
4096	4096	202835.21	40568
4096	8192	186682.27	37337
4096	16384	376693.4	75339
4096	32768	693751.25	138751
4096	65536	681868.5	136374
4096	131072	553.65	111
4096	262144	85.26	18
4096	524288	0.88	1
4096	1048576	411.09	83
4096	2097152	0.98	1
4096	4194304	10.72	3
4096	8388608	21.64	5
4096	16777216	0.02	1
4096	33554432	9.69	2
4096	67108864	0.73	1
4096	100663296	1.33	1
16384	4096	3650.38	731
16384	8192	7.38	2
16384	16384	25.72	6
16384	32768	248.46	50
16384	65536	80.99	17
16384	131072	88.44	18
16384	262144	44.89	9
16384	524288	699.09	140
16384	1048576	5378.65	1076
16384	2097152	182.06	37
16384	4194304	23.43	5
16384	8388608	1.31	1
16384	16777216	2.83	1
16384	33554432	25.44	6
16384	67108864	583.9	117
16384	100663296	1.35	1
65536	4096	25414184.6	5082837

65536	8192	51938.92	10388
65536	16384	136.7	28
65536	32768	53.37	11
65536	65536	0.06	1
65536	131072	18.41	4
65536	262144	48.62	10
65536	524288	9.52	2
65536	1048576	245.46	50
65536	2097152	7250.57	1451
65536	4194304	68281.23	13657
65536	8388608	2680.83	537
65536	16777216	1380.43	277
65536	33554432	102.22	21
65536	67108864	83.51	17
65536	100663296	833.81	167
262144	4096	59120904.19	11824181
262144	8192	471255.92	94252
262144	16384	338.57	68
262144	32768	1307502.72	261501
262144	65536	37963.11	7593
262144	131072	6221.57	1245
262144	262144	2642.73	529
262144	524288	7556.94	1512
262144	1048576	46.38	10
262144	2097152	2641.69	529
262144	4194304	148.82	30
262144	8388608	90.56	19
262144	16777216	6436.11	1288
262144	33554432	60908.14	12182
262144	67108864	187446.33	37490
262144	100663296	192067.78	38414
1048576	4096	14861.2	2973
1048576	8192	83.86	17
1048576	16384	320.36	65
1048576	32768	30570.83	6115

1048576	65536	13.18	3
1048576	131072	19332.59	3867
1048576	262144	796.95	160
1048576	524288	9966.92	1994
1048576	1048576	11899.96	2380
1048576	2097152	30037.39	6008
1048576	4194304	59319.25	11864
1048576	8388608	28497.33	5700
1048576	16777216	754306.15	150862
1048576	33554432	278281.38	55657
1048576	67108864	322067.58	64414
1048576	100663296	81514.03	16303

STRIDE WRITE			
IO_SIZE(Bytes)	**Stride(Bytes)**	**Sample Size (n)**	**# of rounds**
4096	4096	5770.13	1155
4096	8192	105410.9	21083
4096	16384	47924.56	9585
4096	32768	23277.94	4656
4096	65536	4297.88	860
4096	131072	6063.01	1213
4096	262144	443.64	89
4096	524288	7.83	2
4096	1048576	0.19	1
4096	2097152	107.67	22
4096	4194304	287.2	58
4096	8388608	82.23	17
4096	16777216	35.09	8
4096	33554432	59.68	12
4096	67108864	108.16	22
4096	100663296	111.34	23
16384	4096	74172.66	14835
16384	8192	97834.69	19567

16384	16384	8483.24	1697
16384	32768	159.05	32
16384	65536	99.95	20
16384	131072	5838.63	1168
16384	262144	23.6	5
16384	524288	18.23	4
16384	1048576	73.08	15
16384	2097152	2375.71	476
16384	4194304	9149.85	1830
16384	8388608	11195.67	2240
16384	16777216	2581.3	517
16384	33554432	23.21	5
16384	67108864	34.67	7
16384	100663296	1465.37	294
65536	4096	2754216.03	550844
65536	8192	527885888	105577178
65536	16384	44968.92	8994
65536	32768	34757.56	6952
65536	65536	35569.57	7114
65536	131072	8148.59	1630
65536	262144	5704.35	1141
65536	524288	6525.38	1306
65536	1048576	6363.52	1273
65536	2097152	28268.75	5654
65536	4194304	22347.58	4470
65536	8388608	764.32	153
65536	16777216	1053.83	211
65536	33554432	6676.79	1336
65536	67108864	11795.68	2360
65536	100663296	1308.27	262
262144	4096	448508410	89701682
262144	8192	67255298.3	13451060
262144	16384	21790.82	4359
262144	32768	2640.16	529
262144	65536	47604.65	9521

262144	131072	2287336.48	457468
262144	262144	38122.34	7625
262144	524288	135.11	28
262144	1048576	406.24	82
262144	2097152	281.42	57
262144	4194304	5166.77	1034
262144	8388608	160.16	33
262144	16777216	16495.04	3300
262144	33554432	119800.02	23961
262144	67108864	18415.81	3684
262144	100663296	210.86	43
1048576	4096	162742835.9	32548568
1048576	8192	82592769.93	16518554
1048576	16384	61509.91	12302
1048576	32768	9937.73	1988
1048576	65536	46603.21	9321
1048576	131072	141630.09	28327
1048576	262144	343182.72	68637
1048576	524288	48486.44	9698
1048576	1048576	257590.28	51519
1048576	2097152	15608.3	3122
1048576	4194304	4522.12	905
1048576	8388608	355559.01	71112
1048576	16777216	108585.81	21718
1048576	33554432	286884.56	57377
1048576	67108864	97177.96	19436
1048576	100663296	673971.05	134795