Project 3 Report

1. Test results

All tests are performed 5 times. The average value of each item is shown below.

Test #	Step Size	R/W ratio	I/O Depth	***Read*[1]**	***Write*[1]**	***Latency (avg)*[2]**
1	4k	50:50	64	82.2k / 337	81.8k / 335	260 / 187
2	64k	50:50	64	19.7k / 1288	20.1k / 1318	1167 / 1993
3	128k	50:50	64	11.4k / 1492	12.0k / 1576	1218 / 4097
4	4k	100:0	64	189k / 774	N/A	248 / NA
5	4k	0:100	64	N/A	152k / 624	NA / 230
6	4k	50:50	16	76.1k / 312	75.6k / 310	128 / 52
7	4k	50:50	256	86.1k / 353	85.7k / 351	829 / 731
8	4k	50:50	1024	88.1k / 361	87.6k / 359	2981 / 2880

1: Read/Write Throughput, in form of IOPS **/** MB per second

2: Latency of Read/Write in us.

2. Impact of Read/Write

Generally writing is more complicated than reading, thus causing a higher latency. From the experiment results, we can see that for very small data access sizes like 4K, write operation has a lower latency compared to read operation. Since there are a total of 30 tests of 4K read/write, it is unlikely to be caused by randomness. Write caching may explain this result.

Many modern SSDs use write buffers to speed up small write operations. When writing a small amount of data (like 4 KB), the data can be quickly written to the buffer instead of being immediately committed to the slower NAND cells. Also the read mode in the experiment is random read, which can have higher latency because the SSD needs to locate and fetch data from different memory cells. On the other hand, small writes can be buffered and then written sequentially, reducing latency. Furthermore, SSD controllers are often optimized to handle small writes efficiently.

3. Impact of Data Access Size

For smaller access sizes (e.g., 4 KB), SSDs generally have lower latency because the operations can be processed quickly. However, as the access size increases (e.g., 128 KB), the latency tends to increase since larger blocks of data take longer to read or write. Larger data access sizes increase throughput in MB/s but decrease IOPS.

It is also notable that write latency increases much faster than read latency with larger data access sizes. When data access size increases, it becomes harder to maintain this level of efficiency as of 4K.

The 4K write-only test shows a higher performance than an enterprise-level SSD. This may due to that enterprise SSDs are typically optimized for sustained workloads, endurance, and reliability over time rather than just peak performance for short bursts of activity. They are designed to achieve consistent performance under heavy workloads that can be very rare in personal daily use. Customer level SSD performs exceptionally well in short bursts, particularly in some benchmark scenarios.

4. Impact of I/O Depth

I/O depth	Read Speed	Write Speed	Latency (R)	Latency (W)

16	1	312	1	310	1	128	1	52	1
64	4x	337	+8%	335	+8%	260	2x	187	3.6x
256	16x	353	+13.1%	351	+13.2%	829	6.5x	731	14x
1024	64x	361	+15.7%	359	+15.8%	2981	23.3x	2880	55.4x

Both Throughput (in terms of MB/s) and latency (in terms of us) increases as queue depth increases.
As I/O depth increases, the extra gain in throughput becomes smaller but the extra delay becomes more significant which lines up with the queuing theory.