Micron 7500 NVMe™ SSD RocksDB Performance[1]

This technical brief compares the Micron 7500 SSD to two mainstream NVMe SSDs from Competitor A and Competitor B[2] using RocksDB and the db_bench benchmark.[3] This comparison is based on following testing performed by Micron:

- **Random read** (readrandom): This test reads data randomly from an existing database.
- **Random read while writing** (readwhilewriting): This test uses multiple threads for reading and one thread for writing.

Micron chose RocksDB for the comparison because it is built for extreme performance and is optimized for fast, low-latency storage. RocksDB is part of a Meta open-source community.[4]

Performance and application responsiveness are shown for 4KB block sizes while scaling the thread counts from 8 to 128.[5] The host hardware configuration is the same for each SSD under test. All SSDs have an advertised capacity of 7.68TB.[6]

Test results show that the Micron 7500 SSD demonstrates consistently higher performance and better application responsiveness (lower latency).

The Micron 7500 SSD performance advantage over the competing SSDs increases as the thread count scales from 8 to 128 (increasing thread count reflects increased workload). Application responsiveness remains more linear (flat) than the competitors, making workload responsiveness easier to predict.

Micron 7500 SSD (U.2/U.3; 800GB to 15.36TB)

Fast facts

The Micron 7500 SSD consistently demonstrates higher performance and better application responsiveness than two other mainstream, data center NVMe SSDs evaluated.

Random read

This workload randomly reads data from an existing database. The Micron 7500 SSD achieves up to:

59% Higher Maximum Performance

54% Better Application Response Time

Random read while writing

This workload uses multiple threads for reads and one thread for writes. The Micron 7500 SSD shows up to:

2.1x Higher Maximum Performance

49% Better Application Response Time

1. This document uses the terms performance and operations per second interchangeably.
2. Class and leading competitors is defined as mainstream, data center, NVMe SSD suppliers with at least 10% data center NVMe SSD market share as of August '23 as noted in Forward Insights analyst report *FI 202308 SSD Supplier Status_Q223_P*. Competitor A uses three bits per cell (TLC) NAND while competitor B uses four bits per cell NAND (QLC). All tested SSDs rated at 7.68TB capacity and intended for mainstream use. Unformatted capacity. 1GB = 1 billion bytes, formatted capacity is less.
3. Additional details on the db_bench benchmark available here: https://github.com/EighteenZi/rocksdb_wiki/blob/master/Benchmarking-tools.md
4. Retrieved from rocksdb.org/ and https://opensource.fb.com/ at the date of this document's publication.
5. Thread counts beyond 128 were not tested.
6. Unformatted capacity. 1GB = 1 billion bytes, formatted capacity is less.

Performance and response time

In the performance scaling figures (Figures 1 and 3), higher performance (operations per second) is shown as a taller bar along the vertical axis, while thread count is shown increasing along the horizontal axis (8, 16, 32, 64, 96, and 128). The maximum performance difference between the Micron 7500 SSD and either competitor is highlighted in each performance scaling figure.

The second figure (Figures 2 and 4) in each pair shows application responsiveness (99% QoS[7] latency) along the vertical axis and performance along the horizontal axis. Values that are lower and farther to the right are better. The greatest responsiveness difference between the Micron 7500 SSD and either competitor is highlighted.

Note that the maximum performance difference and greatest responsiveness difference between the Micron 7500 SSD and either competitor may occur at different thread counts.

Random read: This workload randomly reads data from an existing database

The Micron 7500 SSD, Competitor A, and Competitor B performance scaling (expressed as performance versus increasing thread count from 8 to 128) is shown in Figure 1. The largest performance difference occurs when the thread count is 64. At this thread count, the Micron 7500 SSD shows 616,344 operations per second while Competitor B shows 559,924 and Competitor A shows just 388,751. This equates to a maximum performance improvement of 59% for the Micron 7500 SSD as highlighted in Figure 1.[8]

Figure 2 shows that the largest application responsiveness (latency) improvement between the Micron 7500 SSD and either competitor is 54%,[9] and it occurs when the thread count is 16, 32, and 64 (only the improvement at thread count 64 is highlighted).

Random read workload analysis

Performance: Figure 1 shows that the Micron 7500 SSD 4KB random read performance is consistently higher than Competitor A and Competitor B (i.e., the Micron 7500 SSD performance bar is taller for each thread count value).

Response time: The Micron 7500 SSD also demonstrates superior application response, demonstrating up to 54% better responsiveness as seen in Figure 2.

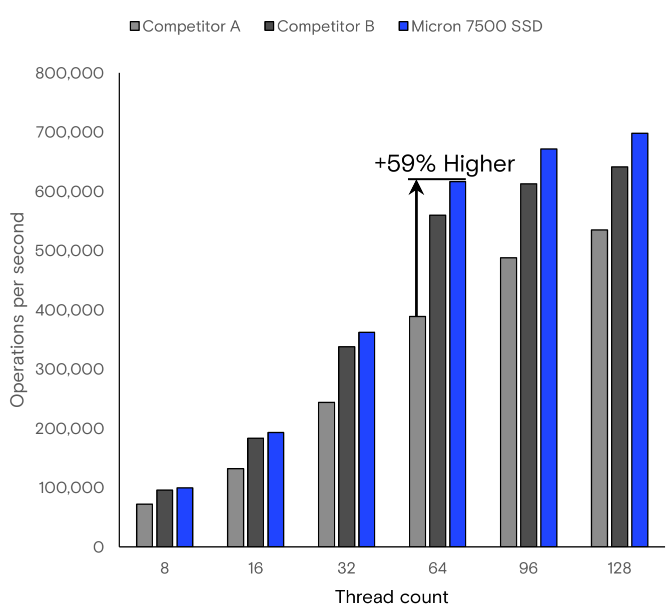

Figure 1: 4KB random read performance scaling by thread count

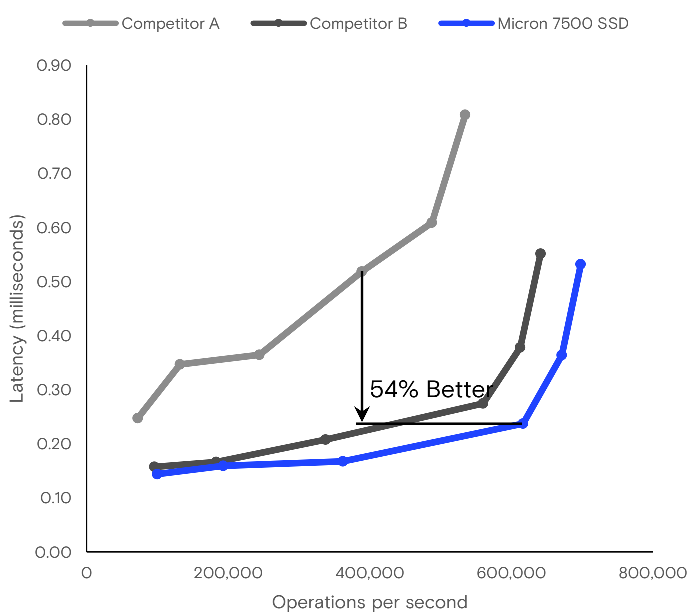

Figure 2: Application responsiveness vs. 4KB random read performance

7. Quality of Service (QoS) is a measure of the full span of response times by IO completion percentages. In other words, QoS shows at what time value a given percent of the IOs will complete. See https://www.snia.org/europe/news/understanding-datacentre-workload-quality-service for additional information.
8. Note: 616,344 operations per second divided by 388,751 operations per second = 1.59, a 59% improvement.
9. Note: Percentage improvement = (Micron 7500 SSD latency – Competitor A latency) / Competitor A latency; (0.24ms – 0.52ms) / 0.52ms = -54% (shown as 54% better in Figure 2).

Random read while writing: This workload uses multiple threads for reads and one thread for writes

Performance and application 99% response time comparisons for this workload are shown in Figures 3 and 4. The Micron 7500 SSD, Competitor A, and Competitor B performance scaling is shown in Figure 3. The Micron 7500 SSD shows maximum performance gain of 2.1x when the thread count = 96 and 128. At thread count = 128 (highlighted in figure 3), the Micron 7500 SSD reaches 616,223 operations per second, while Competitor B reaches 496,175 and Competitor A just 300,580.

Figure 4 shows that the Micron 7500 SSD greatest application responsiveness (latency) improvement is 49%, occurring at thread count = 8 as highlighted.[10]

Random read while writing workload analysis

Performance: Figure 3 shows that the Micron 7500 SSD 4KB random read while writing performance is consistently higher than Competitor A and Competitor B (i.e., the Micron 7500 SSD performance bar is taller for each thread count value).

Response time: The Micron 7500 SSD demonstrates superior application response, demonstrating up to a 49% application response time improvement at maximum performance as seen in Figure 4.

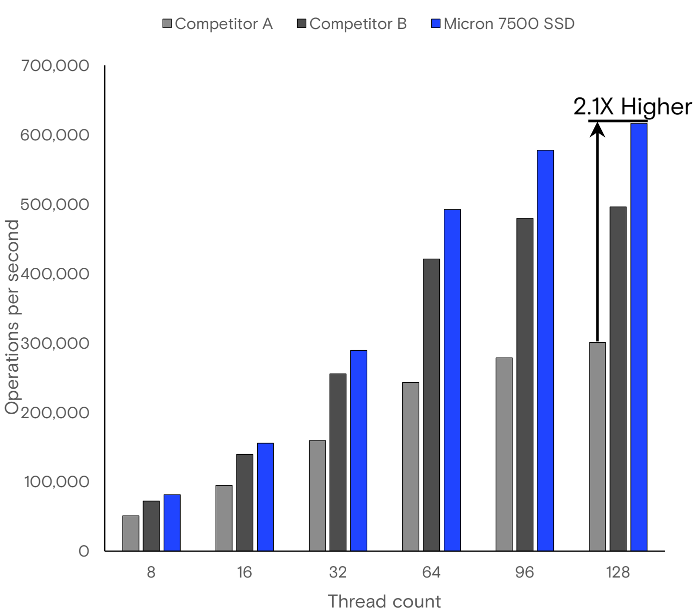

Figure 3: 4KB random read while writing performance scaling by thread count

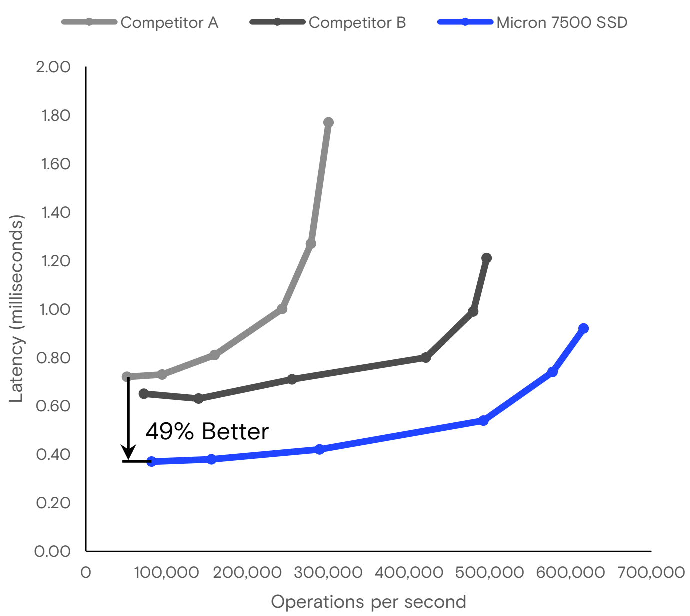

Figure 4: Application responsiveness vs. 4KB random read while writing performance

Conclusion

Evaluating the Micron 7500 NVMe SSD RocksDB performance and responsiveness against two leading competitors reveals some significant differences. The data in these tests shows that:

1. The Micron 7500 SSD offers superior RocksDB 4KB block size performance (in both read and read while writing workloads) across all tested thread counts (8 to 128). Further, the Micron 7500 SSD shows maximum performance advantages from 59% to 2.1x.
2. Applications whose storage demands are similar to those tested are more responsive with the Micron 7500 SSD. The Micron 7500 SSD response time improvements are 54% for read and 49% for read while writing workloads.

Note: Percentage difference = (Micron 7500 SSD latency – Competitor A latency) / Competitor A latency; (0.37ms – 0.72ms) / 0.72ms = –49% (shown as 49% better in Figure 4).

3. The Micron 7500 SSD application responsiveness is more consistent as the workload increases. This is seen in Figure 2 and 4, where the Micron 7500 SSD application responsiveness is both lower and more linear as the thread count increases along the horizontal axis from left to right.

The Micron 7500 SSD is optimized for high-performance workloads, demonstrating exceptional read and mixed performance. These workloads are typical for a broad range of use cases such as database acceleration, online transaction processing, high-frequency trading, and content delivery.

The Micron 7500 SSD is the most advanced mainstream PCIe® Gen4 data center SSD and first with 200+ layer NAND, providing superior QoS and performance when compared to its competition.

How We Tested[11]

We used db_bench to benchmark RocksDB performance. According to the RocksDB wiki, db_bench was enhanced by RocksDB from prior work related to LevelDB. The tool was later enhanced to support additional options (a list of supported db_bench workloads is available on GitHub).

Server Hardware Configuration	
Server	Supermicro AS-1115CS-TNR
CPU	AMD EPYC™ 9654 96-Core Processor
Memory	768GB Micron DDR5 (12 x 64GB, 1 DPC – limited to 256GB via kernel parameters)
Server Storage	Micron 7500 SSD configuration: 1x Micron 7500 PRO 7.68TB NVMe SSD Competitor A configuration: 1x read-intensive, competitor A 7.68TB NVMe SSD Competitor B configuration: 1x read-intensive, competitor B 7.68TB NVMe SSD
Boot Drive	Micron 7450 960GB M.2 NVMe SSD
RocksDB version	8.1.1
OS	Ubuntu 20.04
Kernel	5.15.0-67-generic

Table 1: Server hardware configuration

Server Software Configuration	
Filesystem	XFS Version: 5.0.0 Mount options: “noatime,discard” Mount point: /mnt_db/nvme

Table 2: Server filesystem configuration

micron.com/7500

11. Kernel buffers were cleared before running each workload using the command sync; echo 3 > /proc/sys/vm/drop_caches.