Micron® Technical Brief: Micron 9400 NVMe™ SSD RocksDB Performance

THE MICRON 9400 SSD ENABLES CLASS-LEADING PERFORMANCE[1] FOR DEMANDING DATA CENTER WORKLOADS

Micron delivers data center NVMe SSDs with high performance, industry-leading capacities and the power efficiencies that data center workloads demand.

This technical brief compares the Micron 9400 SSD to two performance-focused NVMe SSDs from competitors[2] using RocksDB and the db_bench benchmark.[3] Micron chose RocksDB for this comparison because it is built for extreme performance and fast storage.[4]

- **Random read** (readrandom): Read data randomly from an existing database.
- **Random read, random write** (readrandomwriterandom): Separate threads execute an 80% read and 20% write (% of the total operations).
- **Random read while writing** (readwhilewriting): Multiple threads read while one thread writes.

Performance and application responsiveness are shown for 4KB and 16KB block sizes with scaling the thread counts from 4 to 64.[3] The configuration is the same for each SSD under test.

Test results show that the Micron 9400 SSD demonstrates higher performance and better application responsiveness across all tested workloads, block sizes and queue depths.

The Micron 9400 SSD performance advantage over the competitive SSDs increased as the thread count scaled from 4 to 64 (increasing thread count reflects increased workload).[5] Application responsiveness remained more linear (flat) than the competitors.

1. In this document, we use the terms performance and operations per second interchangeably.
2. Competitors as noted in SSD Insights Q4/22 (analyst firm Forward Insights).
3. Additional details on db_bench are available here: https://github.com/EighteenZi/rocksdb_wiki/blob/master/Benchmarking-tools.md
4. Retrieved from rocksdb.org/ at the date of this technical brief's publication.
5. Thread counts beyond 64 were not tested since the thread count per database instance should not exceed the available number of local cores in the system. Failing to observe this may lower performance and application responsiveness due to thread contention.
6. Responsiveness improvements for 4KB and 16KB transfer sizes listed separately. Each value shown is the maximum measured improvement.

Fast Facts

The Micron 9400 SSD consistently demonstrates higher performance and better application responsiveness than the other leading data center NVMe SSDs tested.

Random Read

25% to 34% Higher Performance

Micron 9400 SSD 4KB random read maximum improvement over the competitors' ranges from 25% (4KB) to 34% (16KB) higher performance.

32% to 34% Better Responsiveness

Application responsiveness is also better, with a maximum improvement of 32% (4KB) to 34% (16KB).[6]

Random Read, Random Write

32% to 34% Higher Performance

Random read, random write performance for the Micron 9400 also exceeds the competition, ranging from a maximum improvement of 32% (16KB) to 34% (4KB).

43% to 50% Better Responsiveness

Application responsiveness is again better, with a maximum improvement of 43% (4KB) to 50% (16KB).

Random Read While Writing

23% to 54% Higher Performance

Micron 9400 SSD random read while writing performance exceeds the competition, ranging from a maximum of 23% (4KB) to 54% (16KB).

47% to 70% Better Responsiveness

Application responsiveness is better, with a maximum improvement of 47% (4KB) to 70% (16KB).

Higher performance (operations per second) is shown as a taller bar in the performance scaling figures (these figures also highlight the maximum measured performance difference for each workload and block size). Better application responsiveness is shown as a lower value in the application responsiveness figures.

Random Read

This workload randomly reads data from an existing database.

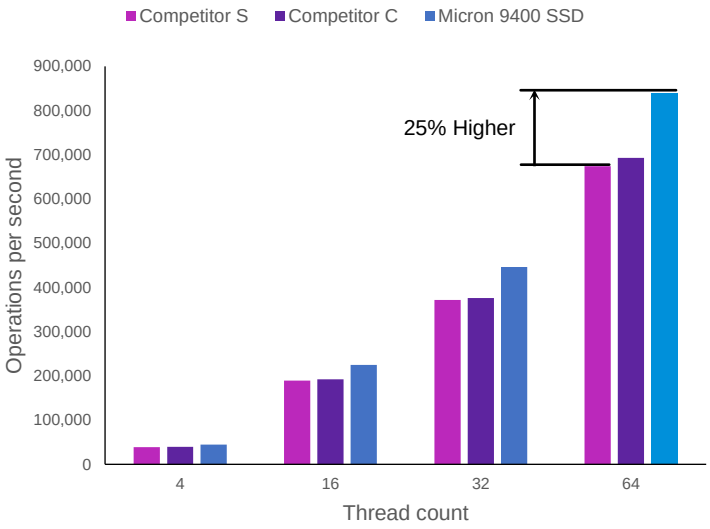

Figure 1a: 4KB random read performance by thread count

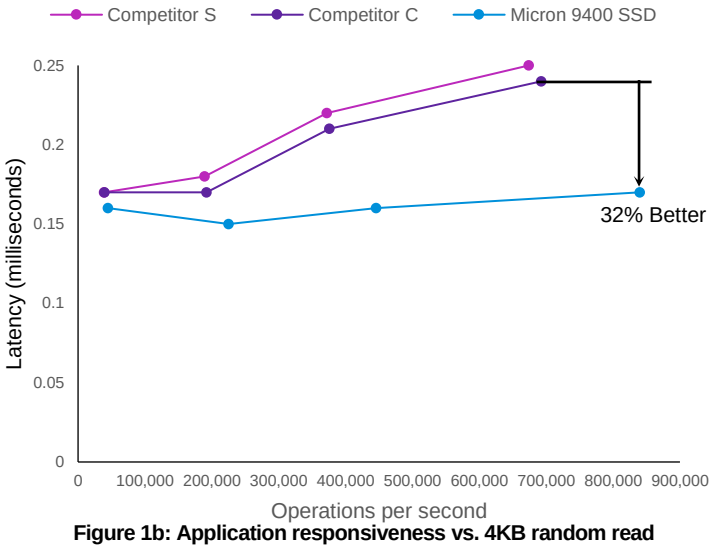

Figure 1b: Application responsiveness vs. 4KB random read performance

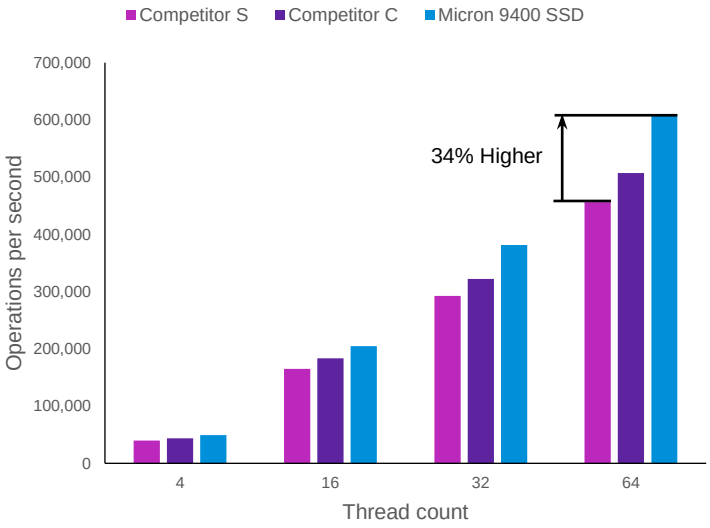

Figure 2a: 16KB random read performance by thread count

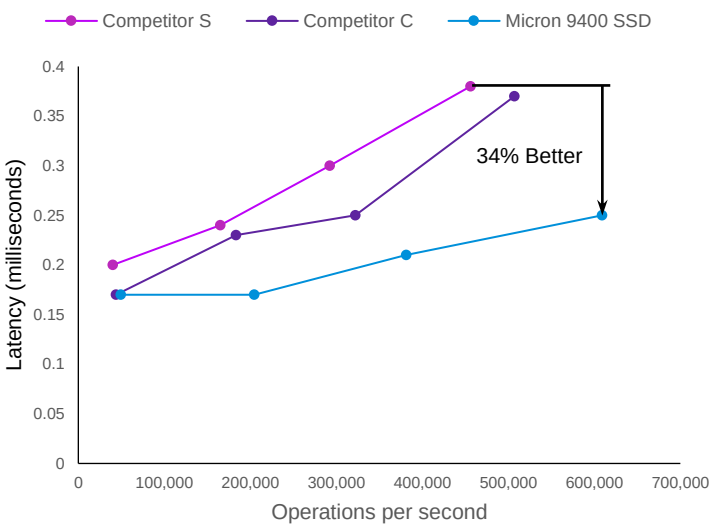

Figure 2b: Application responsiveness vs. 16KB random read performance

Random Read Workload Analysis

4KB Performance: Figure 1a shows that the Micron 9400 SSD 4KB random read performance is consistently higher than any of the other leading competitors, reaching a maximum of 840,097 operations per second (up to 25% higher performance) while also improving application response time by up to 32% (Figure 1b).

16KB Performance: Figure 2a shows that the Micron 9400 SSD 16KB random read performance is again consistently higher than the competitors. The Micron 9400 SSD reaches a maximum of 608,886 operations per second, up to 34% higher than the competitors while also improving application response time by up to 34% (Figure 2b).

Random Read, Random Write

This workload uses separate threads for an 80% read and 20% write (% of the total operations).

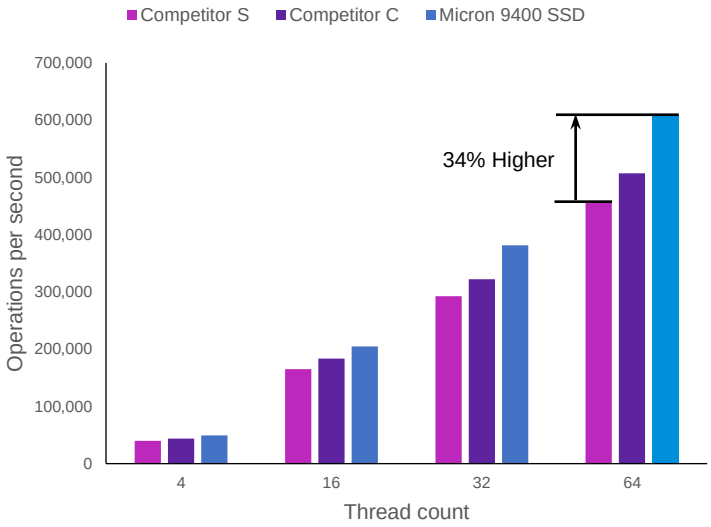

Figure 3a: 4KB random read and random write performance by thread count

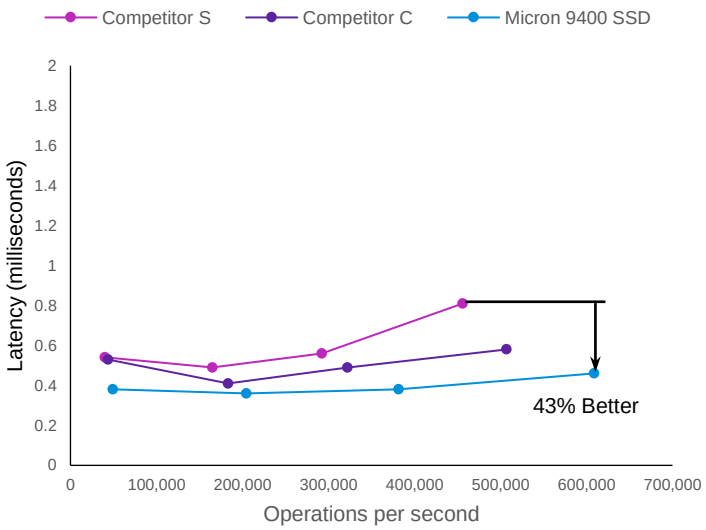

Figure 3b: Application responsiveness vs. 4KB random read and random write performance

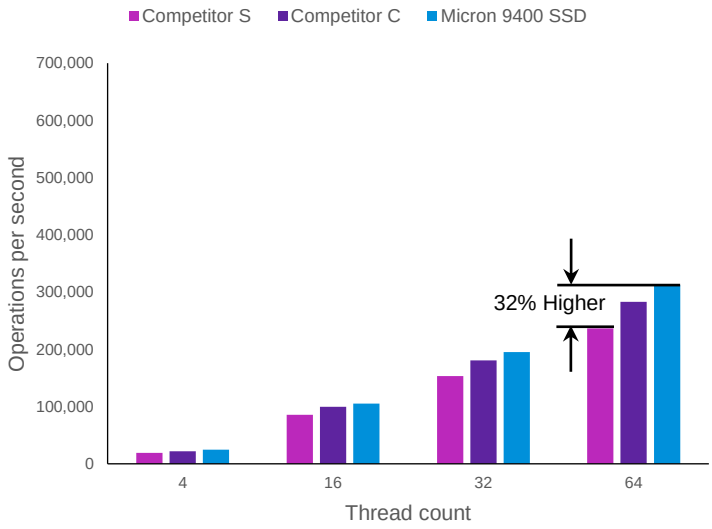

Figure 4a: 16KB random read and random write performance by thread count

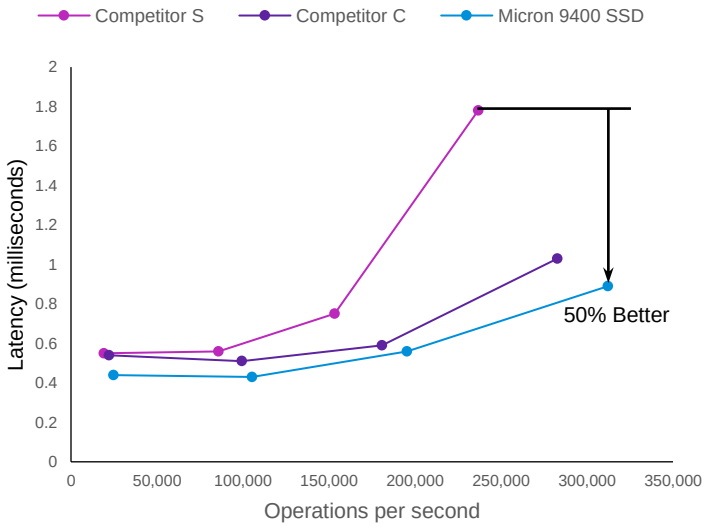

Figure 4b: Application responsiveness vs. 16KB random read and write performance

Random Read, Random Write Workload Analysis

4KB Performance: Figure 3a shows that the Micron 9400 SSD 4KB random read and random write performance is consistently higher than the other leading competitors, reaching a maximum of 608,886 operations per second (up to 34% higher performance) while also improving application response time by up to 43% (Figure 3b).

16KB Performance: Figure 4a shows that the Micron 9400 SSD 16KB random read performance is again consistently higher than the competitors. The Micron 9400 SSD reached a maximum of 312,214 operations per second, up to 32% higher than the competitors, while also improving application response time by up to 50% (Figure 4b).

Random Read While Writing

This workload uses multiple threads for reads and just one thread for writes.

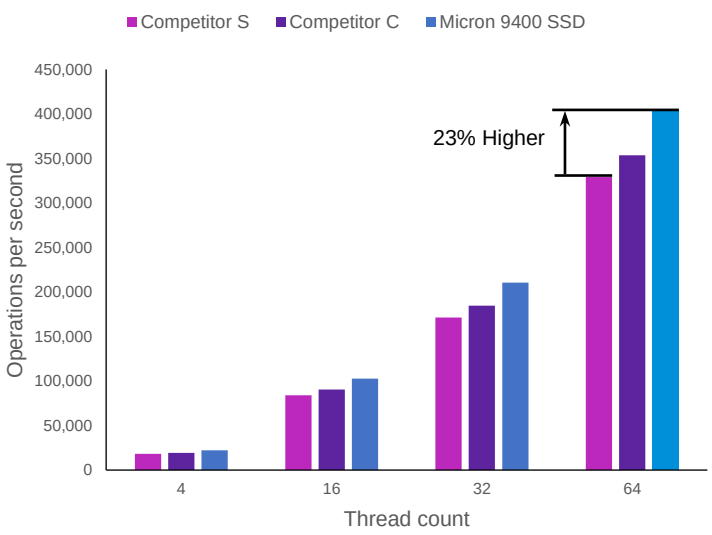

Figure 5a: 4K random read while writing performance by thread count

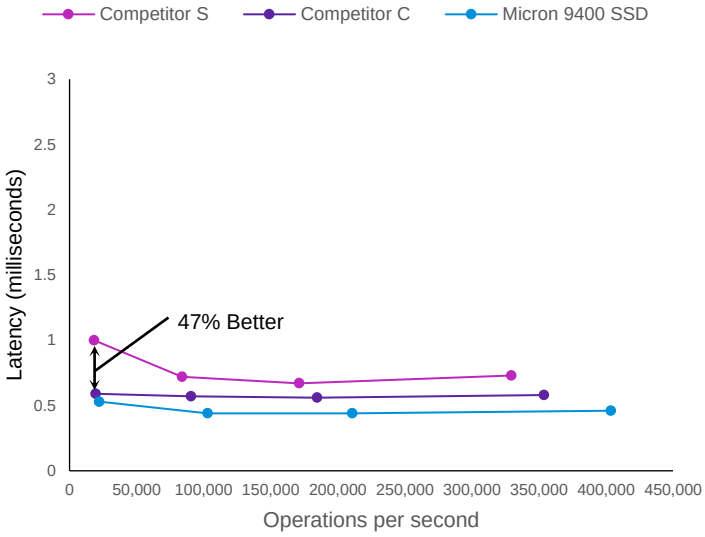

Figure 5b: Application responsiveness vs. 4KB random read while writing performance

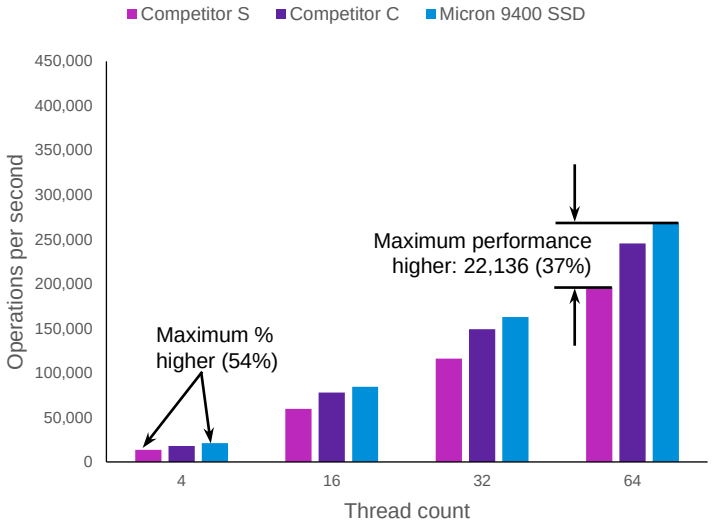

Figure 6a: 16K random read while writing performance by thread count

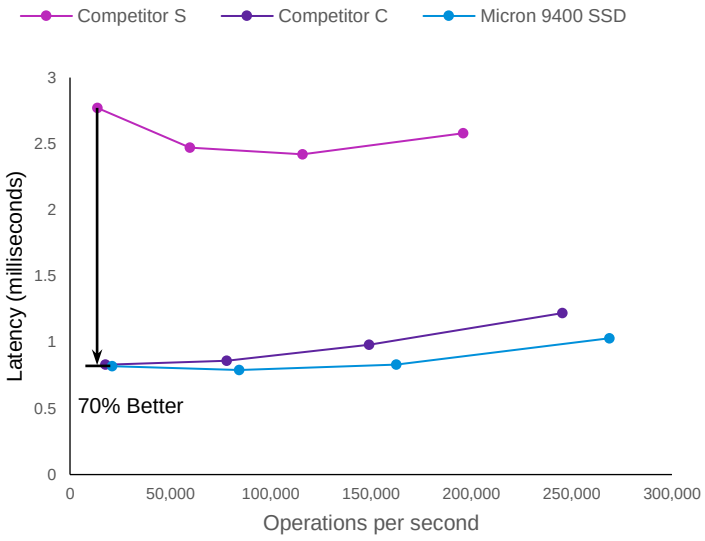

Figure 6b: Application responsiveness vs. 16KB random read while writing performance

Random Read While Writing Workload Analysis

4KB Performance: Figure 5a shows that the Micron 9400 SSD 4KB random read while writing performance is consistently higher than the other leading competitors, reaching a maximum improvement of 23%. Applications respond more quickly by a maximum of 47% (Figure 5b).

16KB Performance: Figure 6a shows that the Micron 9400 SSD 16KB random read performance is again consistently higher than the competitors. Note that the Micron 9400 SSD shows a maximum percentage improvement of 54%, while its maximum operations per second improvement is 22,136. Applications were up to 70% more responsive, as shown in Figure 6b.

Conclusion

Testing the Micron 9400 NVMe SSD RocksDB performance and responsiveness against two leading competitors reveals some important differences. The data in these tests shows that:

1. The Micron 9400 SSD offers superior RocksDB performance across all thread counts for both 4KB and 16KB block sizes, ranging from a 23% improvement to a maximum of 54% improvement.
2. Applications whose storage demands are similar to those tested are more responsive with the Micron 9400 SSD. Improvements range from 32% to 70%.
3. The Micron 9400 SSD application responsiveness is more consistent as the workload increases. This is seen in figure titles ending in "b," including 1b through 6b, where the Micron 9400 SSD's application responsiveness shows far more linearity as the thread count increases.

The Micron 9400 SSD is optimized for high-performance workloads, including those for mixed performance. These workloads cover a broad range of core data center needs, such as caching, database acceleration, online transaction processing, high-frequency trading, artificial intelligence training, content delivery (caching), and performance-focused databases that thrive on extreme performance.

How We Tested

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. Note that SSDs were erased and preconditioned before each test. We also cleared kernel buffers before running each workload using the command: `sync; echo 3 > /proc/sys/vm/drop_caches`

Server Hardware Configuration	
Server	Dell PowerEdge R7525
CPU	AMD EPYC 7713 64-Core Processor
Memory	512GB Micron DDR4-3200
Server Storage	Micron 9400 SSD configuration: 1x Micron 9400 Pro 7.68TB NVMe SSD Competitor C configuration: 1x mixed-use, competitor C 7.68TB NVMe SSD Competitor S configuration: 1x mixed-use, competitor S 7.68TB NVMe SSD
Boot Drive	Micron 7300 Pro 960GB M.2 NVMe SSD
RocksDB version	7.4
OS	CentOS Linux 8
Kernel	4.18.0-348.7.1.el8_5.x86_64

Table 1: RocksDB server 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/9400

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