Micron® Technical Brief: Micron 7400 SSD RocksDB Performance

THE MICRON 7400 SSD BUILDS SOLID PERFORMANCE[1] FOR NoSQL DATABASES

The Micron 7400 PCIe Gen4 SSD with NVM Express™ (NVMe™) is built to meet the demands of rapidly changing data center applications. Not only is it available in the industry's broadest variety of form factors (U.3 as tested here, M.2, and E1.S), but it's designed with flexibility, performance and security to help you get the most from your data center.

This technical brief compares the Micron 7400 SSD to an existing PCIe Gen3 SSD with NVMe[2] using RocksDB and workloads similar to the Yahoo! Cloud Serving Benchmark (YCSB). It shows workloads results across multiple thread counts (#Threads).[3] Aside from different SSDs, each configuration was the same.

Test results showed that the Micron 7400 SSD demonstrated higher peak performance and lower read latency across all tested workloads, resulting in much greater application performance.

Micron chose RocksDB for this comparison because it is built for extreme performance and fast storage.[4] We tested multiple thread counts for both devices (Table 6 details servers and CPUs).

Test results are organized by workload, with a brief workload description and example use case (based on the YCSB workload descriptions from GitHub). See github.com/brianfrankcooper/YCSB.

Figures in this technical brief show database performance (operations per second) and average read latency (in milliseconds) by thread count. Thread counts beyond 256 were not tested due to extremely high latencies.

Fast Facts

The Micron 7400 SSD demonstrated consistently higher peak performance and lower average read latency across all tested workloads than the prior-generation[2] Micron SSD.

Recording User Sessions

44% Higher peak performance
51% Lower average read latency

Tagging Existing Assets

28% Higher peak performance
21% Lower average read latency

Caching User Profiles

11% Higher peak performance
11% Lower average read latency

Status Updates

31% Higher peak performance
21% Lower average read latency

Users Modifying Records

50% Higher peak performance
51% Lower average read latency

1. In this document, we use the terms performance and operations per second interchangeably.
2. We used a U.2 Micron 7300 PCIe Gen3 SSD with NVMe for this comparison. Both the Micron 7400 SSD and the Micron 7300 SSD are 3.84TB versions.
3. We did not test an I/O profile similar to Workload E as it is not universally supported.
4. Retrieved from rocksdb.org/ at the date of this technical brief's publication.

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A Closer Look at Micron 7400 SSD RocksDB Performance

From edge to cloud, your applications demand the fast, low-latency and consistent performance of the Micron 7400 SSD. Built for workloads that demand high throughput and low latency, the Micron 7400 is well suited for broadly deployed, mixed read-write, compute and virtualized workloads like NoSQL databases.

Recording User Sessions

This is an update-heavy workload where about 50% of all the storage I/O is written and 50% is read. Examples of this workload can be seen when user sessions are recorded.

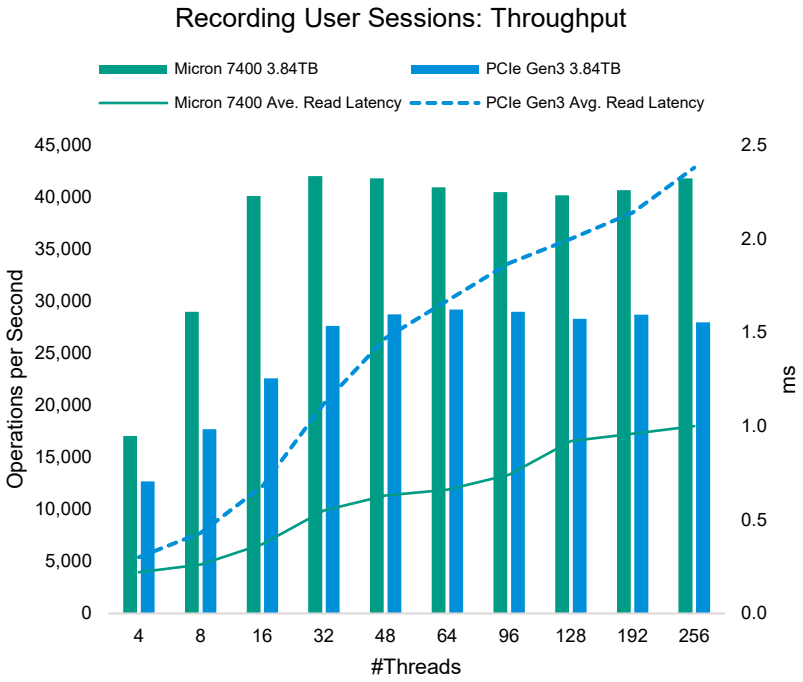

Figure 1: Recording User Sessions Throughput

Recording User Sessions: Peak Throughput vs. #Threads

#Threads	Micron 7400 3.84TB	PCIe Gen3 3.84TB	Micron 7400 Improvement
4	17,060	12,694	34%
8	28,990	17,696	64%
16	40,114	22,591	78%
32	**42,012**	27,635	52%
48	41,805	28,755	45%
64	40,940	**29,195**	40%
96	40,477	28,987	40%
128	40,184	28,317	42%
192	40,679	28,705	42%
256	41,808	27,987	49%

Table 1: Recording User Sessions Details

Workload Analysis

Performance: Figure 1 shows that the Micron 7400 SSD's performance was consistently higher than the PCIe Gen3 SSD's. Table 1 shows the Micron 7400 SSD reached 42,012 peak operations per second compared to just 29,195 operations per second for the PCIe Gen3 SSD (each shown in **bold** in Table 1), a 44% peak performance improvement.

The Micron 7400 SSD showed a 49% increase in operations per second over the PCIe Gen3 SSD when performance improvements are averaged across all tested #Threads.

Latency: The Micron 7400 SSD configuration's average read latency advantage ranged from 27% (#Threads = 4) to 60% (#Threads = 64 and #Threads = 96). When averaged across all #Threads, the Micron 7400 SSD showed a 51% better (lower) value.

Tagging Existing Assets

This workload is read-heavy, comprising approximately 95% read storage I/O and 5% write. Examples of this workload include adding metadata to existing data (tagging). Most of the tags are read while few are written (or rewritten).

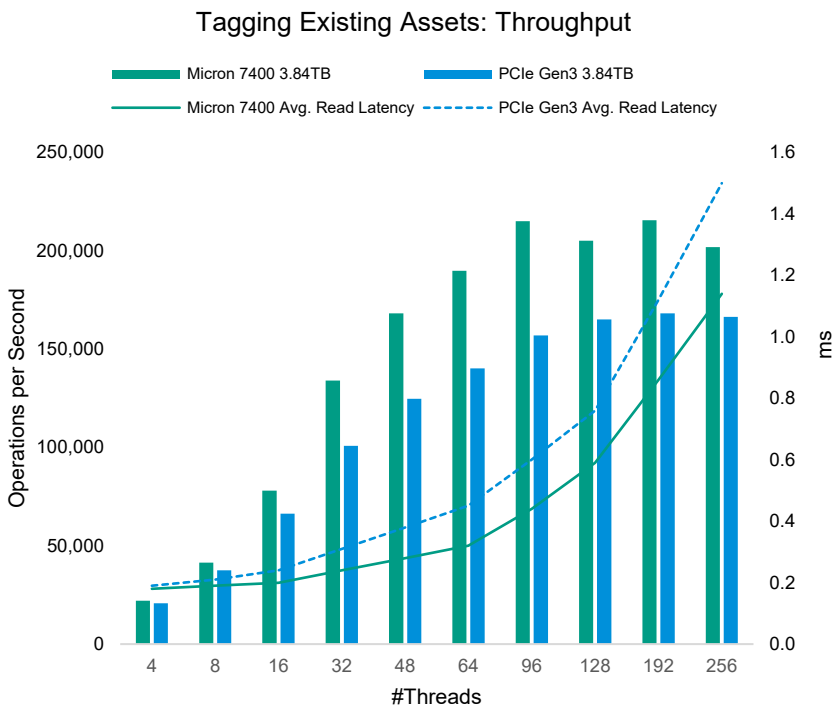

Figure 2: Tagging Existing Assets Throughput

Tagging Existing Assets: Peak Throughput vs #Threads

#Threads	Micron 7400 3.84TB	PCIe Gen3 3.84TB	Micron 7400 Improvement
4	22,056	20,748	6%
8	41,393	37,518	10%
16	78,053	66,341	18%
32	133,932	100,758	33%
48	168,147	124,693	35%
64	189,901	140,182	35%
96	215,049	156,897	37%
128	205,149	165,049	24%
192	**215,569**	**168,213**	28%
256	201,872	166,352	21%

Table 2: Tagging Existing Assets Details

Workload Analysis

Performance: Figure 2 shows that the Micron 7400 SSD's performance was greater than the PCIe Gen3 SSD's, with 215,569 peak operations per second compared to just 168,213 peak operations per second for the Gen3 SSD (each shown in **bold** in Table 2), a 28% peak performance improvement.

Latency: Neither SSD showed marked average read latency increases (spikes). Both SSDs showed average read latencies that started low (#Threads = 4) and smoothly increased with higher #Threads. The PCIe Gen3 SSD higher average read latency is clearly seen when #Threads = 32 and higher.

The Micron 7400 SSD configuration's average read latency advantage ranged from 5% (#Threads = 4) to 29% (#Threads = 64). Both SSDs' read latency started low and stayed low. When averaged across all #Threads, the Micron 7400 SSD showed a 21% better (lower) value.

Caching User Profiles

This workload is 100% read (data does not change). Examples include reading immutable data for user authentication or reading a profile cache (when a user or system profile was created elsewhere).

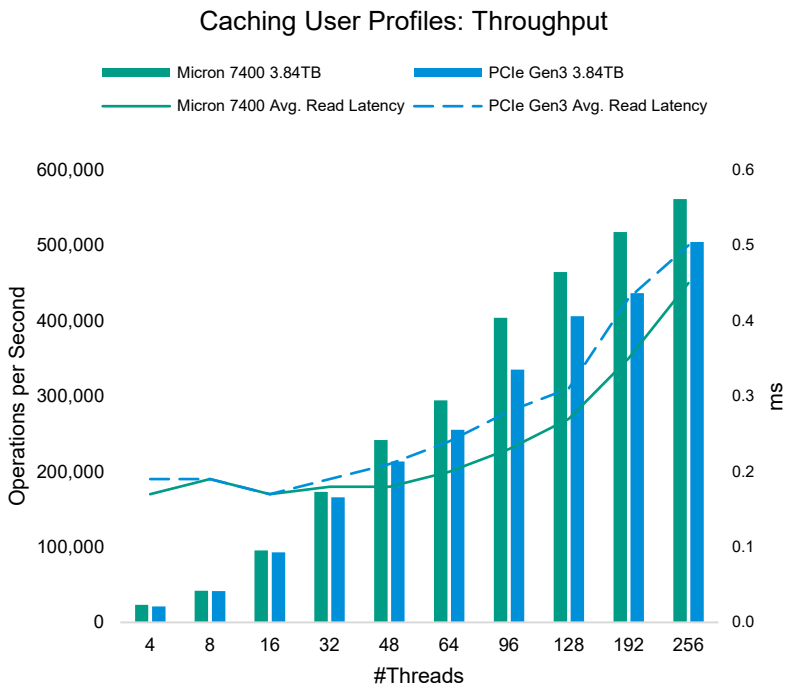

Figure 3: Caching User Profiles Throughput

Caching User Profiles: Peak Throughput vs #Threads

#Threads	Micron 7400 3.84TB	PCIe Gen3 3.84TB	Micron 7400 Improvement
4	23,354	21,053	11%
8	41,883	41,502	1%
16	95,597	92,640	3%
32	173,004	165,879	4%
48	241,911	213,410	13%
64	294,436	255,183	15%
96	403,828	335,116	21%
128	464,611	406,239	14%
192	517,575	436,418	19%
256	**561,359**	**504,687**	11%

Table 3: Caching User Profiles Details

Workload Analysis

Performance: The Micron 7400 SSD's peak performance was 11% higher than the PCIe Gen3 SSD, with 561,359 peak operations per second compared to 504,687 peak operations per second for the Gen3 SSD (each shown in **bold** in Table 3). The 7400 SSD also showed an 11% improvement in average operations per second across all tested #Threads.

Latency: The Micron 7400 SSD configuration's average read latency was nearly identical to the PCIe Gen3 SSD's average read latency when #Threads = 8, increasing to 19% maximum improvement when #Threads = 192.

When averaged across all #Threads, the Micron 7400 SSD showed a 11% better (lower) value.

Status Updates

This workload inserts new records and reads the entire data set uniformly (95% read, 5% insert). This is similar to a social media storage access model, adjusted to ensure additional storage accesses.[5]

Status Updates: Throughput

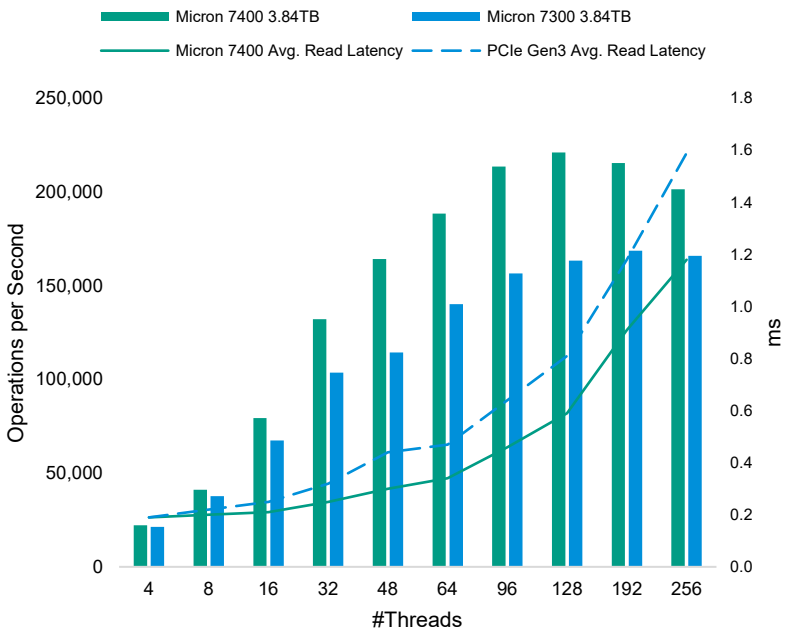

Figure 4: Status Updates Throughput

Status Updates: Peak Throughput vs #Threads

#Threads	Micron 7400 3.84TB	PCIe Gen3 3.84TB	Micron 7400 Improvement
4	22,159	21,296	4%
8	41,218	37,689	9%
16	79,469	67,431	18%
32	132,139	103,624	28%
48	164,202	114,443	43%
64	188,490	140,253	34%
96	213,559	156,511	36%
128	**221,182**	163,442	35%
192	215,576	**168,706**	28%
256	201,591	165,908	22%

Table 4: Status Updates Details

Workload Analysis

Performance: Figure 4 shows that the Micron 7400 SSD's performance was consistently higher than the PCIe Gen3 SSD's. The Micron 7400 SSD showed 221,182 peak operations per second compared to just 168,706 peak operations per second for the Gen3 SSD (each shown in **bold** in Table 4), a 31% peak performance improvement.

The 7400 SSD also showed a 24% average operations per second improvement over the PCIe Gen3 SSD across all tested #Threads.

Latency: While both SSDs showed similar read latency at low #Threads, the Micron 7400 SSD configuration's lower average read latency can be clearly seen at #Threads = 16 and above. Neither SSD showed marked latency increases (spikes). While the PCIe Gen3 SSD's latency also started low (#Threads = 4), it increased rapidly.

The Micron 7400 SSD configuration's average read latency ranged from the same at #Threads = 4 to a maximum of 32% (#Threads = 48). When averaged across all #Threads, the Micron 7400 SSD showed a 21% better (lower) value.

5. Workload D defaults to a preference for reading the recently inserted records. For details on the default access pattern for Workload D, see https://github.com/brianfrankcooper/YCSB/wiki/Core-Workloads

Users Modifying Records

This is a 50% read, 50% write workload. It reads a record, modifies it and then writes it back (read-modify-write). This workload models common database and user activity.

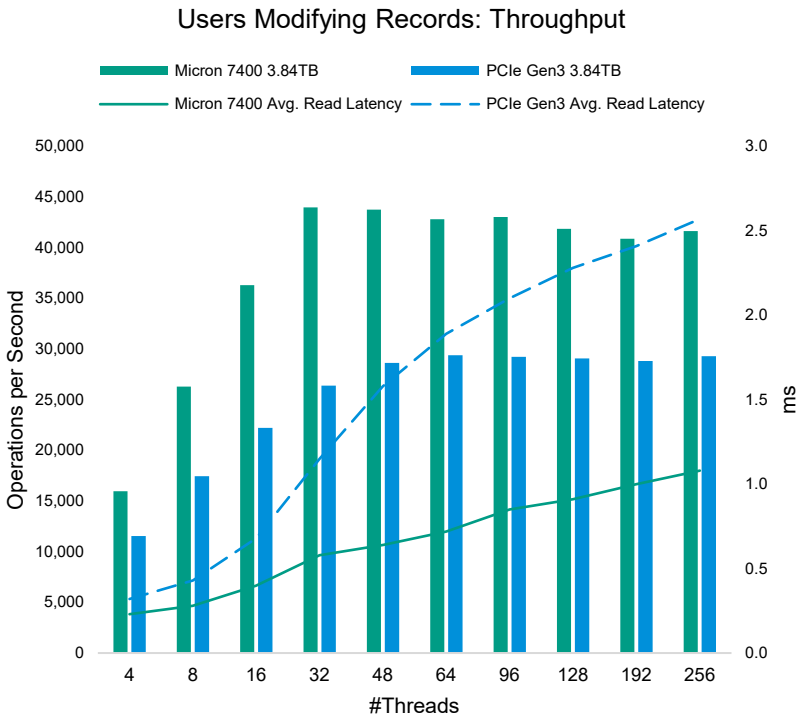

Figure 5: Read-Modify-Write Throughput

Users Modifying Records: Peak Throughput vs. #Threads

#Threads	Micron 7400 3.84TB	PCIe Gen3 3.84TB	Micron 7400 Improvement
4	15,966	11,537	38%
8	26,280	17,453	51%
16	36,299	22,217	63%
32	**43,982**	26,400	67%
48	43,760	28,646	53%
64	42,804	**29,378**	46%
96	43,023	29,235	47%
128	41,869	29,078	44%
192	40,879	28,819	42%
256	41,646	29,293	42%

Table 5: Read-Modify-Write Details

Workload Analysis

Performance: Figure 5 shows the Micron 7400 SSD's performance improvement by #Threads is significant. Even at the lowest #Threads (#Threads = 4), the Micron 7400 SSD reached 38% higher performance.

The Micron 7400 SSD showed 43,982 peak operations per second compared to just 29,378 peak operations per second for the Gen3 SSD, a 50% improvement (each shown in **bold** in Table 5). The Micron 7400 SSD also showed a 49% increase in average operations per second over the PCIe Gen3 SSD across all tested #Threads.

Latency: While both SSDs showed similar read latency at low #Threads, the Micron 7400 SSD configuration's lower read latency can be clearly seen at #Threads = 8 and above. While the Micron 7400 SSD showed a smooth latency increase as #Threads increases, the PCIe Gen3 SSD is not as smooth.

The Micron 7400 SSD configuration's average read latency improvement ranged from 28% (#Threads = 4) to 62% (#Threads = 64). When averaged across all #Threads, the Micron 7400 SSD showed a 51% lower value.

Conclusion

The Micron 7400 SSD with NVMe demonstrated higher peak performance in several common NoSQL use cases. Performance improvements ranged from 11% when caching user profiles to 50% when users are modifying records. These performance increases were not accompanied by read latency increases — just the opposite. Average read latency improvements ranged from 11% (also caching user profiles) to 57% (users modifying records). The small improvement in user profile caching may be due to system limitations like core and thread contention.

This improved performance can have a real-world impact, making the Micron 7400 SSD a great storage building block in your RocksDB clusters. However, PCIe Gen4 increased bandwidth alone doesn't mean that all application and workload performance doubles. You need to look at the application level results to see how a well-architected SSD maximizes the benefit for the application of PCIe Gen4.

How We Tested

Hardware Configuration	
Server	Dell PowerEdge R7525
CPU	AMD EPYC 7713 64-Core Processor
Memory	512GB Micron DDR4-3200
Server Storage	Micron 7400 Configuration: 1x Micron 7400 Pro 3.84TB NVMe SSD PCIe Gen3 Configuration: 1x Micron 7300 Pro 3.84TB NVMe SSD
Boot Drive	Micron 7300 Pro 960GB M.2 NVMe SSD
YCSB Version	YCSB 0.17.0 (HSE fork — https://github.com/hse-project/hse-ycsb)
OS	CentOS Linux 8
Kernel	4.18.0-240.22.1.el8_3.x86_64

Table 6: RocksDB Server Configuration

System/Software Configuration	
File System	XFS
Mount Options	noatime, nodiratime, norelatime
Mount Point	/var/lib/rocksdb

Table 7: Device Configuration

The Yahoo Cloud Service Benchmark (YCSB) framework was originally designed to facilitate performance comparisons between various cloud data serving systems for transaction-processing workloads.

The core workloads provided by YCSB are listed in Table 8.

Use Case	IO Type	Ratio
Recording User Sessions	Update heavy	50% read, 50% write
Tagging Existing Assets	Read mostly	95% read, 5% write
Caching User Profiles	Read only	100% read, 0% write
Status Updates	Insert and read uniformly	95% read, 5% insert
Users Modifying Records	Read-modify-write	50% read, 50% read-modify-write

Table 8: Workload Overview

We used the HSE fork of YCSB due to an issue in the default 0.17.0 RocksDB binding, which caused performance to drop beyond 64 threads. This issue is fixed if YCSB is recompiled with a newer version of RocksDB, but the HSE version already contains this fix. The code can be found at https://github.com/hse-project/hse-ycsb.

The testing methodology was designed to show the performance of a single device to store and access a RocksDB database. Single-device performance differences help characterize their suitability as a storage building block for a broad range of node and cluster configurations. Actual results may vary based on configuration specifics.

The database was initially created by using the YCSB load parameter, which generated a dataset of approximately 1TB. After completing the load, the test sequence (in the order listed) was executed using the following parameters (Table 9). We used a uniform distribution to cause more stress on the storage subsystem.

Parameters	Value	Description
Number of threads (#Threads)	4, 8, 16, 32, 48, 64, 96, 128, 192, 256	Number of threads to generate
Fieldcount	4	4KB record size
Fieldlength	1,024	
Recordcount	250 million	Number of records in the database
Operationcount	200 million	Dataset size within database
Distribution	Uniform	Distribution of record accesses in database for each workload

Table 9: Testing Parameters

Each test sweep ran once for the Micron 7400 SSD with NVMe and once for the PCIe Gen3 SSD with NVMe.

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