OPTIMIZE MICROSOFT® SQL SERVER® ANALYTICS WORKLOADS WITH MICRON® 6500 ION SSD AND MICRON® XTR SSD

Building efficient, optimized analytics platforms requires storage performance,[1] the right SSD endurance[2] and memory optimization. Capacity-focused SSDs like the Micron® 6500 ION deliver the performance needed for analytics workloads, while the endurance-focused Micron® XTR SSD is ideal for write-intensive operations like the tempdb volume — especially when combined with the Micron 6500 ION.[3]

This technical brief discusses analytics workload test results using Microsoft SQL Server with the Micron 6500 ION SSD and the Micron XTR SSD.[4] This affordable all-flash configuration is evaluated against a configuration using the now discontinued[5] Intel® Optane™ P5800x and Micron 6500 ION SSD.

Results Summary:

- Adding memory lowers query processing time (improves performance).
- The Micron XTR SSD performs extremely well for the high-endurance portions of an analytics workload (tempdb volume).
- The Micron XTR SSD paired with the Micron 6500 ION SSD shows the same workload performance as the discontinued Intel Optane P5800x paired with the Micron 6500 ION SSD.

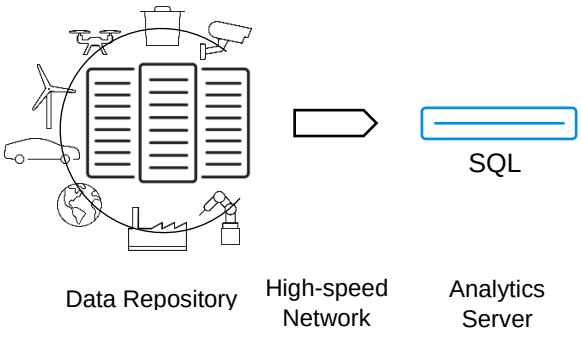

Figure 1: Testing layout overview[6]

Fast Facts

Adding Memory Accelerates Query Processing Time

Expanding the memory capacity provides dramatic improvements in query processing time (i.e., more memory equals faster query processing) for multi-stream analytics workloads. This makes it simple to improve an analytics server by adding additional memory.

However, there may be a point of diminishing returns.

The Micron XTR SSD Has the Right Endurance for Busy Analytics Servers

Increasing memory has the side effect of changing the overall write rate to the tempdb volume.

Active analytics servers write a lot of data to the tempdb volume, regardless of the amount of memory available. As a result, care must be taken when choosing the SSD endurance rating for the tempdb volume.

Micron XTR SSD delivers excess endurance for this task — even when analytics servers are extremely busy.

Micron XTR SSD Paired With the Micron 6500 ION SSD Is a Highly Performant Combination

SSDs on SQL Server work in a pseudo-tiered combination, with a high-capacity SSD used for the main data store and a high-speed, high-endurance companion for internal database task storage (tempdb).

The Micron XTR SSD (tempdb drive) paired with the Micron 6500 ION SSD (primary storage) shows nearly the same query processing times as a now-discontinued Intel Optane P5800x (tempdb drive) when paired with the same-data store SSD.

These results show that the Micron XTR SSD is an excellent choice that is available at a far lower price point.[7]

1. In this document, performance means database query completion time, storage throughput (in MB/s), or any combination thereof.
2. In this document, endurance means the SSD's rated endurance.
3. See https://learn.microsoft.com/en-us/sql/relational-databases/databases/tempdb-database?view=sql-server-ver16 for more information on tempdb.
4. Additional information on the NVMe™ SSDs used is available here: www.micron.com/6500ION and www.micron.com/XTR.
5. See the notice posted here: https://www.intel.com/content/www/us/en/support/articles/000091826/memory-and-storage.html. These tests used an Intel Optane P5800x, 1.6TB, U.2 form factor. All stated capacities are unformatted. 1GB = 1 billion bytes. Formatted capacity is less.
6. Example deployment for the type of SQL analytics platform evaluated. Other deployments and configurations may produce different results.
7. Based on publicly available list pricing information available at the time of this document's publication.
8. The TPC-H specification benchmark measures decision-support system performance. The TPC home page has additional details: http://www.tpc.org/tpch/#:~:text=The%20TPC%2DH%20is%20a,have%20broad%20industry%2Dwide%20relevance.

ADDING MEMORY REDUCES QUERY RUN TIME (IMPROVES PERFORMANCE)

This section discusses the query processing speed effects of adding additional memory to SQL Server with multiple, simultaneous queries (an analytics workload).

About Multiple Stream Workloads

All tests used a multiple-stream workload, with results that reflect multiple queries being run concurrently. Completion time for all queries is measured. Lower query completion time is better.

Scaling Memory Lowers Query Completion Time

Figure 2 shows that adding memory to the server results in decreased completion time (shown in green).

Increasing memory from 256GB to 384GB results in a 13% query completion time reduction, while an additional increase from 384GB to 512GB results in a further reduction of 14%.

Note that these results are specific to the database, hardware configuration, and queries evaluated. Exact differences may be observed at different points.

These results are also shown in Table 1.

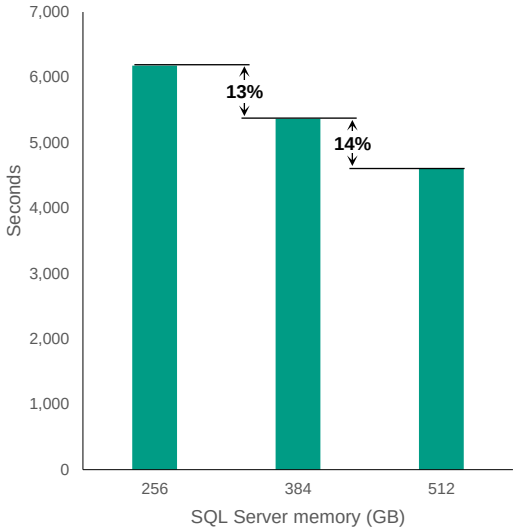

Figure 2: Multi-stream query run time improvement versus server memory

SQL Server Memory (GB)	Queries Run Time (seconds)	Improvement
256	6,179	Baseline
384	5,366	13%
512	4,606	14%

Table 1: Memory capacity and query completion time

MICRON XTR SSD ENDURANCE EASILY MEETS TEMPDB VOLUME NEEDS

When selecting the optimal SSD configuration for an analytics workload, endurance may not be the first consideration. This is because analytics workloads are typically thought of as read-intensive (about 99% read for the main data store).[9] However, the overall endurance story is more complex and the tempdb volume endurance must also be considered.

This section analyzes the tempdb SSD volume endurance requirements for that SSD to stay at or below its rated total endurance. This section assumes that the analytics platform operates continuously at maximum performance for 24 hours per day over a platform lifecycle of five years. It compares these requirements versus the rated endurance for the Micron XTR SSD and Intel Optane.

9. Based on empirical test data.

Write Rates for the tempdb Volume Are Demanding

Figure 3a represents the tempdb volume write rate as additional memory is added to SQL Server (moving along the x-axis from left to right). The tempdb volume write rate decreases from its maximum of 482 MB/s at 256GB of server memory down to 458 MB/s at 512GB of server memory — about 42 TB/day maximum across the tested memory values.

The write rate decreases due to the additional memory enabling the server to process more queries in-memory, which allows access the tempdb storage volume less frequently.

Micron XTR SSD Has More Than Enough Endurance

Figure 3b represents tempdb volume write traffic in TB written per day for 256GB, 384GB, and 512GB of memory available to SQL Server, with the dashed gray line representing the tempdb volume required endurance rating in TB written per day (TB/day) to support a five-year platform lifespan.

The highest TB/day write value shown in Figure 3b coincides with 384GB of memory available to the SQL Server. The tempdb volume SSD endurance rating would need to meet or exceed 42 TB/day to support this.

The solid blue line at the top of Figure 3b represents the rated endurance (in TB/day) for the Micron XTR SSD 1.92TB (67.2 TB/day for five years).

Figure 3b clearly shows that tempdb volume write traffic in this test is well within the rated endurance (in TB/day) for the Micron XTR SSD. This indicates that the Micron XTR SSD has sufficient endurance to serve this workload for five years.[10]

MICRON XTR SSD SHOWS THE SAME PERFORMANCE AS INTEL OPTANE

Figure 4 shows query processing time for the two tested SQL Server configurations. The blue bars represent the query completion times for Micron XTR SSD combined with the Micron 6500 ION SSD, while the gray bars represent the query completion times for an Intel Optane P5800x combined with the same-capacity database storage drive.

Comparing the results of each SQL Server memory value (along the x-axis) shows little to no difference in query completion time for these two configurations.

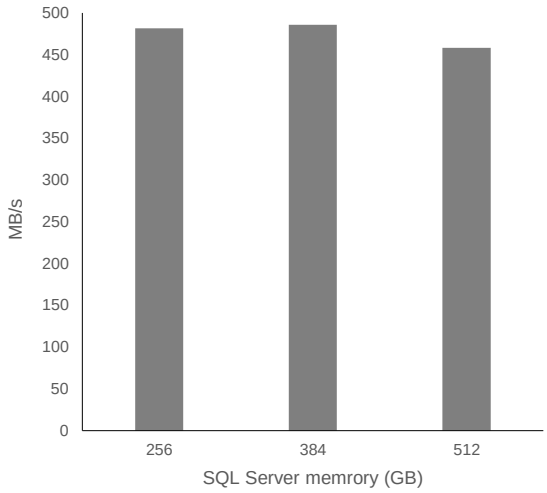

Figure 3a: tempdb volume write rate versus server memory

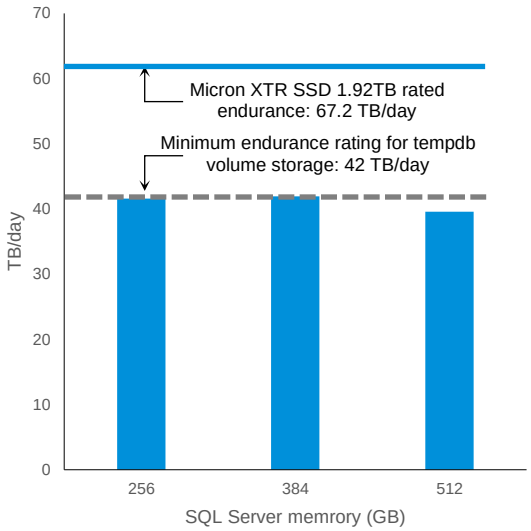

Figure 3b: tempdb write rate versus Micron XTR SSD rated endurance

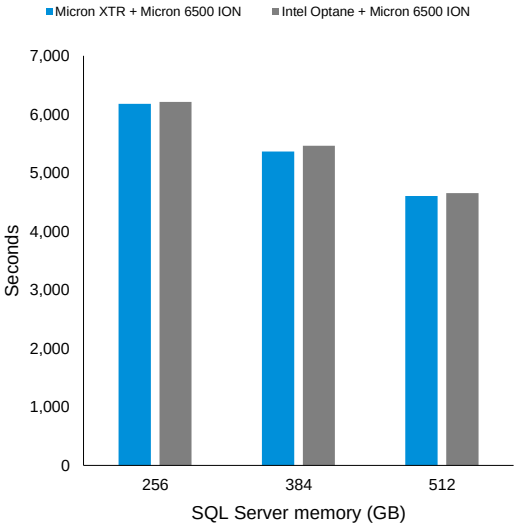

Figure 4: Query run time comparison

10. See https://www.micron.com/support/sales-support/returns-and-warranties/enterprise-ssd-warranty for warranty details.

This comparison indicates that the Micron XTR SSD combination provides nearly identical performance as the Intel Optane configuration in real-world SQL Server analytics workloads while exceeding endurance needs.

CONCLUSION

When designing SQL analytics platforms, these three elements are essential to consider:

1. **Adding memory improves results:** Additional memory can speed analytics queries while also changing the intensity of the tempdb workload. This is one of the simplest ways to improve performance.
2. **The Micron 6500 ION is well-suited for analytics workloads:** Its leading 30.72TB capacity and best-of-breed performance[11] compared to competing QLC SSDs make the Micron 6500 ION SSD an excellent choice for large, active database storage as the active data store.
3. **The Micron XTR SSD easily supports tempdb volume endurance requirements:** Increasing memory has a side effect — it changes the overall tempdb storage write rate. It is necessary to plan for SSD endurance appropriately. The Micron XTR SSD shows more than sufficient endurance for these tests and is readily available, while the Intel Optane P5800x is not.

Sizing analytics platforms correctly, understanding the resultant workload changes, and identifying endurance needs can help ensure that a system is built right the first time.

11. Best-of-breed is defined as high-capacity (32TB), value-focused, data center NVMe SSDs.

TEST DETAILS

Hardware

Database Server	Qty.	Description
Server	1	Supermicro® AS-1115CS-TNR
CPU	1	AMD® EPYC 9654 96-Core Processor
Database Volume	1	Micron 6500 ION SSD (30.72TB)
tempdb Volume	1	Micron XTR SSD (1.92TB)
		Intel Optane P5800x (1.6TB)
Storage: OS	1	Micron 7450 PRO NVMe SSD (960GB)

Table 2: Hardware Configuration

Software

Database Server	Ver.	Description
Rocky Linux	8.5	Operating System
Microsoft SQL Server	2019	Microsoft SQL Server 2019 Enterprise Core Edition (x64)

Table 3: Operating System and Database Software

Test Process

The following steps were completed prior to testing:

1. Restored SSDs to fresh-out-of-box (FoB)[12] state (via NVMe format)
2. Created partitions or namespaces for:
    - Data
    - tempdb

    Note: During testing, the refresh functions were not used. Consequently, there was no activity to the SQL logs, so they remained on the boot device with the SQL Server application. Your configuration may differ.

3. Restored database from a previously created backup
4. Created columnstore indexes
5. Gathered statistics

For each test run, the following steps were completed:

1. Set database parameters
2. Restarted database
3. Started data captures
4. Began query execution
5. Completed queries
6. Stopped data captures

12. For a better understanding of FoB state and other SSD performance states, see “Understanding SSD Performance Using the SNIA SSS Performance Test Specification,” Section 2: https://www.snia.org/sites/default/files/UnderstandingSSDPerformance.Jan12.web .pdf