



Optimizing Microsoft SQL Server 2022 on Lenovo ThinkSystem SR650 V3

Solution Brief

Data growth problem and a solution

In today's world information is a valuable asset that demands the right tools to collect and manage critical business data. As the volume and velocity of data increase, however, extracting meaningful insight in a timely manner becomes more complex. It's important for businesses of all sizes to choose a database solution that matches the requirements of the company, resulting in the most efficient outcome.

Lenovo Solutions for Microsoft SQL Server on ThinkSystem SR650 V3 are optimized for both Online Transaction Processing (OLTP) and Data Warehouse (DW) and are **Accelerated by Intel** offerings. This technical brief features Microsoft SQL Server 2022 running on a high-performance Lenovo dual-socket 2U rack mount enterprise server. The server can support both 4th and 5th Generation Intel® Xeon® Scalable processors, TruDDR5 4800MHz memory and P5620 NVMe drives among a variety of storage options, including support for the PCIe 5.0 standard devices for I/O. The Intel 5th generation processors support up to 64 cores, 385 watts and 96GB 5600 speed memory (The performance test section provides a comparison between 4th and 5th generation Intel processors).

The SR650 V3 server is a storage dense offering, with up to 40 2.5" drive bays in the front, middle and rear of the server and 5 different slot configurations at the rear of the server. Onboard NVMe PCIe ports allow direct connections to 16 NVMe SSDs, which frees up PCIe slots and lowers NVMe solution acquisition costs.

Enterprise database solutions with faster time-to-value

Lenovo SR650 V3 systems are methodically tested and tuned to save you months of configuration, setup, testing, and tuning. With these new servers, you get the following advantages:

- Realize 40% better performance for workloads running on 4th generation Intel Xeon Scalable processors than on similar servers equipped with previous generation processors
- Improve performance of SQL Server solutions with higher core counts, memory bandwidth and PCIe Gen 5 devices
- Improve density and support more and larger databases per host

Highlights

- Reduce time to value with pretested and sized hardware configurations
- Simplified evaluation, fast and easy deployment and workload optimized performance
- Database sized solution with optimal compute, memory, storage and networking components
- Reduce TCO through better performance, rapid deployment and advanced hardware
- Optimize performance with pretested ThinkSystem SR650 V3 hardware configurations

Microsoft SQL Server 2022

SQL Server 2022 includes updates to existing features like Intelligent Query Processing in addition to management, platform or language.

Starting with SQL 2022, runtimes for R, Python, and Java are no longer installed with SQL Setup. Instead, install any desired custom runtime(s) and packages.

Here are some performance enhancements in SQL Server 2022:

- Improvements have been made to all columnstore indexes that benefit from enhanced segment elimination by data type.
- Concurrent updates to global allocation map pages reduce page latch contention
- Improvements in buffer pool scan operations on large-memory systems by using multiple CPU cores for parallel scans
- Improvements to Clustered ColumnStore Indices to sort existing data in memory before index builder compresses the data
- Support for Intel QuickAssist Technology (QAT) backup compression with software or hardware acceleration
- TempDB performance enhancements for scalability
- Shrink database uses low priority processing to minimize impact on performance
- In-memory OLTP enhancements

Here are some management improvements:

- Additional Azure integration
- Link to Azure SQL Managed Instance
- Accelerated Database Recovery (ADR)
- Always On Availability Group enhancements

SQL Server Enterprise Edition delivers comprehensive database capabilities with end-to-end business intelligence, enabling high service levels for mission-critical workloads. SQL Server Standard Edition includes basic database and business intelligence for smaller organizations that need less features, benefiting from the lower cost compared to SQL Server Enterprise Edition. A detailed comparison of SQL editions can be found [here](#).

Lenovo ThinkSystem SR650 V3

Lenovo ThinkSystem SR650 V3 offerings are ideal for modernizing your legacy SQL Server applications because of their low cost and high-performance capabilities. They are industry standard x86 servers providing cost effective computing and fast high-density local storage.

Lenovo ThinkSystem SR650 V3 servers offer the necessary performance for bare metal or virtualized SQL Servers. High performance can be achieved using Hyper-V and Storage Spaces Direct technology which are built into Windows Server. Several technologies like NVMe storage and Remote Direct Memory Access (RDMA) networking are natively supported in Windows Server to enable the highest levels of performance.

The configurations feature the following main components:

Table 1. Lenovo Solution Configurations

Database	Microsoft SQL Server 2022 Enterprise Edition	Microsoft SQL Server 2022 Standard Edition
OS	Microsoft Windows Server 2022	Microsoft Windows Server 2022
Server	Lenovo ThinkSystem SR650 V3	Lenovo ThinkSystem SR650 V3
Processor	2x 4th Gen Intel Xeon Scalable, 6448Y 2.1 GHz 32 core	2x 4th Gen Intel Xeon Scalable, 8444H 2.9 GHz 16 core
Memory	1TB of TRUDDR5 4800 MHz memory	2TB of TRUDDR5 4800 MHz memory
DB Storage	6x Intel P5620 3.2TB NVMe SSDs	6x Intel P5620 1.6TB NVMe SSDs
Log Storage	2x Intel P5620 3.2TB NVMe SSDs Raid1	2x Intel P5620 1.6TB NVMe SSDs Raid1
OS Storage	2x 480GB M.2 SATA SSDs for the operating system (RAID 1)	2x 480GB M.2 SATA SSDs for the operating system (RAID 1)

These high-performance database solutions with Microsoft SQL Server 2022 Enterprise and Standard Editions feature the latest Intel Optane NVMe SSDs. These SSDs help build a low latency solution for mission critical SQL Server applications.

Backup Compression and Off-Loading

SQL Server 2022 introduces backup performance improvements with a new compression algorithm and hardware offloading and acceleration with Intel QuickAssist Technology (QAT).

Improvements can be seen with either software only compression or by using Intel hardware that supports QAT offloading and acceleration. Intel offers on-chip QAT hardware offloading with the latest Intel Xeon Scalable processors. **SQL Server 2022 Enterprise Edition supports hardware or software QAT while SQL Server 2022 Standard Edition only supports software QAT.**

The benefits of hardware QAT include:

- Reduced backup capacity
- Minimal CPU impact
- Minimal workload impact
- Faster backups
- Faster restores

In software only mode, it still utilizes the Intel QAT algorithm to improve backup times.

The table below shows Lenovo test results of hardware mode QAT backups. We saw considerable performance improvement over the standard MS_XPRESS compression method and additional improvement with Intel Gen5 processors.

Backup and Restore Tests

The tests were run with the server under load, at 98% CPU usage, backing up a 1000 scale TPCB database. This is where the most benefit can be seen with QAT as it performs a hardware offload to improve backup performance. There is significant improvement over the standard SQL compression during heavy loads.

Table 2. Comparison of MS_XPRESS and Intel QuickAssist Technology (QAT) Compression (with 4th and 5th Gen processors)

Compression Type	Time (sec)	MB/sec	Backup File Size
MS_XPRESS			
Backup	2299	216	390 GB
Restore	994	500	
QAT HW Offloaded			
Backup			
- with 4th Gen 8480+ processors	919	542	357 GB
- with 5th Gen 8592V processors	810	594	357 GB
Restore			
- with 4th Gen 8480+ processors	447	1112	
- with 5th Gen 8592V processors	405	1203	

Enable and Configure QAT

Enable QAT:

```
sp_configure 'show advanced options', 1
```

```
GO
```

```
RECONFIGURE with override
```

```
GO
```

```
sp_configure 'hardware offload enabled', 1
```

```
GO
```

```
RECONFIGURE with override
```

```
GO
```

Restart SQL to apply

Enable QAT hardware mode

```
ALTER SERVER CONFIGURATION
```

```
SET HARDWARE_OFFLOAD = ON (ACCELERATOR = QAT)
```

Restart SQL to apply

Verify QAT status:

```
SELECT * FROM  
sys.dm_server_accelerator_status;  
GO
```

Restart the SQL instance to apply changes

Run Backups

No compression

```
BACKUP DATABASE [TPC-H1000] TO DISK = 'D:\backups\MSSQL1.bak' WITH FORMAT, NO_COMPRESSION
```

MS_XPRESS compression

```
BACKUP DATABASE [TPC-H1000] TO DISK = 'D:\backups\MS-XPRESS.bak' WITH FORMAT, COMPRESSION (ALGORITHM =  
MS_XPRESS)
```

```
GO
```

QAT compression

```
BACKUP DATABASE [TPC-H1000] TO DISK = 'D:\backups\QAT-DEFLATE.bak' WITH FORMAT, COMPRESSION (ALGORITHM  
= QAT_DEFLATE)
```

```
GO
```

Best practices for running SQL Server Enterprise Edition on ThinkSystem SR650 V3

For a high-performance SQL Server solution, implement the following best practices:

- Configure UEFI (Bios) settings to set Operating mode to Maximum performance.
- Configure power profile in Windows Server to 'High performance'.
- SQL server database and log drives are recommended to be formatted with 64KB NTFS cluster size.
- SQL server database and log files should be on separate physical drives.
- The OS and SQL server binary drives are recommended to be formatted with standard 4KB NTFS cluster size.
- TempDB is shared by many processes and users as a temporary working area and should be configured appropriately. Default configuration will be suitable for most workloads. Use the install experience for guided configuration. More info in [Microsoft TempDB Database documentation](#).
- If the server is dedicated to the SQL Server workload, use the default dynamic memory management model or follow Microsoft SQL documentation guidelines for manually configuring memory options if finer grain control is desired.



Figure 1. Lenovo ThinkSystem SR650 V3

Best practices for running SQL Server Standard Edition on ThinkSystem SR650 V3

For a high-performance SQL Server Standard Edition solution, implement the following best practices:

- Configure UEFI (BIOS) settings to set Operating mode to Maximum performance.
- Enable Hyper-threading in the BIOS
- In the Bios, set the core count per processor to 12 because SQL Standard Edition is limited to 48 processors. With 2 sockets, and Hyper-threading enabled this equals 48.
- Configure power profile in Windows Server to 'High performance'.
- SQL server database and log drives are recommended to be formatted with 64KB NTFS cluster size.
- SQL server database and log files should be on separate physical drives.
- The OS and SQL server binary drives are recommended to be formatted with standard 4KB NTFS cluster size.
- TempDB is shared by many processes and users as a temporary working area and should be configured appropriately. Default configuration will be suitable for most workloads. Use the install experience for guided configuration. More info in [Microsoft TempDB Database documentation](#).
- If the server is dedicated to the SQL Server workload, use the default dynamic memory management model or follow Microsoft SQL documentation guidelines for manually configuring memory options if finer grain control is desired.

Performance Testing Details and Results

HammerDB Configuration and Intel Gen 3 - Gen 4 - Gen 5 Comparison

HammerDB is an open-source load testing / benchmarking tool for databases available at: <http://www.hammerdb.com>. It offers tools for testing performance on OLTP and Analytics workloads. The OLTP workload is based on TPC-C benchmark from <http://www.tpc.org> and the Analytics workload is based on TPC-H benchmark from [tpc.org](http://www.tpc.org). Hammerdb 4.7 was run on a separate load server. Below are details of the testing and results.

Table 3. TPC-C and TPC-H performance testing details and results

Database tested	MS SQL Server 2022 Enterprise Edition	MS SQL Server 2022 Enterprise Edition	MS SQL Server 2022 Enterprise Edition	MS SQL Server 2022 Standard Edition
Processor Generation	SR650 V3 - 5th Gen Intel Xeon SP	SR650 V3 - 4th Gen Intel Xeon SP	SR650 V2 - 3rd Gen Intel Xeon SP	SR650 V3 - 4th Gen Intel Xeon SP
Hardware Configuration	ThinkSystem SR650 V3, 2x Intel Xeon 8562Y+ processors, 1TB 5600MT/s memory, Intel P5620 NVMe drives	ThinkSystem SR650 V3, 2x Intel Xeon 6448Y 32 core processors, 1TB memory, Intel P5620 NVMe drives	ThinkSystem SR650 V2, 2x Intel Xeon 8380 processors, 2TB memory, Intel P5600 NVMe drives	ThinkSystem SR650 V3, 2x Intel Xeon 8444H 16 core 2.9 Ghz processors, 2TB memory, Intel P5620 NVMe drives
Benchmarks simulated	TPC-C and TPC-H	TPC-C and TPC-H	TPC-C and TPC-H	TPC-C and TPC-H
Database size: TPC-C	100 GB, 800 warehouse, distributed over 8 NVMe drives (6 DB, 2 Log)	100 GB, 800 warehouse, distributed over 8 NVMe drives (6 DB, 2 Log)	100 GB, 800 warehouse, distributed over 8 NVMe drives (6 DB, 2 Log)	100 GB, 800 warehouse, distributed over 8 NVMe drives (6 DB, 2 Log)
Database size: TPC-H	1000 Scale Factor	1000 Scale Factor	1000 Scale Factor	
Run time parameters: TPC-C				
Virtual users	150	150	150	150
User delay	1 ms	1 ms	1 ms	1 ms
Run time parameters: TPC-H				
Virtual users	7	7	7	7
Scale	1000	1000	1000	1000
TPC-C results				
TPM (million)	6.64	5.63	4.49	3.67
TPC-H results				
QpH	2438	1739	1251	95

TPM = Transactions per minute; QpH = Queries per hour

Bill of Materials (Enterprise Edition solution)

Table 4. Bill of Materials (Enterprise Edition solution - 4th Gen processors)

7D76CTO1WW	Server: ThinkSystem SR650 V3 - 3yr Warranty	1
BLKK	ThinkSystem V3 2U 24 x 2.5" Chassis	1
BPQD	Intel Xeon Gold 6448Y 32C 225W 2.1GHz Processor	2
BKTN	ThinkSystem 64GB TruDDR5 4800 MHz (4Rx4) 3DS RDIMM	16
BNEH	ThinkSystem 2.5" U.2 P5620 3.2TB Mixed Use NVMe PCIe 4.0 x4 HS SSD	8
B8LU	ThinkSystem 2U 8 x 2.5" SAS/SATA Backplane	1
BH8D	ThinkSystem 2U/4U 8 x 2.5" NVMe Backplane	1
BM8X	ThinkSystem M.2 SATA/x4 NVMe 2-Bay Enablement Kit	1
BQ20	ThinkSystem M.2 960GB 5400 Pro SATA 6Gbps Non-Hot Swap SSD	2
BCD6	ThinkSystem Intel E810-C-Q2 2 port Ethernet Adapter 10/25 GbE	1
BLKM	ThinkSystem V3 2U x16/x16/E PCIe Gen4 Riser1 or 2	2
BMUF	ThinkSystem 1800W 230V Platinum Hot-Swap Gen2 Power Supply	2
BLL6	ThinkSystem 2U V3 Performance Fan Module	6
BRQ1	ThinkSystem SR650 V3,SATA CBL,SLx8-SLx4,M.2-M.2(MB),150mm	1
BSYM	ThinkSystem SR650 V3,PCIe4 Cable,Swift8x-SL8x,2in1,PCIe 6/5(MB) to BP1/BP2/td>	1
BETS	ThinkSystem V3 2U SFF C0 (RAID) to Front 8x2.5" BP1	1
BPE3	ThinkSystem SR650 V3 MCIO8x to SL8x CBL, PCIe4, 8x2.5 AnyBay, 200mm	2
BQ12	G4 x16/x16/E PCIe Riser BLKM for Riser 1 Placement	1
BQ19	G4 x16/x16/E PCIe Riser BLKM for Riser 2 Placement	1
7S0XCTO2WW	Lenovo XClarity XCC2 Platinum Upgrade	1
5641PX3	XClarity Pro, Per Endpoint w/3 Yr SW S&S	1
1340	Lenovo XClarity Pro, Per Managed Endpoint w/3 Yr SW S&S	1
QAA8	SR650 V3 3Y STANDARD	1

Bill of Materials (Standard Edition solution)

Table 5. Bill of Materials (Standard Edition solution)

7D76CTO1WW	Server: ThinkSystem SR650 V3 - 3yr Warranty	1
BLKK	ThinkSystem V3 2U 24 x 2.5" Chassis	1
BPPH	Intel Xeon Platinum 8444H 16C 270W 2.9GHz Processor	2
BNFC	ThinkSystem 128GB TruDDR5 4800 MHz (4Rx4) 3DS RDIMM	16
B8NY	ThinkSystem RAID 940-8i 4GB Flash PCIe Gen4 12Gb Adapter	1
BNEG	ThinkSystem 2.5" U.2 P5620 1.6TB Mixed Use NVMe PCIe 4.0 x4 HS SSD	8
B8LU	ThinkSystem 2U 8 x 2.5" SAS/SATA Backplane	1
BH8D	ThinkSystem 2U/4U 8 x 2.5" NVMe Backplane	1
BM8X	ThinkSystem M.2 SATA/x4 NVMe 2-Bay Enablement Kit	1
AUUV	ThinkSystem M.2 128GB SATA 6Gbps Non-Hot Swap SSD	2
B93E	ThinkSystem Intel I350 1GbE RJ45 4-port OCP Ethernet Adapter	1
BLKM	ThinkSystem V3 2U x16/x16/E PCIe Gen4 Riser1 or 2	2
BMUF	ThinkSystem 1800W 230V Platinum Hot-Swap Gen2 Power Supply	2
BLL6	ThinkSystem 2U V3 Performance Fan Module	6
BRQ1	ThinkSystem SR650 V3,SATA CBL,SLx8-SLx4,M.2-M.2(MB),150mm	1
BSYM	ThinkSystem SR650 V3,PCIe4 Cable,Swift8x-SL8x,2in1,PCIe 6/5(MB) to BP1/BP2/td>	1
BETS	ThinkSystem V3 2U SFF C0 (RAID) to Front 8x2.5" BP1	1
BPE3	ThinkSystem SR650 V3 MCIO8x to SL8x CBL, PCIe4, 8x2.5 AnyBay, 200mm	2
BQ12	G4 x16/x16/E PCIe Riser BLKM for Riser 1 Placement	1
BQ19	G4 x16/x16/E PCIe Riser BLKM for Riser 2 Placement	1
7S0XCTO2WW	Lenovo XClarity XCC2 Platinum Upgrade	1
5641PX3	XClarity Pro, Per Endpoint w/3 Yr SW S&S	1
1340	Lenovo XClarity Pro, Per Managed Endpoint w/3 Yr SW S&S	1
QAA8	SR650 V3 3Y STANDARD	1

Accelerated by Intel

To deliver the best experience possible, Lenovo and Intel have optimized this solution to leverage Intel capabilities like processor accelerators not available in other systems. Accelerated by Intel means enhanced performance to help you achieve new innovations and insight that can give your company an edge.



Why Lenovo

Lenovo is a US\$70 billion revenue Fortune Global 500 company serving customers in 180 markets around the world. Focused on a bold vision to deliver smarter technology for all, we are developing world-changing technologies that power (through devices and infrastructure) and empower (through solutions, services and software) millions of customers every day.

For More Information

To learn more about this Lenovo solution contact your Lenovo Business Partner or visit:
<https://www.lenovo.com/us/en/servers-storage/solutions/database/>

References:

Lenovo ThinkSystem SR650 V3: <https://lenovopress.lenovo.com/lp1601>

Microsoft SQL Server 2022: <https://learn.microsoft.com/en-us/sql/sql-server/what-s-new-in-sql-server-2022?view=sql-server-ver16>

Related product families

Product families related to this document are the following:

- [Microsoft Alliance](#)
- [Microsoft SQL Server](#)
- [ThinkSystem SR650 V3 Server](#)

Notices

Lenovo may not offer the products, services, or features discussed in this document in all countries. Consult your local Lenovo representative for information on the products and services currently available in your area. Any reference to a Lenovo product, program, or service is not intended to state or imply that only that Lenovo product, program, or service may be used. Any functionally equivalent product, program, or service that does not infringe any Lenovo intellectual property right may be used instead. However, it is the user's responsibility to evaluate and verify the operation of any other product, program, or service. Lenovo may have patents or pending patent applications covering subject matter described in this document. The furnishing of this document does not give you any license to these patents. You can send license inquiries, in writing, to:

Lenovo (United States), Inc.
8001 Development Drive
Morrisville, NC 27560
U.S.A.
Attention: Lenovo Director of Licensing

LENOVO PROVIDES THIS PUBLICATION "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Some jurisdictions do not allow disclaimer of express or implied warranties in certain transactions, therefore, this statement may not apply to you.

This information could include technical inaccuracies or typographical errors. Changes are periodically made to the information herein; these changes will be incorporated in new editions of the publication. Lenovo may make improvements and/or changes in the product(s) and/or the program(s) described in this publication at any time without notice.

The products described in this document are not intended for use in implantation or other life support applications where malfunction may result in injury or death to persons. The information contained in this document does not affect or change Lenovo product specifications or warranties. Nothing in this document shall operate as an express or implied license or indemnity under the intellectual property rights of Lenovo or third parties. All information contained in this document was obtained in specific environments and is presented as an illustration. The result obtained in other operating environments may vary. Lenovo may use or distribute any of the information you supply in any way it believes appropriate without incurring any obligation to you.

Any references in this publication to non-Lenovo Web sites are provided for convenience only and do not in any manner serve as an endorsement of those Web sites. The materials at those Web sites are not part of the materials for this Lenovo product, and use of those Web sites is at your own risk. Any performance data contained herein was determined in a controlled environment. Therefore, the result obtained in other operating environments may vary significantly. Some measurements may have been made on development-level systems and there is no guarantee that these measurements will be the same on generally available systems. Furthermore, some measurements may have been estimated through extrapolation. Actual results may vary. Users of this document should verify the applicable data for their specific environment.

© Copyright Lenovo 2024. All rights reserved.

This document, LP1750, was created or updated on December 15, 2023.

Send us your comments in one of the following ways:

- Use the online Contact us review form found at:
<https://lenovopress.lenovo.com/LP1750>
- Send your comments in an e-mail to:
comments@lenovopress.com

This document is available online at <https://lenovopress.lenovo.com/LP1750>.

Trademarks

Lenovo and the Lenovo logo are trademarks or registered trademarks of Lenovo in the United States, other countries, or both. A current list of Lenovo trademarks is available on the Web at <https://www.lenovo.com/us/en/legal/copytrade/>.

The following terms are trademarks of Lenovo in the United States, other countries, or both:

Lenovo®

AnyBay®

ThinkSystem®

XClarity®

The following terms are trademarks of other companies:

Intel®, Intel Optane™, and Xeon® are trademarks of Intel Corporation or its subsidiaries.

Microsoft®, Azure®, Hyper-V®, SQL Server®, Windows Server®, and Windows® are trademarks of Microsoft Corporation in the United States, other countries, or both.

TPC, TPC-C, and TPC-H are trademarks of Transaction Processing Performance Council.

Other company, product, or service names may be trademarks or service marks of others.