Reference Architecture: SQL Server on ThinkSystem SR665 V3 with AMD 5th Gen processors

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Technical overview of AMD Turin architecture on ThinkSystem servers

Contains SQL Server performance test data and sizing guidance

Covers reliability and performance benefits of 5th generation AMD solutions

Includes detailed configuration and best practices for optimized performance

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Table of Contents

1 Introduction

This document describes the reference architecture for Microsoft SQL Server 2022 on Lenovo ThinkSystem SR665 servers running AMD 5th generation processors. This paper is intended to provide the planning, design considerations, and best practices for implementing Microsoft SQL Server 2022 on AMD 9005 based Lenovo servers.

Lenovo supports the newest addition to the AMD EPYC family, the 5th Gen AMD EPYC 9005 series processors, formerly codenamed “Turin”. These processors are supported on the ThinkSystem V3 servers that currently support the 4th Gen "Genoa" processors.

Organizations continue to deploy additional server hardware at an unprecedented pace as the demand for data center processing increases. SQL server provides many companies critical data storage and processing. The ability to consolidate multiple instances of SQL server on powerful servers is key to managing scalable growth and ensuring hardware efficiency. Lenovo’s high storage density servers provide fast reliable local storage options for SQL server deployments.

Microsoft SQL Server is one of the most widely adopted business critical database solutions which requires an infrastructure layer with consistent performance, high availability, and simplified management. There is an evolution of modern hardware platforms like the Lenovo SR665 v3 taking place. Server CPU cores counts are increasing dramatically, 25/100Gbps networking is growing rapidly, and NVMe SSD drives of NAND flash technology are becoming dominant. It is time to redefine how SQL Server environments can leverage the new hardware platform to take a big leap forward.

In this solution, we provide design and virtualized sizing guidance, solution validation reports, and best practices for enterprise infrastructure administrators and SQL Server application workload owners to run virtualized SQL Server workloads.

The intended audience of this document is IT professionals, technical architects, sales engineers, and consultants to assist in planning, designing and implementing Microsoft SQL Server on Lenovo servers. It is assumed that the reader is familiar with the concepts, administration and operations of Microsoft SQL Server, Windows command line, Lenovo ThinkSystem rack servers, and related components.

2 Business problem and business value

This section will cover some of the business problems modern IT organizations are facing, followed by how this solution solves the problem and provides business value.

2.1 Business problem

In many of today's enterprise data centers, IT administrators are overwhelmed by excessive amounts of data. Traditional servers no longer provide the return on investment nor meet the required performance efficiency to manage all of this data. Companies are also faced with increasing data storage costs and inadequately tuned hardware bandwidth.

Additionally, organizations are struggling with complex processes and manual operating procedures that introduce potential for human error while managing the companies most critical data. Configuring high availability is often a complex task that ends up misconfigured resulting in data loss or business down time. IT managers would rather spend time optimizing and running the business applications, not worrying about the underlying infrastructure.

2.2 Business value

Consolidated SQL server configurations provide a high level of performance and efficiency from next-generation hardware devices with optimized throughput, superior efficiency, enhanced resilience, and agile operation. Business critical applications like SQL Server are one of the top use cases for virtualized workloads that offer reduced internal storage costs compared to legacy storage solutions.

Lenovo enables customers to focus on the outcome of mission-critical applications rather than on building your infrastructure by providing simple, pre-tested, and cost-effective solutions to support the business needs.

Here are the benefits of deploying SQL Server on powerful Lenovo SR665 V3 5th Gen AMD servers:

- Next-generation storage: The Lenovo SR665v3 unlocks the capabilities of modern hardware by adding optimization for high-performance, internal NVMe-based flash devices.
- Reliable resilience: RAID backed volumes, whether hardware or software based, improves data availability with hot spare fail-over and cloud-based data protection workflows for backup/restore. Additionally, SQL Server 2022 offers redundancy and disaster recovery options, covered below.
- Intuitive operations: Windows Server 2025 provides simplified operations for storage device provisioning and servicing, and proactive insights to detect anomalies and prevent potential issues with Windows Admin Center.
- Lenovo high density storage servers deliver scalable and consistent performance for mission-critical SQL Server database workloads.

3 Architectural overview

This section covers the solution architecture, including the SQL Server environment, and the Lenovo SR665 AMD based server.

The diagram below shows the high-level typical SQL Server 2022 architecture. It deploys a standard client server architecture with clients connecting to applications and SQL databases for online data processing (OLTP) or data warehouse (DW) workloads. SQL Server uses a common set of tools to deploy and manage databases for in-house and cloud environments The SQL workloads rely on the Lenovo SR665 V3 AMD servers and internal storage arrays for data storage and processing.

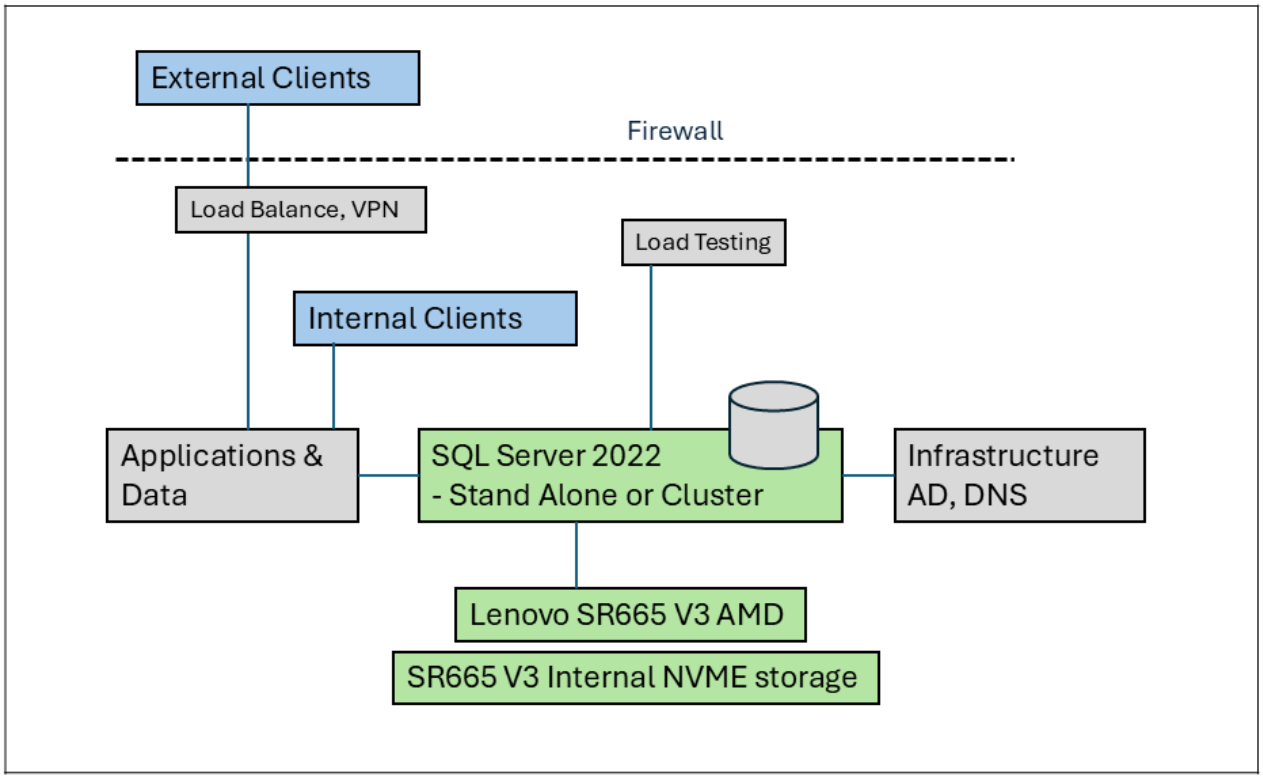

Figure 1 SQL Server 2022 high level architecture

The drawing below shows the system architecture of dual socket Lenovo servers with AMD 5th generation processors. The figure shows a block diagram of the SR665 V3, showing the major components and their connections.

Note that one of the xGMI links between the processors can be used instead as two PCIe 5.0 x16 connections. These PCIe connections can be used for additional NVMe drive support.

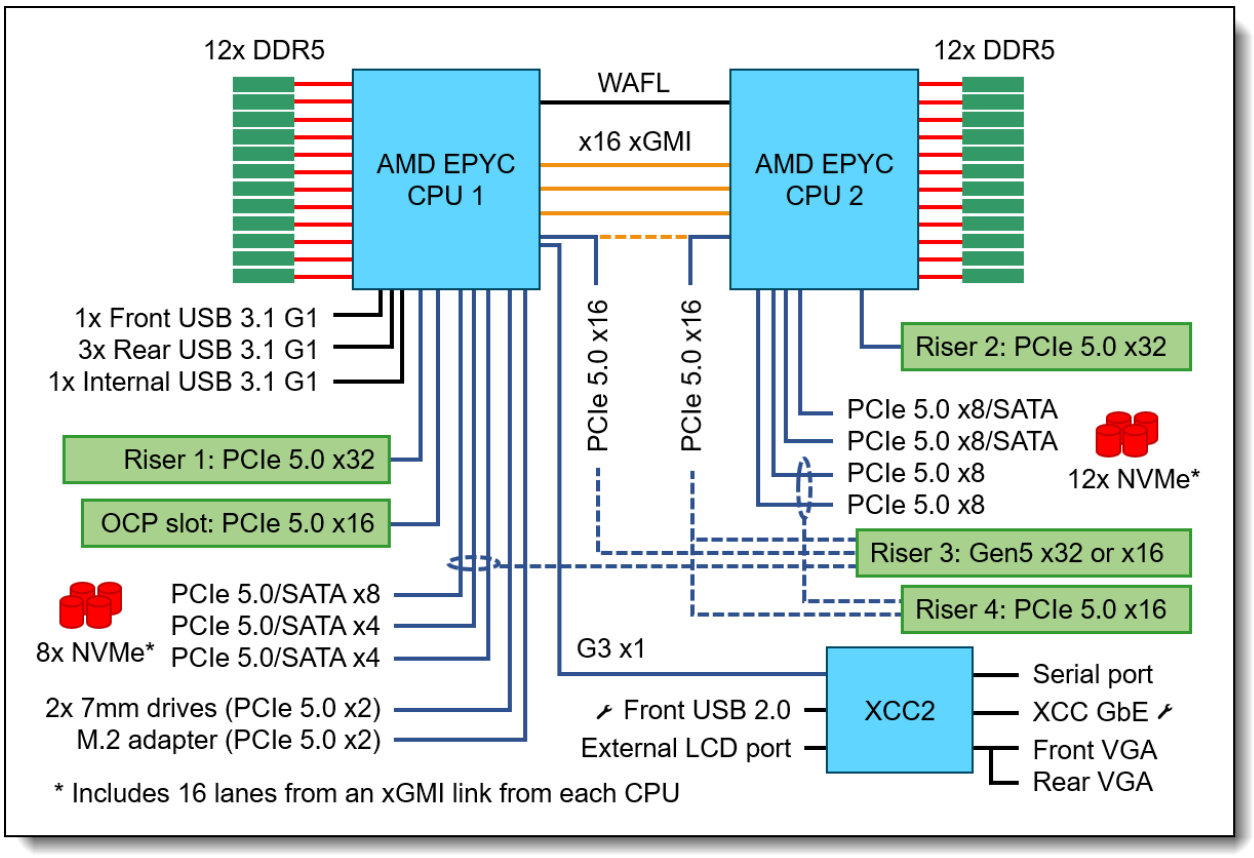

Figure 2 Hardware architecture of the Lenovo SR665 V3 server

4 Component model

The solution technology components covered in this section include the following:

- Microsoft Windows Server 2025 Operating System
- Lenovo ThinkSystem SR665 v3 AMD Turin based servers
- Microsoft SQL Server 2022

4.1 Microsoft Windows Server 2025 OS

Windows Server 2025 is Microsoft's latest operating system for server environments. It builds on the Windows 11 foundation, with several enhancements.

Security enhancements include system features like Hotpatching, allowing security updates without restarts, and strengthened Active Directory security with LDAP encryption and TLS 1.3 support. Hybrid cloud Integration offers seamless integration with Azure Arc, enabling unified management across on-premises and cloud environments.

Performance improvements are faster networking and storage capabilities, including GPU partitioning for edge inferencing, enhancing overall system performance. User experience improvements such as a modernized desktop experience, aligning with Windows 11 look and feel, and includes Bluetooth connectivity and the Windows Terminal for improved usability.

Windows Server 2025 is available in Standard, Datacenter, and Datacenter: Azure Edition editions, catering to diverse organizational needs.

4.2 Lenovo ThinkSystem SR665 V3 AMD based servers

Lenovo ThinkSystem servers are a fully integrated system built on the most reliable and secure servers that are tested and validated for SQL Server performance. The SR665 V3 servers help you modernize your core data center and deploy a reliable high performance database environment.

ThinkSystem SR665 V3 servers support the latest 5th Gen AMD EPYC™ processor family CPU´s that include enhancements in performance, security, and energy efficiency. These next generations support new DDR memory, PCIe Gen5 PCIe I/O. All-NVMe SSD models support inline de-duplication, compression, and encryption to give you an optimized, secure, high-performance platform with maximum usable capacity.

The Lenovo ThinkSystem SR665 V3 is a 2-socket 2U server that features the 5th Gen AMD EPYC 9005 "Turin" family of processors. With up to 160 cores per processor and support for the new PCIe 5.0 standard for I/O, the SR665 V3 offers the ultimate in two-socket server performance in a 2U form factor. The server is ideal for dense workloads that can take advantage of high-speed processing and high-performance NVMe drives.

Figure 3 Front view of Lenovo SR665 V3 server

4.3 Microsoft SQL Server 2022

Microsoft SQL Server 2022 is a data platform to help ensure uptime with fully managed disaster recovery, high availability and integration with Azure cloud services and management. It takes advantage of performance and availability for faster queries and to help ensure business continuity and accelerate query performance and tuning with no code changes required.

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.

Performance enhancements in SQL Server 2022 include:

- 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
- TempDB performance enhancements for scalability
- Shrink database uses low priority processing to minimize impact on performance
- In-memory OLTP enhancements

SQL Server management improvements include:

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

In this solution, we adopted SQL Server 2022 workloads on Lenovo ThinkSystem series using all NVMe SSD drives with Windows 2025 RAID to demonstrate unprecedented performance capability, scalability, and resiliency.

The main two virtualization options are virtual machines or scale out SQL Server instances. The total number of transactions attained on one server is usually higher with multiple instances or VMs. For this paper we used the multiple instances approach.

5 Deployment considerations

This section covers the solution deployment resources and configuration, including the following.

- Hardware resources
- Software resources
- Network configuration
- Storage configuration
- SQL Server HA considerations

5.1 Hardware resources

The solution was composed of the following hardware.

Table 1 Hardware configuration (per server)

PROPERTY	SPECIFICATION
Server model name	Lenovo ThinkSystem SR665 V3
CPU	2 x AMD 9355 32C 3545 Mhz 5th Gen (Turin) Processors
RAM	2.2 TB DDR5 5600
Network adapter	ThinkSystem Broadcom 57414 10/25GbE SFP28 2-port PCIe Ethernet Adapter ThinkSystem Broadcom 5719 1GbE RJ45 4-port OCP Ethernet Adapter
Disks	8 x 3.8 TB NVMe for databases 4 x same for Logs

5.2 Software resources

The following software and levels were used in the solution.

Table 2 Software resources

Software	Version	Purpose
Windows Server 2025	24H2	Operating System

Microsoft SQL Server 2022 Enterprise	RTM-CU16 16.0.4165.4	Microsoft SQL Server database server platform
HammerDB	4.2	Generate OLTP workload derived from TPC-C like benchmark

5.3 Network configuration

SQL Server typically requires a 25GbE network to support the high-speed client network. In this solution, we used 10/25 GbE network between the client or testing tool server to exploit the capabilities of high-performing NVMe devices and avoid any network bottleneck. The HammerDB test tool typically uses up to 3 Gb/s of bandwidth per instance connection.

5.4 Storage Configuration

In this solution, we used Windows RAID for the databases on an 8 disk RAID 0 striped array for maximum performance. The logs were on a pair of 2 disk RAID1 mirrored arrays. The OS boot drive used a M.2 SSD mirror.

5.5 SQL Server HA considerations

This section covers SQL Server high availability options.

SQL Server supports two types of high availability and disaster-recovery technologies that are both fully supported: Always on Availability Groups (AG) and Failover Cluster Instances (FCI).

Always On Availability Group

SQL Server AG maximizes the availability of a set of user databases that fail over together—primary database and up to 8 secondary replicas, to a separate server with non-shared storage. By running AG's it provides database-level HA protection.

Failover Cluster Instance

SQL Server FCI is used to create a highly scalable and high-performance solution. Windows Cluster Shared Volumes (CSV) provide access to shared storage via Storage Spaces Direct (S2D) with resiliency and failover. By taking advantage of CSVs, shared disks that are required by SQL Server FCI are easy to manage, and simple to migrate without the need for separate shared SAN storage.

5.6 Best practices

The following list of recommendations provide the best practices and sizing guidance to run SQL Server on Windows Server 2025.

Size the SQL Server instance or VM based on the performance and capacity requirements of the desired workload in terms of the database customer count, IOPS numbers, and others for typical OLTP workloads.

Avoid over-committing physical CPU resources even if hyper-threading is enabled, since over-committing CPU resources does not guarantee further performance.

For mission-critical workloads to achieve better performance, configure the Operating Mode for Maximum Performance in the BIOS settings.

Enable Hyper-Threading in the BIOS settings or experiment with it on and off depending on workload.

Configure the power profile in Windows Server to "High performance".

Set the Windows page file to fixed size of 4 GB and ensure is not on and data drives. We lock pages in memory below anyway to avoid SQL Server using the page file.

Used fixed size virtual disks (VHD) for the SQL data drives not dynamic thin provisioned.

SQL Server database and log drives are recommended to be formatted with 64KB NTFS cluster size.

The OS and SQL Server binary drives can be formatted with standard default 4KB NTFS cluster size.

High performance can be achieved using multiple Hyper-V virtual machines or with multiple instances of SQL Server. Technology like low latency NVMe storage is natively supported in Windows Server to enable the highest levels of performance.

TempDB is shared by many processes and users as a temporary working area. Default configuration will be suitable for most workloads. Use the SQL install experience for guided configuration. More info in Microsoft TempDB Database documentation. Experiment to determine whether more or larger TempDB files are beneficial for your test environment.

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. In general, the recommendation is to reserve 80% of available memory for SQL.

Use 25Gbps network as a minimum requirement. For better performance and throughput, consider 40Gbps/100Gbps network for mission-critical SQL Server workloads.

Use RDMA capable network adapters to offload host CPU utilization and boost the SQL Server workloads.

Use multiple database files and separate data, log, and TempDB on different virtual disks.

For mission-critical workloads, configure the max degree of parallelism (MAXDOP) depending on the number of logical processors per NUMA node. For OLTP workloads, this is usually set to 1 which disables parallelism. However, consider experimenting with different MAXDOP settings depending on your test environment. See *Configure the max degree of parallelism*.

6 Solution validation

This section covers the solution testing. It includes the monitoring and benchmark tools, configuration and final results.

6.1 Monitoring tools

The following tools were used to monitor and log the performance testing.

Windows Performance Monitor

Windows Performance Monitor is a Windows tool that enables users to capture statistics about CPU, memory, and disk utilization from operating system levels. It also provides counters for monitoring SQL Server performance and status.

Here are the major performance counters we collected during the tests:

- Logical disk
- Processor information
- SQL Server: Database TPS

HammerDB Transaction Counter

HammerDB provides a real-time graph view of the transactions rates occurring. This can help gauge whether the test is performing as expected or is experiencing performance bottlenecks. The pattern should be mostly even, without strong peaks and valleys.

6.2 Workload generation tool

The OLTP workload tested in this solution is derived from Microsoft TPC-C using HammerDB. This tool can run industry-standard benchmark and scalability testing. With HammerDB, you can verify your database environment size and loads.

HammerDB is an open-source load testing and benchmarking tool for databases, available from http:///www.hammerdb.com. It offers tools for testing performance of OLTP and Analytics workloads. The OLTP workload is based on TPC-C benchmark from http://www.tpc.org. Hammerdb was run on separate load servers to avoid impacting performance of the system under test (SUT). Network connectivity between the load server and SUT should allow for 3 Gb/s bandwidth per instance.

6.3 Performance Test Results

This section covers the test server configuration details and results of performance testing.

Important note: The OLTP workload tested in this solution is derived from the TPC-C Benchmark and is not comparable to published TPC-C Benchmark results, as the implementation does not comply with all requirements of the TPC-C Benchmark. The TPM results published in this solution is a normalized value.

Benchmarks simulated: TPC-C and TPC-H on 4 and 8 SQL instances

Database size: Each instance has a 100 GB database, comprised of 800 warehouses.

Processor: AMD 5th Generation 9355 32 core

Run time parameters:
Virtual users: 400
User delay: 1 ms

The following table lists the benchmark results.

Table 3 Benchmark results

Metric TPC-C	**4 Instances total**	**8 Instances total**
Transactions Per Minute (TPM)	12 million	14.6 million

Metric TPC-H	**1 Instance**	
Queries per Hour (QpH)	Results coming soon	

6.4 Processor generation comparisons

This section looks at the previous CPU generation and compares the sizing and performance results.

These comparisons were done over several years, and by different teams, so the test methods and parameters may vary slightly.

The following table summarizes the comparisons of TPC-C results

Table 4 Benchmark details and comparison

Processor generation	SR665 V3, 5th Gen AMD Turin 9355 32C 3.5 GHz	SR665 V3, 4th Gen AMD Genoa 9334 32C 2.7 GHz
Database tested	SQL 2022 Enterprise	SQL 2022 Enterprise
Hardware configuration (per node)	2.2 TB RAM, 5600 DDR5 12, 3.8TB NVMe	1.5 TB RAM 8, 3.2TB NVMe
Warehouses	800	800

Virtual Users	400	400
TPM (million) 8 VMs		16
TPM (million) 8 Instances	14.6 Further testing in progress	

7 Conclusion

Running SQL Server on Windows Server 2025 and Lenovo ThinkSystem SR665 V3 with AMD 5th Gen processors is a fast way to unlock capabilities, improve efficiency, and achieve high performance on a next-generation hardware platform for mission-critical database workloads.

In this solution we demonstrated the performance of consolidating SQL Server instances as opposed to one large bare metal instance. By combining the latest hardware advancements with the rich feature set of Windows Server 2025, resiliency and high performance can be achieved with technology that comes built into Windows Server.

8 Appendix: Lenovo Bill of materials

This appendix contains the bill of materials (BOMs) for the solution.

The BOM lists in this appendix are not meant to be exhaustive and must always be double-checked with the configuration tools. Any discussion of pricing, support, and maintenance options is outside the scope of this document.

Server: ThinkSystem SR665 V3-3yr Warranty	1
ThinkSystem V3 2U 24x2.5" Chassis	1
Operating mode selection for: "Maximum Performance Mode"	1
Data Center Environment 30 Degree Celsius / 86 Degree Fahrenheit	1
ThinkSystem AMD EPYC 9335 32C 210W 3.0GHz Processor	2
ThinkSystem SR665 V3 2U High Performance Heatsink	2
Platform Secure Boot Enable	1
ThinkSystem 96GB TruDDR5 6400MHz (2Rx4) RDIMM-A	24
Select Storage devices - no configured RAID required	1
Non RAID NVMe	1
ThinkSystem 2.5" U.3 PM1733a 3.84TB Read Intensive NVMe PCIe 4.0 x4 HS SSD	16
ThinkSystem 2U/4U 8x2.5" NVMe Backplane	2
ThinkSystem M.2 NVMe 2-Bay RAID Adapter	1
M.2 NVMe	1
ThinkSystem M.2 PM9A3 960GB Read Intensive NVMe PCIe 4.0 x4 NHS SSD	2
ThinkSystem Broadcom 5719 1GbE RJ45 4-port OCP Ethernet Adapter	1
ThinkSystem Broadcom 57414 10/25GbE SFP28 2-port PCIe Ethernet Adapter	1
ThinkSystem V3 2U x16/x16/E PCIe Gen4 Riser1 or 2	1
ThinkSystem V3 2U x16/x16/E PCIe Gen4 Riser1 or 2	1
ThinkSystem 1800W 230V Titanium Hot-Swap Gen2 Power Supply	2
2.8m, 13A/100-250V, C13 to C14 Jumper Cord	2
ThinkSystem 2U V3 Performance Fan Module	6
ThinkSystem Toolless Slide Rail Kit v2	1

Resources

To learn more about this Lenovo solution contact your Lenovo Business Partner or visit the following pages.

- *Microsoft SQL Server 2022*
- *Lenovo ThinkSystem SR665 V3 AMD 5th Gen*
- *Windows Server 2025 new features*

Document history

Version 1.0	March 2025	First version of document, based on Lenovo RA template

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