

Behind the Report:

Bare Metal with NVMe[®] RAID Comes Out on Top

This document provides the system-configuration details and step-by-step procedures that Prowess Consulting used to perform benchmark testing on the following Dell Technologies™ platforms:

- 1 x Dell™ PowerEdge™ R750 server with Dell™ PowerEdge™ RAID Controller 11 (PERC 11) H755N Front (NVM Express[®] [NVMe[®]])
- 1 x PowerEdge R740xd server with Dell PERC 10 H740P Front (Serial ATA [SATA])

For the full analysis, read the report at www.prowesscorp.com/project/dell-poweredge-r750-bare-metal-with-nvme-raid-boosts-performance/.

Testing was concluded on August 4, 2023.

Server Configurations

Configuration	Dell™ PowerEdge™ Server Platform	
Server	1 x Dell™ PowerEdge™ R740xd	1 x Dell™ PowerEdge™ R750
Processor	Intel® Xeon® Gold 6238 processor	Intel® Xeon® Gold 6338 processor
Number of CPUs	2	2
Cores/threads per CPU	22/44	32/64
Cores/threads total	44/88	64/128
Frequency (base/SCT/MCT)	2.10 GHz	2.00 GHz
Storage controller 01	Dell™ PowerEdge™ RAID Controller 10 (PERC 10) H740P Front Broadcom® LSI	Dell™ PowerEdge™ RAID Controller 11 (PERC 11) H755N Front Broadcom® LSI
Disk	960 GB Samsung® MZ7LH960HBJR0D3 SATA SSD	3.2 TB KIOXIA® Dell™ CM6 MU NVMe® SSD (KCM6X-VUL3T20)
Number of disks	16	8
Storage controller 02	Dell™ Boot Optimized Server Storage (BOSS)-S1	Dell™ PERC 11 H755N Front NVMe® Broadcom® controller
Disk	240 GB Intel® SSDSCKKB240G8R M.2 SATA	3.2 TB KIOXIA® Dell™ CM6 MU NVMe® SSD (KCM6X-VUL3T20)
Number of disks	2	8
Storage controller 03	–	Marvell® Technology Group Ltd. Dell™ BOSS-S2
Disk	–	480 GB Micron® MTFDDAV480TDS
Number of disks	–	2
Installed Memory	256 GB	256 GB
Memory DIMM	SK hynix® HMA84GR7JJR4N-WM DDR4	SK hynix® HMA82GR7DJR8N-XN 16 GB dual-rank DDR4

Memory speed	2,933 megatransfers per second (MT/s)	3,200 megatransfers per second (MT/s)
Number of memory DIMMs	8 x 32 GB	16 x 16 GB
Network	Broadcom® BCM57416 NetXtreme® E-Series dual-media 10 Gb remote direct memory access (RDMA) Ethernet controller NetXtreme® BCM5720 Gb Ethernet PCIe® 25 Gb dual-port Intel® Ethernet Network Adapter E810-XXV	1 x Broadcom® advanced dual 25 Gb Ethernet
Operating system (OS)	Red Hat® Enterprise Linux® 8.5 (Ootpa)	Red Hat® Enterprise Linux® 8.8 (Ootpa)
OS kernel	Linux® 4.18.0-348.20.1.el8_5.x86_64	Linux® 4.18.0-477.15.1.el8_8.x86_64
BIOS version	2.13.3	1.10.2
OS performance profile	Tuned for Microsoft® SQL Server®	Tuned for Microsoft® SQL Server®
Microsoft SQL Server version	Microsoft® SQL Server® 2019 (RTM-CU15) (KB5008996)—15.0.4198.2 (x64)	Microsoft® SQL Server® 2022 (RTM-CU6) (KB5027505)—16.0.4055.4 (x64)

Testing Summary

Prowess Consulting engineers ran tests comparing the following two configurations:

- A single PowerEdge R750 bare-metal server with two Dell PERC 11 H755N Front controllers and eight 3.2 TB Dell™ NVMe CM6 drives, running Red Hat® Enterprise Linux® 8.8 with Microsoft® SQL Server® 2022 (RTM-CU6)
- A single PowerEdge R740xd bare-metal server with a Dell PERC 10 H740P Front controller and sixteen 960 GB Samsung SATA MZ7LH960HBJR0D3 drives, running Red Hat Enterprise Linux 8.5 with SQL Server 2019 (RTM-CU15)

Testing Procedures

We completed the following procedures on both servers to test SQL Server performance using the BenchCraft benchmarking tool on the standalone PowerEdge R750 and PowerEdge R740xd servers.

Red Hat® Enterprise Linux® Installation and Configuration

1. Launch the server into Integrated Dell™ Remote Access Controller (iDRAC).
2. Select **Install firmware updates**.
3. On the **Firmware update** page, select **Dell website**, and then click **Next**.
4. On the **Firmware update: Launch firmware update** page, click **Next**.
5. If prompted for **Proxy**, click **Yes**.
6. Select the **Updates** page, review the updates, and then click **Apply**.
7. Reboot the server when directed.
8. Log in to iDRAC.
9. Select **Storage > Overview**.
10. Select the first RAID controller.
11. From the **Actions** drop-down menu, select **Create Virtual Disk**.
 - a. On the **Set up virtual disk** page, select or enter the following:
 - i. **Name: Data**
 - ii. **Controller: PERC H755N Front (Embedded)**
 - iii. **Layout: RAID-5**
 - iv. **Media Type: SSD**
 - v. **Physical Disk Selection: New Group**
 - vi. **Security: Disabled**
 - vii. **Stripe Element Size: 64 KB**
 - viii. **Read Policy: No Read Ahead**
 - ix. **Write Policy: Write Through**
 - x. **Disk Cache Policy: Disabled**

- b. Select the **Physical Disk** page, select eight disks, and then click **Next**.
 - c. On the **Virtual Disk Settings** page, click **Next**.
 - d. On the **Confirmation** page, click **Add to Pending**.
 - e. Click **Apply Now**.
 - f. On the **Information** page, click **OK**.
12. Select the second RAID controller.
13. From the **Actions** drop-down menu, select **Create Virtual Disk**.
 - a. On the **Set up virtual disk** page, select/enter the following:
 - i. **Name: Logs**
 - ii. **Controller: PERC H755N Front (Embedded)**
 - iii. **Layout: RAID-10**
 - iv. **Media Type: SSD**
 - v. **Physical Disk Selection: New Group**
 - vi. **Security: Disabled**
 - vii. **Stripe Element Size: 256 KB**
 - viii. **Read Policy: No Read Ahead**
 - ix. **Write Policy: Write Through**
 - x. **Disk Cache Policy: Disabled**
 - b. Complete the same steps as above to create the Data Virtual Disk RAID configuration.
14. Reboot the server, if needed, to begin the RAID creation job.
15. From iDRAC, select the virtual remote connection to the server.
16. Select **Virtual Media**.
17. On the **Map CD/DVD** page, select **Map device**.
18. In the **Location** field, select the **Red Hat Enterprise Linux ISO**, and then click **Map device**.
19. Click **Close**.
20. Click **Boot**, and then select **Virtual CD/DVD/ISO**.
21. Reboot the server.
22. When booted into the Red Hat Enterprise Linux installation media, select **Install Red Hat Enterprise Linux 8.8**.
23. From the **Welcome to Red Hat Enterprise Linux** page, leave the default settings, and then click **Continue**.
24. Select **Date and Time**, update to **Pacific time zone**, and then click **Done**.
25. Select **Root password**, enter the same password twice, and then click **Done**.
26. Select **Software selection**, select **Server**, and then click **Done**.
27. Select **Installation destination**.
28. Select the Dell™ Boot Optimized Server Storage (BOSS) disk location.
29. From **Storage configuration**, click **Custom**.
 - a. Click **Done**.
 - b. Under **New Red Hat Enterprise Linux 8.8 installation**, click **Click here to create them automatically** to create the mount points.
 - c. Update the mount points as follows:
 - **/home: 100 GiB**
 - **swap: 16 GiB**
 - **/root:** remaining disk space
 - d. Click **Done**.
30. If prompted, click **Accept Changes**.
31. Click **Network and Host name**.
 - a. In the **Host Name** field, enter a name for the server.
 - b. From the network adapter list, enable network interface controllers (NICs) that are connected, and then click **Done**.
32. Click **Connect to Red Hat**.
 - a. Enter account information to connect to Red Hat services, click **Register**, and then click **Done**.
33. Click **Begin Installation**.
34. When installation is complete, click **Reboot system**.
35. Log in to the server.

36. Run the following command to get the IP address:

```
ip a
```

37. Run the following command to install updates:

```
dnf update -y && dnf upgrade -y
```

38. Run the following commands to enable additional Red Hat Enterprise Linux repository access:

```
subscription-manager repos --enable codeready-builder-for-rhel-8-$(arch)-rpms
dnf install https://dl.fedoraproject.org/pub/epel/epel-release-latest-8.noarch.rpm
dnf install -y epel-release
```

39. Run the following command to install fio:

```
dnf install fio -y
```

40. Run the following command to precondition the disks:

```
fio --ioengine=libaio --invalidate=1 --fsync_on_close=1 --direct=1 --output=steady.tmp --norandommap --
numjobs=8 -- name=/dev/<deviceID> --filename=/dev/<deviceID> --rw=write --bs=4k --iodepth=32 --randrepeat=0
--size=2000G
fio --ioengine=libaio --invalidate=1 --fsync_on_close=1 --direct=1 --output=steady.tmp --norandommap --
numjobs=8 --name=/dev/<deviceID> --filename=/dev/<deviceID> --rw=write --bs=4k --iodepth=32 --randrepeat=0
--size=2000G
```

41. Run the following command to install the SQL Server Red Hat Enterprise Linux TuneD profile:

```
yum install tuned-profiles-mssql
```

42. Run the following command to set the SQL Server TuneD profile:

```
tuned-adm profile mssql
```

43. Run the following command to verify the SQL Server TuneD profile:

```
tuned-adm active
```

44. Run the following command to download the SQL Server 2022 Red Hat Enterprise Linux repository config file:

```
sudo curl -o /etc/yum.repos.d/mssql-server.repo https://packages.microsoft.com/config/rhel/8/mssql-
server-preview.repo
```

45. Run the following command to install SQL Server 2022:

```
yum install -y mssql-server
```

46. Run the following command to configure SQL Server 2022:

```
/opt/mssql/bin/mssql-conf setup
```

- At the **Enter your edition** prompt, enter **1**, and then press **Enter**.
- At the **Do you accept the license terms** prompt, enter **Yes**, and then press **Enter**.
- At the **Enter the SQL Server system administrator password** prompt, enter a password, and then press **Enter**.
- At the **Confirm the SQL Server system administrator password** prompt, reenter the password, and then press **Enter**.

47. Run the following command to check the SQL Server status:

```
systemctl status mssql-server
```

48. Run the following command to set mssql-conf into the PATH variable:

```
echo 'export PATH="$PATH:/opt/mssql/bin"' >> ~/.bash_profile
echo 'export PATH="$PATH:/opt/mssql/bin"' >> ~/.bashrc
source ~/.bashrc
```

49. Run the following command to stop the SQL Server service:

```
systemctl stop mssql-server
```

50. Run the following command to create directories for SQL Server database and log files:

```
mkdir -p /mssql/data /mssql/logs
```

51. Run the following commands to create a file system on the two storage devices:

```
mkfs.xfs -L logs /dev/sdb -f; mkfs.xfs -L data /dev/sdc -f
```

52. Run the following command to mount the storage devices to the file directories:

```
mount /dev/sdb /mssql/logs; mount /dev/sdc /mssql/data
```

53. Run the following commands to add additional directories to support the backup and TempDB locations:

```
mkdir -p /mssql/data/backup /mssql/logs/tempdb
```

54. Run the following command to set permissions on the SQL Server database and log file directories:

```
chown -R mssql:mssql /mssql
chmod 777 -R /mssql
```

55. Run the following commands to set the directory location for the SQL Server databases:

```
mssql-conf set filelocation.defaultdatadir /mssql/data; mssql-conf set filelocation.defaultlogdir /
mssql/logs; mssql-conf set filelocation.defaultbackupdir /mssql/data/backup
```

56. Run the following commands to install SQL Server tools:

```
sudo curl -o /etc/yum.repos.d/msprod.repo https://packages.microsoft.com/config/rhel/8/prod.repo
sudo yum install -y mssql-tools unixODBC-devel
echo 'export PATH="$PATH:/opt/mssql-tools/bin"' >> ~/.bash_profile
```

57. Run the following command to enter SQL commands:

```
sqlcmd -S localhost -U sa
```

58. Run the following commands to set the TempDB database location:

```
ALTER DATABASE tempdb MODIFY FILE
(NAME = tempdev, FILENAME = '/mssql/logs/tempdb/tempdb.mdf', SIZE = 1024, FILEGROWTH = 8192MB)
GO
ALTER DATABASE tempdb MODIFY FILE
(NAME = templog, FILENAME = '/mssql/logs/tempdb/templog.ldf', SIZE = 1024, FILEGROWTH = 8192MB)
GO
ALTER DATABASE tempdb
ADD FILE (NAME = tempdb2, FILENAME = '/mssql/logs/tempdb/tempdb2.ndf', SIZE = 1024, FILEGROWTH =
8192MB);
ALTER DATABASE tempdb
ADD FILE (NAME = tempdb3, FILENAME = '/mssql/logs/tempdb/tempdb3.ndf', SIZE = 1024, FILEGROWTH =
8192MB);
ALTER DATABASE tempdb
ADD FILE (NAME = tempdb4, FILENAME = '/mssql/logs/tempdb/tempdb4.ndf', SIZE = 1024, FILEGROWTH =
8192MB);
ALTER DATABASE tempdb
ADD FILE (NAME = tempdb5, FILENAME = '/mssql/logs/tempdb/tempdb5.ndf', SIZE = 1024, FILEGROWTH =
8192MB);
ALTER DATABASE tempdb
ADD FILE (NAME = tempdb6, FILENAME = '/mssql/logs/tempdb/tempdb6.ndf', SIZE = 1024, FILEGROWTH =
8192MB);
ALTER DATABASE tempdb
ADD FILE (NAME = tempdb7, FILENAME = '/mssql/logs/tempdb/tempdb7.ndf', SIZE = 1024, FILEGROWTH =
8192MB);
ALTER DATABASE tempdb
ADD FILE (NAME = tempdb8, FILENAME = '/mssql/logs/tempdb/tempdb8.ndf', SIZE = 1024, FILEGROWTH =
8192MB);
GO
```

59. Run the following command to delete the old TempDB files:

```
rm -rf /var/opt/mssql/data/temp*
```

Benchmark Testing New Orders per Minute (NOPM)¹

After software is installed and pretesting has verified proper configurations, run the benchmark tests to compare the performance between the systems. Run the following workload three times, taking the median of the scores.

Configure the Windows® 10/Windows Server® 2022 Client Test Machine

1. Configure an Open Database Connectivity (ODBC) data source for the Linux SQL Server:
 - a. Launch Microsoft® ODBC Data Source Administrator (32-bit).
 - b. Click **Add**.
 - c. Select **SQL Server Native Client 11.0**, and then click **Finish**.
 - d. In the **Create a New Data Source to SQL Server** window, in the **Name** field, enter a unique name to identify the Linux SQL Server.
 - e. In the **Server** field, enter a name or IP address to connect to the Linux SQL Server, and then click **Next**.
 - f. In the **How should SQL Server verify the authenticity of the login ID** field, select **With SQL Server authentication**.
 - g. In the **Login ID** field, enter **SA**.
 - h. In the **Password** field, enter the **SA password**.
 - i. Click **Next**.
 - j. Click **Next** again.
 - k. Click **Finish**.
 - l. Click **Test Data Source** to verify connectivity.
2. Download and install the following SQL Server client tools:
 - a. Client Tools Connectivity
 - b. Client Tools Backwards Compatibility
 - c. Client Tools SDK
3. Copy the provided **MSTPCC.470.tar** file to the testing client.
4. Unzip the .tar file to **C:\MSTPCC.470**.
5. In File Explorer, browse to **C:\MSTPCC.470\SETUP\scripts\1400.war\database**.
6. Open **createdb.sql**, and then update the **FILENAME** path for each file.
7. In File Explorer, browse to **C:\MSTPCC.470\BC-TPCC-v1.6.0**.
8. Double-click **BenchCraft-TPCC.msi** to install BenchCraft, accepting the default settings.²
9. Open a command prompt or PowerShell® session.
10. Run the following command to build the test database:

```
.\setup.cmd /s:<IP or Hostname> /U:sa /P:<password> /W:1400 /B:full /D:normal /v:true
```
11. Once the database build is complete, take a backup of the database.
12. Launch the BenchCraft application:
 - a. Click **New Profile**.
 - b. Click **Browse**, and then select the **TPCC_SQLServer.bdll** plugin file.
 - c. Click **Next**.
 - d. Select **ThreadGroup-1**, and then enter the following values for each setting:
 - **Thread Count: 100**
 - **W_ID Range End: 1400**
 - **W_ID Maximum: 1400**
 - **Server Name or IP: IP or name of the Linux SQL Server**
 - **User Name: SA**
 - **Password: SA password**
13. Save the profile.
14. Select the **Drivers** page.
15. Select **Launch**.
16. Wait five minutes before pressing **F1** to run the load.
17. Run the load for 45 minutes or until the load is at a steady state, and then take the last 15 minutes of the load as the scored value.
18. Once the test is complete, delete and restore the database.
19. Double-click the saved profile to launch the BenchCraft workload utility to run the workload again.

¹ Servers were configured and tested serially, which resulted in updates/patches being applied on different days to achieve the same patch version.

² Note that this workload is derived from the TPC-C® benchmark and is not comparable to published TPC-C benchmark results, as this implementation does not comply with all requirements of the TPC-C benchmark.



The analysis in this document was done by Prowess Consulting and commissioned by Dell Technologies.

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