Microsoft SQL Server 2017 OLTP Workloads on HPE MSA 2052 Storage

Using the Linux operating system
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Executive summary

Among the challenges IT organizations might face in administering online transaction processing (OLTP) are increased sensitivity to cost, wider variation in service-level agreements (SLAs), and fewer staffing resources. Ease of use, maintainability, and excellent customer support are critical for Microsoft® SQL Server 2017 OLTP environments. In addition, you might be considering deployment of MS SQL Server Always On capabilities, which can enable high availability (HA) and data recovery (DR) in database environments—without requiring a dedicated storage infrastructure.

The hybrid flash HPE MSA 2052 Storage system can be used for smaller SQL Server OLTP infrastructures—generally iSCSI-based—with shared storage and DR requirements, but without the need for high performance on the storage fabric. Infrastructure design can include multiple application workloads and a virtualization layer.

This white paper highlights the benefits of deploying HPE MSA 2052 Storage in a Microsoft SQL Server 2017 OLTP environment running on a Linux® server (Red Hat®). This platform provides a storage foundation that is simple, easily managed, highly affordable, and highly scalable. HPE MSA 2052 Storage delivers performance and HA benefits that are key to OLTP database workloads. And, as business expands, the number of supported servers and total capacity can be increased to adapt to changing business needs.

Target audience: This document is intended for IT administrators, storage administrators, and solution architects planning a Microsoft SQL Server 2017 deployment with HPE MSA 2052 Storage on Linux operating systems. Readers should be familiar with the fundamentals of Microsoft SQL Server and HPE MSA 2052 Storage systems.

Document purpose: This document is for HPE customers seeking a storage solution for their Microsoft SQL OLTP workload—especially those customers who face fast growth of SQL server data and require rapid response times.

Introduction

Microsoft is driving SQL Server to open source platforms so that it can run in more IT ecosystems, allowing SQL Server to work on multiple OS’s, containers, on premises, and cloud platforms. SQL Server can now be used by developers regardless of programming languages, toolsets, and frameworks. SQL Server is optimized for OLTP workloads with In Memory OLTP available, providing higher performance and lower total cost of ownership.
Solution overview

This solution uses Microsoft SQL Server 2017 on Red Hat Enterprise Linux 7.3, installed on an HPE ProLiant DL380 Gen9 Server. HPE MSA 2052 SAN Storage is attached via 10Gb iSCSI. Figure 1 shows a diagram of the components used in this solution.

![Diagram of components](image)

**Figure 1.** Microsoft SQL Server 2017 on Linux with HPE MSA 2052 Storage

Microsoft SQL Server 2017 is managed by the Microsoft SQL Server Management Studio software. The HPE MSA 2052 Storage is managed using the HPE Storage Management Utility (SMU) which is part of the HPE MSA 2052 Storage firmware.

This document assumes configuration knowledge of the products and is not a step-by-step setup guide. Some basic setup steps are not included; however, documentation links are included with the topic.

Solution components

**Hardware**

**HPE ProLiant DL380 Gen9 Server**

The HPE ProLiant DL380 Generation9 (Gen9) Server is designed to address the needs of large enterprises to remote office and branch office environments. With Gen9, it delivers the best performance and expandability in the Hewlett Packard Enterprise 2-processor (2P) rack portfolio. Reliability, serviceability, and near-continuous availability, backed by a comprehensive warranty, make it ideal for any environment.

Key features:

- The HPE ProLiant DL380 Gen9 Server supports industry standard Intel® Xeon® E5-2600 v3 and E5-2600 v4 processors with up to 22 cores, 12 Gb/s SAS and 40 Gb NICs with a broad range of compute options, and leverages the latest 2400 MHz DDR4 HPE Smart Memory supporting up to 3.0 TB.

- It has redundant HPE Flexible Slot power supplies, an HPE Flexible Slot Battery Backup module, and support for HPE Power Discovery Services offering.

- The redesigned chassis can accommodate 8 to 24 SFF drives or 4 to 12 LFF drives, also NVMe options, and a choice of embedded 4x1 GbE, HPE FlexibleLOM, or PCIe standup 1 GbE to 40 GbE adapters. In conjunction with the embedded SATA HPE Dynamic Smart Array B140i
controller for boot, data, and media needs, the redesigned HPE Flexible Smart Array and HPE Smart SAS HBA controllers allow the flexibility to choose the optimal 12 Gb/s controller for your needs.

- The HPE ProLiant DL380 Gen9 Server can be managed and monitored by HPE iLO, HPE OneView, or HPE Smart Update Manager (SUM), with each tool providing a variety of management functions.

Figure 2 shows the HPE ProLiant DL380 Gen9 Server hardware. See the HPE ProLiant DL380 Generation9 QuickSpecs for more details at https://www.hpe.com/h20195/v2/GetDocument.aspx?docname=c04375627

HPE MSA 2052 Storage

The hybrid flash HPE MSA 2052 Storage system with the new Gen10 ProLiant Branding is designed for affordable application acceleration that is ideal for small and remote office deployments. The HPE MSA 2052 Storage system provides the combination of simplicity, flexibility to grow now and into the future, and advanced features not expected in an entry-priced array. Start with 1.6 TB of flash capacity included and scale as needed with any combination of solid state disks (SSD) and high-performance Enterprise or lower-cost Midline SAS-based drives.

HPE MSA Storage has been the industry-leading entry-storage SAN platform for the past eight years, with nearly 500,000 storage systems sold worldwide. Delivering performance in excess of 200,000 IOPS, the hybrid flash HPE MSA 2052 Storage system can save up to 40% with an all-inclusive software suite and 1.6 TB of flash capacity included.

- HPE MSA 2052 performs in excess of 200,000 IOPS for affordable application acceleration
  - Delivers 2x IOPS performance than the previous generation MSA 2042
  - Save 40% on the hybrid flash MSA 2052 with all-inclusive software and 1.6 TB of SSD capacity included

- Advanced data services with no experience required
  - Easy to install, easy to use, easy to maintain—no storage expertise necessary
  - Automated tiering dynamically responds to workload changes

- Keep your business running with expanded data protection features
  - New virtualized snapshot technology makes data protection and instant recovery a snap
  - Remote replication with FC and iSCSI supports affordable disaster recovery
• Grow flexibly now and into the future
  
  – Data-in-place upgrades protect drive investments and eliminate data migrations
  – Start small and scale as needed with any combination of SSD and Enterprise or Midline SAS drives

Figure 3, Figure 4, and Figure 5 show the HPE MSA 2052 Storage hardware. See the *HPE MSA 2052 Storage QuickSpecs* for more details at [https://www.hpe.com/h20195/v2/GetDocument.aspx?docname=a00008277enw](https://www.hpe.com/h20195/v2/GetDocument.aspx?docname=a00008277enw).

![Figure 3. HPE MSA 2052 (front facing, bezel, SFF drives)](image1)

![Figure 4. HPE MSA 2052 (rear facing, dual controllers)](image2)
Networking
The HPE MSA 2052 Storage and RHEL server were connected via an HPE FlexFabric 5900 10Gb Ethernet switch. (See the HPE FlexFabric 5900 Switch Series QuickSpecs for details at https://www.hpe.com/h20195/v2/GetDocument.aspx?docname=c04111469.) iSCSI traffic between the server and storage were put on a separate VLAN. The HPE MSA 2052 Storage had one 10Gb port configured for each of its two controllers. Multipath was set up on the server to provide multiple data paths to each controller, as detailed in the Configure RHEL 7 for HPE MSA volumes section.

Software
The software components used are:

- Red Hat Enterprise Linux 7.3
- Microsoft SQL Server 2017 for Linux

Application software
The application software used is Microsoft SQL Server Management Tools for Windows, as shown in Figure 6.
HPE MSA Storage Management Utility (SMU) is used to manage the HPE MSA 2052, as shown in Figure 7. The management includes creating and managing hosts, pools, volumes, mapping and replication. The SMU can also monitor the performance of the array. For an in-depth discussion of how storage pools, disk groups, and virtual volumes support each other, see the HPE MSA 2050/2052 Best Practices Guide.

![Figure 7. HPE MSA Storage Management Utility](image)

**Note**
Not all features are currently available for managing servers on Linux with the Windows toolset. Please check the latest Microsoft release notes for compatibility.

**Best practices and configuration guidance**

**Red Hat Enterprise Linux 7.3 setup**

Follow these steps to set up RHEL 7.3:

1. Install RHEL – for instructions, see the Red Hat Enterprise Linux 7 installation guide.
2. Network configuration for this test:
   - 1 Gb to public network
   - 10 Gb to storage using iSCSI protocol and network traffic was put on a separate VLAN between storage and server
3. Enable and install critical OS updates. A Red Hat account is required to register the server for updates - https://access.redhat.com/support/

4. Download and install the HPE Service Pack for ProLiant for the latest HPE ProLiant DL380 Gen9 Server drivers, firmware, and patches. (This requires an HPE Passport account and current warranty contract.)
   - Download location
   - Installation instructions

**Configure HPE MSA 2052 Storage**

Perform the following steps to configure the HPE MSA 2052 Storage.

1. Connect to the HPE MSA 2052 CLI Controller by following the instructions in: [Connecting to the MSA CLI management port](#)

2. Log in to the CLI and verify the port mode by entering the command:

   ```
   # show ports
   ```

   ![Ports Media Action Target ID Status Speed(A) Health Reason](image)

3. If the ports are not configured for iSCSI, enter the following command to change the port mode:

   ```
   # set host-port-mode iscsi
   ```

4. Connect to the HPE MSA Storage Management Utility (SMU) via a web browser.

5. Configure the iSCSI target ports from the **System** tab → **Action** → **Set Up Host Ports**, as shown in **Figure 8**.

   ![Host Ports Settings](image)

   **Figure 8. iSCSI Host Port Settings**
6. Create appropriate disk pools for your configuration, as shown in Figure 9. (Two were created for this test.)

7. The HPE MSA 2052 comes standard with SSDs for read cache. (HPE MSA 2050 includes only HDDs and this step can be skipped.)

For read cache, a two-SSD disk group was added to each of the two pools created in step 6. This is shown in Figure 10.
8. Figure 11 shows the SSD cache added to pool A. Repeat the same steps to add a SSD cache to pool B using the remaining two unallocated SSDs.

Figure 11. SSD cache group created

9. Create the volumes to be presented to the server, as shown in Figure 12.

The volumes created were named Avol00, Bvol00, and Log00.

Figure 12. HPE MSA volumes

10. On the RHEL server, install the iSCSI initiator by entering the command:

```
# yum install iscsi-initiator-utils
```

(See the iSCSI initiator creation guide for details.)

11. Obtain the iSCSI initiator ID with the following command on the RHEL server:

```
[lab@RHEL-172190 ~]$ more /etc/iscsi/initiatorname.iscsi
InitiatorName=iqn.1994-05.com.redhat:ala565eadeb
```
12. Add the RHEL server iSCSI initiator ID to the HPE MSA Hosts, as shown in Figure 13.

![Figure 13](image13.png)

**Figure 13.** Adding iSCSI initiator ID to HPE MSA hosts

13. Map the HPE MSA Storage volumes (created in step 7) to the RHEL Host entry, as shown in Figure 14.

![Figure 14](image14.png)

**Figure 14.** Mapping HPE MSA storage volumes to RHEL host

**Configure RHEL7 for HPE MSA volumes**

Perform the following steps to configure RHEL7 for HPE MSA volumes.

1. Discover the iSCSI targets presented by the HPE MSA 2052, in RHEL7, with the following command (IP info will differ from the example below, according to your network setup):

   ```bash
   ```

2. Log in to target sessions via iscsiadm.

3. Install the DM multipath. See the Installation guide for details.
4. Configure `/etc/mpathd.conf` for HPE MSA 2052 Storage by adding the following entries:

```plaintext
devices {
  device {
    vendor                  "HP"
    product                 "MSA 2040 SAN"
    path_grouping_policy    group_by_prio
    uid_attribute           "ID_SERIAL"
    prio                    alua
    path_selector           "round-robin 0"
    path_checker            tur
    hardware_handler        "0"
    failback                immediate
    rr_weight               uniform
    rr_min_io_rq            1
    no_path_retry           18
  }
}
blacklist {
}
defaults {
  find_multipaths yes
  user_friendly_names yes
}
```

5. Restart the `multipathd` service by entering the command:

```
# systemctl restart multipathd
```

6. Enable multipath at startup by entering the command:

```
# systemctl enable multipathd
```
7. View the multipath connections on the server:

```
[root@RHEL7-172190 lab]# multipath -ll
mpathd (3600c0ff00028c44f52b05f5901000000) dm-6 HPE ,MSA 2050 SAN
size=3.6T features '0' hwhandler='0' wp=rw
  |- policy='service-time 0' prio=1 status=active
  |  `-- 7:0:0:2 sgd 8:176 active ready running
  `-- policy='service-time 0' prio=1 status=enabled
    |  `-- 6:0:0:2 sgd 8:160 active ready running
    `-- policy='service-time 0' prio=1 status=enabled
      |  `-- 9:0:0:2 sdm 8:192 active ready running
      `-- policy='service-time 0' prio=1 status=enabled
        |  `-- 8:0:0:2 sdn 8:208 active ready running
mpathc (3600c0ff00028d55151b05f5901000000) dm-5 HPE ,MSA 2050 SAN
size=3.7T features '0' hwhandler='0' wp=rw
  |- policy='service-time 0' prio=1 status=active
  |  `-- 8:0:0:1 sdj 8:144 active ready running
  `-- policy='service-time 0' prio=1 status=enabled
    |  `-- 9:0:0:1 sdl 8:128 active ready running
    `-- policy='service-time 0' prio=1 status=enabled
      |  `-- 6:0:0:1 sdp 8:96 active ready running
      `-- policy='service-time 0' prio=1 status=enabled
        |  `-- 7:0:0:1 sdh 8:112 active ready running
mpathb (3600c0ff00028c44f50b05f5901000000) dm-4 HPE ,MSA 2050 SAN
size=3.8T features '0' hwhandler='0' wp=rw
  |- policy='service-time 0' prio=1 status=active
  |  `-- 6:0:0:0 sdc 8:32 active ready running
  `-- policy='service-time 0' prio=1 status=enabled
    |  `-- 7:0:0:0 sdd 8:48 active ready running
    `-- policy='service-time 0' prio=1 status=enabled
      |  `-- 9:0:0:0 sdf 8:80 active ready running
      `-- policy='service-time 0' prio=1 status=enabled
        |  `-- 8:0:0:0 sde 8:64 active ready running
```

8. Create the device mount points for HPE MSA volumes.

   a. `/dev/mapper/mpath%` corresponds to the added HPE MSA volumes and were mounted as `/mnt/Avol`, `/mnt/Bvol`, and `/mnt/Logsvol`.

   ```
   /dev/mapper/mpathc on /mnt/Bvol type ext4 (rw,noatime,nodiratime,seclabel,nobarrier,stripe=256,data=ordered,_netdev) [Bvol]
   /dev/mapper/mpathb on /mnt/Logsvol type ext4 (rw,noatime,nodiratime,seclabel,nobarrier,stripe=256,data=ordered,_netdev) [Logsvol]
   /dev/mapper/mpathd on /mnt/Avol type ext4 (rw,noatime,nodiratime,seclabel,nobarrier,stripe=256,data=ordered,_netdev) [Avol]
   ```

   b. Added volumes were formatted ext4

**Microsoft SQL Server 2017 setup**

1. Install SQL Server 2017. See the Installation guide for Red Hat Enterprise Linux for details. This instance was installed with default settings.

2. Complete SQL Server 2017 setup. Use `mssql-conf` to complete the SQL Server setup.

   Enter the following command to configure licensing options and the SA password:

   ```
   # sudo /opt/mssql/bin/mssql-conf setup
   ```
3. SQL Server default data directories must be changed to the HPE MSA iSCSI volumes that were presented to the OS. See Configure SQL Server on Linux for details.
   a. First, grant permission to mssql for the HPE MSA data volumes. (See https://docs.microsoft.com/en-us/sql/linux/sql-server-linux-configure-mssql-conf#datadir for details.) Enter the following commands:
      I. # sudo chown mssql /mnt/Avol (Repeat this command for the Bvol volume)
      II. # sudo chgrp mssql /mnt/Avol (Repeat this command for the Bvol volume)
      III. # sudo /opt/mssql/bin/mssql-conf set filelocation.defaultdatadir /mnt/Avol (Repeat this command for the Bvol volume)
   b. Next, grant mssql permissions to the Logsvol. (See https://docs.microsoft.com/en-us/sql/linux/sql-server-linux-configure-mssql-conf#datadir for details.) Enter the following commands:
      I. # sudo chown mssql /mnt/Logsvol
      II. # sudo chgrp mssql /mnt/Logsvol
      Results of the directory changes are updated to the /var/opt/mssql/mssql.conf file.
4. Start SQL Server 2017 with the command:
   # sudo systemctl start mssql-server
   - For documentation about using Windows SSMS with Linux, see https://docs.microsoft.com/en-us/sql/linux/sql-server-linux-manage-ssms
   - The SQL Agent can optionally be installed, but was not used for this test. See https://docs.microsoft.com/en-us/sql/linux/sql-server-linux-setup-sql-agent for details.
   - The Windows SQL Server Management tools can connect to and manage a Linux SQL server installation, but some features and settings currently do not work. In these cases, configuration changes require command line MS SQL tools on the Linux server. For more information on current limitations, see the latest release notes from Microsoft.

Testing
Workload testing included:
- User-generated 1 TB database via DBgen and ran data generation and query scripts
- Ran similar workload tests on Microsoft’s previous SQL Server sample database AdventureWorks 2014. See https://msftdbprodsamples.codeplex.com for details.

The above samples were restored from SQL Server backup. Please note that SQL Server 2017 for Linux is unable to restore databases from outside of the Linux directory structure and requires a mount point if the backup files are not seen as local. See https://docs.microsoft.com/en-us/sql/linux/sql-server-linux-migrate-restore-database for details.

Capacity and sizing
Each of the three presented HPE MSA 2052 volumes were 3.8 TB, 3.9 TB, and 4.0 TB, to easily identify them from the OS without having to look up their volume information. Database and log files were spread across all three volumes in multiple file groups. The HPE MSA’s on-the-fly volume resizing was also tested on these volumes with no issues.
Analysis and recommendations

Both Microsoft SQL Server 2017 for Windows and Linux achieve the same core functionality for OLTP workloads. Installation and configuration steps documented by Microsoft are straightforward. A familiarity with Red Hat Enterprise Linux 7 and SQL Server is helpful in getting through the initial setup process. Database operations showed expected performance and the testing with OLTP workloads was straightforward.

Though this test was installed on Red Hat Enterprise Linux, SQL Server 2017 installation guides for Ubuntu Server and SUSE Enterprise Linux are also available.

Summary

HPE MSA 2052 Storage for on-disk OLTP workloads is a cost-effective platform that is easily expandable for future growth. Although not as fast (or nearly as costly) as in-memory OLTP solutions, HPE MSA Storage provides excellent performance per dollar for organizations looking to upgrade their database storage system. Dual 10 Gb links per controller provide a total of 40 Gb bandwidth for iSCSI connectivity. Future performance upgrade paths include SSDs in place of spinning disk, which offer a significant I/O boost, while still being much less costly than current in-memory solutions. There are limitations of in-memory OLTP in SQL Server 2017, which may not be optimal for certain organizations data workloads. (See https://docs.microsoft.com/en-us/sql/relational-databases/in-memory-oltp/transact-sql-constructs-not-supported-by-in-memory-oltp for more information.)
## Appendix A: Bill of materials

### Note
Part numbers are at time of publication/testing and subject to change. The bill of materials does not include complete support options or other rack and power requirements. If you have questions regarding ordering, please consult with your HPE Reseller or HPE Sales Representative. (For more details, see hpe.com/us/en/services/consulting.html).

### Table 1a. Bill of materials

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<th>Part Number</th>
<th>Description</th>
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<td><strong>HPE ProLiant Server</strong></td>
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<tr>
<td>1</td>
<td>719064-B21</td>
<td>HPE DL380 Gen9 8-SFF CTO Server</td>
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<tr>
<td>1</td>
<td>719051-L21</td>
<td>HPE DL380 Gen9 Intel® Xeon® E5-2620v3 (2.4GHz/6-core/15MB/85W) FIO Processor Kit</td>
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<tr>
<td>1</td>
<td>719051-B21</td>
<td>HPE DL380 Gen9 Intel® Xeon® E5-2620v3 (2.4GHz/6-core/15MB/85W) Processor Kit</td>
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<td>HPE 800GB SATA 6G Wi SFF SC DS SSD</td>
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<td>733660-B21</td>
<td>HPE 2U SFF Easy Install Rail Kit</td>
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<td>Q1J03A</td>
<td>HPE MSA 2052 SAN Dual Controller SFF Storage</td>
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<td>C8R25B</td>
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<td>HPE MSA 2050 SFF Disk Enclosure</td>
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<td>HPE External Mini SAS 1m Cable</td>
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<td>J9F46A</td>
<td>HPE MSA 600GB 12G SAS 10K SFF(2.5in) Dual Port Enterprise 3yr Warranty Hard Drive</td>
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<td><strong>Software</strong></td>
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<tr>
<td>1</td>
<td></td>
<td>Microsoft SQL Server 2017 for Linux</td>
</tr>
</tbody>
</table>
Glossary

**IOPS** - Input/Output Operations per Second

**OLTP** - Online transaction processing

**SSMS** – SQL Server Management Studio

**RHEL** – Red Hat Enterprise Linux

**HDD** – Hard disk drive

**SSD** – Solid state drive

**SMU** – Storage Management Utility
Resources and additional links

HPE Reference Architectures
hpe.com/info/ra

HPE Servers
hpe.com/servers

HPE Storage
hpe.com/storage

HPE Networking
hpe.com/networking

HPE Technology Consulting Services
hpe.com/us/en/services/consulting.html

To help us improve our documents, please provide feedback at hpe.com/contact/feedback.

Learn more at hpe.com/storage