The science behind the report:

Better meet your Oracle database users' needs with a Dell EMC and HGST solution

This document describes what we tested, how we tested, and what we found. To learn how these facts translate into real-world benefits, read the report Better meet your Oracle database users' needs with a Dell EMC and HGST solution.

On July 19, 2018, we finalized the hardware and software configurations we tested. Updates for current and recently released hardware and software appear often, so unavoidably these configurations may not represent the latest versions available when this report appears. For older systems, we chose configurations representative of typical purchases of those systems. We concluded hands-on testing on August 2, 2018.

Our results

The table below presents our findings in detail.

Median runs									
System	Disk	Reads/s	Writes/s	Read MB/s	Write MB/s	Read Lat. (ms)	Write Lat. (ms)	Disk Util %	CPU Util %
Dell EMC™ PowerEdge™ R730xd	Data	409,519.96	106,146.03	3,201.18	835.97	1.01	0.34	100%	82%
	Logs	1.10	2,321.08	0.00	35.94	0.00	0.00	25%	
Dell EMC PowerEdge R740xd	Data	157,711.60	39,811.05	1,233.31	317.51	5.55	6.51	100%	48%
	Logs	1.00	1,212.92	0.00	14.82	0.00	0.00	26%	

System configuration information

The table below presents detailed information on the systems we tested.

Server configuration information	Dell EMC PowerEdge R730xd	Dell EMC PowerEdge R740xd
BIOS name and version	Dell 2.6.0	Dell 1.4.8
Non-default BIOS settings	N/A	N/A
Operating system name and version/build number	Microsoft® Windows Server® 2016 Datacenter Version 1607 Build 14393.2368	Windows Server 2016 Datacenter Version 1607 Build 14393.2368
Date of last OS updates/patches applied	7/19/2018	7/19/2018
Power management policy	Performance	Performance
Processor		
Number of processors	2	2
Vendor and model	Intel® Xeon® E5-2660 v4	Intel Xeon Platinum 8170
Core count (per processor)	14	26
Core frequency (GHz)	2.00	2.10
Stepping	1	4
Memory module(s)		
Total memory in system (GB)	192	192
Number of memory modules	12	12
Vendor and model	Hynix HMA42GR7MFR4N-TF	Hynix HMA82GR7AFR8N-VK
Size (GB)	16	16
Type	DDR-4	DDR-4
Speed (MHz)	2,133	2,666
Speed running in the server (MHz)	2,133	2,666
Storage controller		
Vendor and model	Dell PERC H730 Mini	Dell PERC H740P
Cache size (GB)	1	4
Firmware version	25.5.4.0006	50.0.1-0639
Driver version	6.603.6.0	7.703.6.0
Local storage (type A)		
Number of drives	2	2
Drive vendor and model	Intel SSDSC2BB800G4	HGST HUSMM3280ASS205
Drive size (GB)	800	800
Drive information (speed, interface, type)	6Gb/s, SATA, SSD	12Gb/s, SAS, SSD

Server configuration information	Dell EMC PowerEdge R730xd	Dell EMC PowerEdge R740xd
Local storage (type B)		
Number of drives	8	8
Drive vendor and model	Intel SSDSC2BA800G4R	HGST HUSMM3280ASS205
Drive size (GB)	800	800
Drive information (speed, interface, type)	6Gb/s, SATA, SSD	12Gb/s, SAS, SSD
Network adapter		
Vendor and model	Intel Gigabit 4p X540/I350	QLogic 1/10Gb Ethernet BCM57800
Number and type of ports	2 x 1Gb, 2 x 10Gb rNDC	2 x 1Gb, 2 x 10Gb rNDC
Firmware version	18.3.6	10.00.15
Cooling fans		
Number of cooling fans	6	6
Power supplies		
Vendor and model	Dell E750E-S1	Dell D1100E-S0
Number of power supplies	2	2
Wattage of each (W)	750	1,100

How we tested

Our testing environment consisted of two servers: an R730xd with SATA SSDs and an R740xd with SAS SSDs. We began by putting two disks in a RAID 1 pair on which we installed Windows Server 2016 Datacenter Edition (Desktop Experience). We then put the remaining eight disks used for testing in RAID 1 pairs, enabling the Dell FastPath feature by setting the read policy to No Read Ahead and the write policy to Write Through on each RAID 1 pair.

After installing Server 2016 and applying all of the necessary updates, we installed the Microsoft Hyper-V® role on each server and created the Oracle® Enterprise Linux® VMs. We installed Oracle Database 12c Release 2 on each VM. We then created a roughly 245GB database using Silly Little Oracle Benchmark (SLOB).

In our initial tests, we used Intel Xeon Gold 6130 CPUs in the R740xd and assigned six vCPUs to each VM. After settling on our final SLOB configuration, we noticed a high CPU utilization on the R740xd host (around 90 percent) and within the VMs, which we believed to be a bottleneck. To relieve this, we upgraded the CPU in the R740xd to an Intel Platinum 8170 CPU, and we increased the number of vCPUs on the R740xd from six to 12 in each VM. We did not upgrade the CPU in the system because the CPU utilization on the R730xd with six vCPUs was consistently around 50 percent.

In our final SLOB configuration, we ran a 75/25 read/write workload (to mimic typical online transaction processing input/out patterns) with 0 think time against 128 schemas. We ran the test three times and reported the median run.

Installing Windows Server 2016 Datacenter Edition

1. Insert the installation media into the CD/DVD drive, and restart the server.
2. When the option appears to enter the Boot Manager, press F11.
3. Select UEFI Boot Menu.
4. Select the boot media, and press Enter.
5. When prompted to boot from DVD, press any key.
6. When the installation screen appears, leave language, time/currency format, and input method as default, and click Next.
7. Click Install now.
8. When the installation prompts you, enter the product key.
9. Select Windows Server 2016 Datacenter Edition (Server with a GUI), and click Next.
10. Check I accept the license terms, and click Next.
11. Click Custom: Install Windows only (advanced).
12. Select Drive 0 Unallocated Space, and click Next. This starts Windows automatically, and Windows will restart automatically after completing.
13. When the Settings page appears, fill in the Password and Reenter Password fields with the same password.
14. Log in with the password you set up previously.

Installing the Hyper-V role

1. Open the Server Manager.
2. Click Manage→Add Roles and Features.
3. On the Before You Begin screen, click Next.
4. Choose Role-based or feature-based installation, and click Next.
5. Choose the local server, and click Next.
6. Choose Hyper-V, and when prompted, click Add Features. Click Next.
7. On the Hyper-V Things to note screen, click Next.
8. Choose a port for the virtual switch, and click Next.
9. Choose whether or not you want to add live migration capabilities, and click Next.
10. Set your default storage, and click Next.
11. Check the box for automatic restart, and click Install.

Creating VMs

1. Open the Hyper-V manager.
2. Right-click the host server, and choose New→Virtual Machine.
3. On the Before You Begin screen, click Next.
4. Name the VM, and choose the storage option. Click Next.
5. Choose Generation 2, and click Next.
6. Enter the desired amount of memory for the startup memory, and click Next. In our testing, we used `20480 MB`.
7. Choose the network connection, and click Next.
8. Select Attach a virtual hard disk later, and click Next.
9. Click Finish.

Creating virtual hard disks

1. In the Hyper-V Manager, right-click the server, and select New→Hard Disk….
2. Click Next.
3. Select VHDX, and click Next.
4. Select Fixed Size, and click Next.
5. Name the VHDX, and select the appropriate volume.
6. Click Next.
7. Select Create a new blank virtual hard disk, and enter a size. For our testing we chose 50GB for the OS volume, 90GB for the DATA volumes, and 30GB for the LOG volume.
8. Click Next.
9. Click Finish.
10. To create the DATA volumes and the LOG volume, complete steps 1 through 9 four more times.

Configuring VMs on the PowerEdge R740xd

1. In Hyper-V Manager, right-click the VM, and select Settings.
2. To disable secure boot, click the Security tab, and uncheck Enable Secure Boot.
3. Change the number of processors. For our testing, we set the number of processors to `12`.
4. Click the SCSI Controller, highlight Hard Drive, and click Add.
5. Select Virtual hard disk, and click Browse.
6. Navigate to the storage location, select the OS VHDX, and click Open.
7. For the remaining DATA volumes and LOG volume, complete steps 4 through 6 four more times.
8. Click on the SCSI Controller, highlight DVD Drive, and click Add.
9. Change the Automatic Stop Action to Shut Down.
10. Click Apply.

Configuring VMs on the PowerEdge R730xd

1. In Hyper-V Manager, right-click the VM, and select Settings.
2. To disable secure boot, click the Security tab, and uncheck Enable Secure Boot.
3. Change the number of processors. For our testing we set the number of processors to `6`.
4. Click the SCSI Controller, highlight Hard Drive, and click Add.
5. Select Virtual hard disk, and click Browse.
6. Navigate to the storage location, select the OS VHDX, and click Open.
7. For the remaining DATA volumes and LOG volume, complete steps 4 through 6 four more times.
8. Click the SCSI Controller, highlight DVD Drive, and click Add.
9. Change the Automatic Stop Action to Shut Down.
10. Click Apply.

Installing Oracle Enterprise Linux 7.5 on the VMs

1. Attach an Oracle Enterprise Linux 7.5 ISO to the DVD drive on the VM.
2. Power on the VM and boot from the DVD drive.
3. Select Install or upgrade an existing system.
4. Choose the language you wish to use, and click Continue.
5. Select Installation Destination.
6. Select the desired disk for the OS.
7. Under Other Storage Options, select I will configure partitioning.
8. Click Done.
9. To create the partitions automatically, select Click here.
10. Remove the /home partition.
11. Expand the swap partition to 16GB.
12. Assign all remaining free space to the / partition.
13. Click Done.
14. Click Accept Changes.
15. Select Kdump.
16. Uncheck Enable kdump, and click Done.
17. Select Network & Hostname.
18. Enter the desired hostname for the VM.
19. Turn on the desired network port, and click Configure.
20. On the General tab, select Automatically connect to this network when it is available.
21. On the IPv4 Settings tab, select Manual under Method.
22. Under Addresses, click Add, and enter the desired static IP information for the server.
23. Enter the desired DNS information.
24. Click Save, and click Done.
25. Select Date & Time, and ensure the correct date, time, and time zone are set.
26. To add your NTP server, click the cog for Network Time On/Off.
27. Add the IP address of your NTP server and click +.
28. Uncheck all other NTP servers.
29. Click OK.
30. Click Done.
31. Click Begin Installation.
32. Select Root Password.
33. Enter the desired root password, and click Done.
34. To restart the server when the installation completes, select Reboot.

Configuring OEL 7.5 for Oracle

1. Log onto the server as root.
2. Disable the firewall:

```
systemctl stop firewalld
systemctl disable firewalld
```

3. Disable SELinux:

```
vi /etc/selinux/config
SELINUX=disabled
```

4. Update OEL 7.5

```
yum update
```

5. Using yum, install the following prerequisite packages for Oracle Database:

```
yum install compat-libstdc++-33.i686
yum install glibc-devel.i686
yum install libstdc++-devel.i686
yum install libaio.i686
yum install libaio-devel.i686
yum install libXext.i686
yum install libXtst.i686
yum install unixODBC
```

```
yum install unixODBC-devel
yum install zlib-devel
yum install zlib-devel.i686
yum install xhost
```

6. Disable auditd:

```
systemctl disable auditd
```

7. Create Oracle users and groups by running these shell commands:

```
groupadd -g 54327 asmdba
groupadd -g 54328 asmoper
groupadd -g 54329 asmadmin
usermod -g 54321 -g oinstall -G dba,oper,backupdba,dgdba,kmdba,asmdba,asmoper,asmadmin oracle
```

8. Create passwords for the Oracle account with passwd.

9. Create the following directories, and assign the following permissions.

```
mkdir -p /u01/app/12.2.0.1/grid
mkdir -p /u01/app/oracle/product/12.2.0.1/db_1
chown -R oracle:oinstall /u01
chmod -R 775 /u01/
```

10. Append the following to the /etc/security/limits.conf:

```
oracle - nofile 65536
oracle - nproc 16384
oracle - stack 32768
oracle - memlock 134217728
* soft memlock unlimited
* hard memlock unlimited
```

11. Modify the system's kernel parameters by appending the following to /etc/systctl.conf:

```
vm.nr_hugepages = 8192
vm.hugetlb_shm_group = 54321
```

12. Add the following lines to the .bash_profile for the Oracle user:

```
export TMP=/tmp
export TMPDIR=$TMP

export ORACLE_HOSTNAME= <HOSTNAME>
export ORACLE_UNQNAME=orcl
export ORACLE_BASE=/u01/app/oracle
export GRID_HOME=/u01/app/12.2.0.1/grid
export DB_HOME=$ORACLE_BASE/product/12.2.0.1/db_1
export ORACLE_HOME=$DB_HOME
export ORACLE_SID=orcl
export ORACLE_TERM=xterm
export BASE_PATH=/usr/sbin:$PATH
export PATH=$ORACLE_HOME/bin:$BASE_PATH

export LD_LIBRARY_PATH=$ORACLE_HOME/lib:/lib:/usr/lib
export CLASSPATH=$ORACLE_HOME/JRE:$ORACLE_HOME/jlib:$ORACLE_HOME/rdbms/jlib

alias grid_env='. /home/oracle/grid_env'
alias db_env='.   /home/oracle/db_env'
```

13. Create the following files in the Oracle user's home folder.

```
>>>grid_env<<<
export ORACLE_SID=+ASM
export ORACLE_HOME=$GRID_HOME
export PATH=$ORACLE_HOME/bin:$BASE_PATH

export LD_LIBRARY_PATH=$ORACLE_HOME/lib:/lib:/usr/lib
export CLASSPATH=$ORACLE_HOME/JRE:$ORACLE_HOME/jlib:$ORACLE_HOME/rdbms/jlib
>>>db_env<<<
export ORACLE_SID=orcl
export ORACLE_HOME=$DB_HOME
export PATH=$ORACLE_HOME/bin:$BASE_PATH

export LD_LIBRARY_PATH=$ORACLE_HOME/lib:/lib:/usr/lib
export CLASSPATH=$ORACLE_HOME/JRE:$ORACLE_HOME/jlib:$ORACLE_HOME/rdbms/jlib
```

14. Install the oracleasmlib packages:

    ```
    yum install -y oracleasm-support-*
    ```
15. Using `fdisk`, create a partition on all R1 pairs.
16. Edit /etc/sysconfig/oracleasm to contain the following:

    ```
    # ORACLEASM_ENABLED: 'true' means to load the driver on boot.
    ORACLEASM_ENABLED=true

    # ORACLEASM_UID: Default UID owning the /dev/oracleasm mount point.
    ORACLEASM_UID=oracle

    # ORACLEASM_GID: Default GID owning the /dev/oracleasm mount point.
    ORACLEASM_GID=oinstall

    # ORACLEASM_SCANBOOT: 'true' means fix disk perms on boot
    ORACLEASM_SCANBOOT=true

    # ORACLEASM_USE_LOGICAL_BLOCK_SIZE: 'true' means use the logical block
    # size reported by the underlying disk instead of the physical. The
    # default is 'false' ORACLEASM_USE_LOGICAL_BLOCK_SIZE=false
    ```
17. Run the following command to initialize oracleasm:

    ```
    oracleasm init
    ```
18. Run the following commands to configure all of the disks for Oracle ASM:

    ```
    oracleasm createdisk DATA1 /dev/sdb1
    oracleasm createdisk DATA2 /dev/sdc1
    oracleasm createdisk DATA3 /dev/sdd1
    oracleasm createdisk LOG1 /dev/sde1
    ```

Installing Oracle Grid Infrastructure 12c

1. Log in as the Oracle user.
2. Unzip linuxx64_12201_grid_home.zip
3. Open a terminal to the unzipped database directory.
4. To set the Oracle grid environment, type `grid_env`.
5. To start the installer, type `./gridSetup`.
6. In the Select Installation Option screen, select Install and Configure Grid Infrastructure for a Standalone Server, and click Next.
7. Choose the language, and click Next.
8. In the Create ASM Disk Group screen, choose the Disk Group Name, and change redundancy to External (None).
9. Change the path to /dev/oracleasm/disks, and select the three disks that you are planning to use for the DATA diskgroup.
10. In the Specify ASM Password screen, choose Use same password for these accounts, write the passwords for the ASM users, and click Next.
11. At the Management Options screen, click Next.
12. Leave the default Operating System Groups, and click Next.
13. Leave the default installation, and click Next.
14. Leave the default inventory location, and click Next.
15. Under Root script execution, select Automatically run configuration scripts, and enter root credentials.
16. In the Prerequisite Checks screen, make sure that there are no errors.
17. In the Summary screen, verify that everything is correct, and click Finish to install Oracle Grid Infrastructure.
18. At one point during the installation, the installation prompts you to execute two configuration scripts as root. To run the scripts, follow the instructions.
19. At the Finish screen, click Close.
20. To run the ASM Configuration Assistant, type `asmca`.
21. In the ASM Configuration Assistant, click Create.
22. In the Create Disk Group window, name the new disk group log, choose redundancy External (None), and select the disk for the log diskgroup.
23. Click Show Advanced Options.
24. Set the database compatibility level to 12.2.0.1.0, and click OK.
25. Click OK.
26. Edit the DATA diskgroup to set the compatibility level to 12.2.0.1.0.
27. Exit the ASM configuration Assistant.

Installing Oracle Database 12c

1. Unzip linux_12201_database.zip.
2. Open a terminal to the unzipped database directory.
3. To set the first Oracle database environment, type `db_env`.
4. Run ./runInstaller.sh.
5. Wait for the GUI installer to load.
6. On the Configure Security Updates screen, enter the credentials for My Oracle Support. If you do not have an account, uncheck the box I wish to receive security updates via My Oracle Support, and click Next.
7. At the warning, click Yes.
8. On the Download Software Updates screen, enter the desired update option, and click Next.
9. On the Select Installation Option screen, select Install database software only, and click Next.
10. On the Grid Installation Options screen, select Single instance database installation, and click Next.
11. On the Select Product Languages screen, leave the default setting of English, and click Next.
12. On the Select Database Edition screen, select Enterprise Edition, and click Next.
13. On the Specify Installation Location, leave the defaults, and click Next.
14. On the Create Inventory screen, leave the default settings, and click Next.
15. On the Privileged Operating System groups screen, keep the defaults, and click Next.
16. Allow the prerequisite checker to complete.
17. On the Summary screen, click Install.
18. Once the Execute Configuration scripts prompt appears, SSH into the server as `root`, and run the following command:

    `# /u01/app/oracle/product/12.2.0.1/db_1/root.sh`

19. Return to the prompt, and click OK.
20. Once the installer completes, click Close.

Creating and configuring the database

1. Using Putty with X11 forwarding enabled, SSH to the VM.
2. To switch to the first database environment, type `db_env`.
3. To open the Database configuration assistant, type **dbca**, and press Enter.
4. At the Database Operation screen, select Create Database, and click Next.
5. Under Creation Mode, select Advanced Mode, and click Next.
6. At the Deployment Type screen, select General Purpose or Transaction Processing. Click Next.
7. Enter a Global database name and the appropriate SID, and uncheck Create as Container database. Click Next.
8. At the storage option screen, select Use the following for the database storage attributes.
9. In the dropdown menu, select Automatic Storage Management (ASM). For the file location, select +DATA.
10. At the Network Configuration screen, select the listener, and click Next.
11. At the Data Vault Option screen, leave as default, and click Next.
12. At the Configuration Options screen, set the SGA size to 9216 and the PGA size to 3072, and click Next.
13. At the Management Options screen, select Configure Enterprise Manager (EM) Database Express, and click Next.
14. At the User Credentials screen, select Use the same administrative password for all accounts, enter and confirm the desired password, and click Next.
15. At the Creation Options, select Create Database, and click Next.
16. At the summary screen, click Finish.
17. Close the Database Configuration Assistant.
18. To open the database manager in a Web browser, browse to `https://host.ip.address:5500/em`.
19. Log in as system with the password you specified.
20. Go to Storage→Tablespaces.
21. Click Create.
22. Type `SLOB` as the Name, and check the Set As Default box.
23. Add 16 Oracle-Managed files sized at 16G. Click OK.
24. Go to Storage→Redo Log Groups.
25. Click Actions→Switch file… until you get one of the groups to go inactive.
26. Highlight the inactive group, and click Actions→Drop group.
27. Create two redo log groups, each with a single 10GB file on the +LOG ASM volume.
28. Complete steps 23 and 24, and remove the remaining default redo logs.

Installing SLOB and populating the databases

1. To switch to the first database environment, type `db_env`.
2. Download the SLOB kit from http://kevinclosson.net/slob/
3. Copy and untar the files to `/home/oracle/SLOB`.
4. Edit the slob.conf file to match Appendix D.
5. To start the data population to the SLOB tablespace created earlier, type `./setup.sh SLOB 128`.
6. When the setup completes, verify the database is populated.

Running SLOB

1. Log in as the Oracle user.
2. To switch back to the first database environment, type `db_env`.
3. Navigate to /home/oracle/SLOB.
4. To start the test, type `./runit.sh 128`.

Oracle spfile

Database: ORCL

```
orcl.__data_transfer_cache_size=0
orcl.__db_cache_size=7482638336
orcl.__inmemory_ext_roarea=0
orcl.__inmemory_ext_rwarea=0
orcl.__java_pool_size=67108864
orcl.__large_pool_size=167772160
orcl.__oracle_base='/u01/app/oracle'#ORACLE_BASE set from environment
orcl.__pga_aggregate_target=3221225472
orcl.__sga_target=9663676416
orcl.__shared_io_pool_size=503316480
orcl.__shared_pool_size=1409286144
orcl.__streams_pool_size=0
*.audit_file_dest='/u01/app/oracle/admin/orcl/adump'
*.audit_trail='db'
*.compatible='12.2.0'
*.control_files='+DATA/ORCL/CONTROLFILE/current.263.980886193'
*.db_block_size=8192
*.db_cache_size=0
*.db_create_file_dest='+DATA'
*.db_name='orcl'
*.diagnostic_dest='/u01/app/oracle'
*.dispatchers='(PROTOCOL=TCP) (SERVICE=orclXDB)'
*.local_listener='LISTENER_ORCL'
*.lock_sga=TRUE
*.nls_language='AMERICAN'
*.nls_territory='AMERICA'
*.open_cursors=300
*.pga_aggregate_target=3072m
*.processes=640
*.remote_login_passwordfile='EXCLUSIVE'
*.sga_target=9216m
*.undo_tablespace='UNDOTBS1'
*.use_large_pages='only'
```

Benchmark parameters

```
#### SLOB 2.4.0 slob.conf

UPDATE_PCT=25
SCAN_PCT=0
RUN_TIME=3600
WORK_LOOP=0
SCALE=1960M
SCAN_TABLE_SZ=1M
WORK_UNIT=64
REDO_STRESS=LITE
LOAD_PARALLEL_DEGREE=2

THREADS_PER_SCHEMA=1

DATABASE_STATISTICS_TYPE=awr   # Permitted values: [statspack|awr]

#### Settings for SQL*Net connectivity:
#### Uncomment the following if needed:
#ADMIN_SQLNET_SERVICE="if needed, replace with a valid tnsnames.ora service"
#SQLNET_SERVICE_BASE="if needed, replace with a valid tnsnames.ora service"
#SQLNET_SERVICE_MAX="if needed, replace with a non-zero integer"
#
#### Note: Admin connections to the instance are, by default, made as SYSTEM
#          with the default password of "manager". If you wish to use another
#          privileged account (as would be the cause with most DBaaS), then
#          change DBA_PRIV_USER and SYSDBA_PASSWD accordingly.
#### Uncomment the following if needed:
DBA_PRIV_USER="system"
SYSDBA_PASSWD="password"

#### The EXTERNAL_SCRIPT parameter is used by the external script calling feature of runit.sh.
#### Please see SLOB Documentation at https://kevinclosson.net/slob for more information

EXTERNAL_SCRIPT=''


#########################
#### Advanced settings:
#### The following are Hot Spot related parameters.
#### By default Hot Spot functionality is disabled (DO_HOTSPOT=FALSE).

DO_HOTSPOT=FALSE
HOTSPOT_MB=8
HOTSPOT_OFFSET_MB=16
HOTSPOT_FREQUENCY=3


#### The following controls operations on Hot Schema
#### Default Value: 0. Default setting disables Hot Schema

HOT_SCHEMA_FREQUENCY=0

#### The following parameters control think time between SLOB
#### operations (SQL Executions).
#### Setting the frequency to 0 disables think time.

THINK_TM_FREQUENCY=0
THINK_TM_MIN=.1
THINK_TM_MAX=.5
```

This project was commissioned by Dell Technologies.

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