The science behind the report:

Upgrade to a Dell EMC PowerEdge R740xd database server that harnesses the power of Toshiba HK4R SATA solid-state drives

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 Upgrade to a Dell EMC PowerEdge R740xd database server that harnesses the power of Toshiba HK4 SATA solid-state drives.

On March 18, 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 April 5, 2018.

Our results

The table below presents our findings in detail.

IOPS

	Reads per second	Writes per second	Total
Dell EMC™ PowerEdge™ R740xd with Toshiba HK4R Series SSDs	128,793.47	13,187.00	141,980.47
Dell EMC PowerEdge R730 with older SSDs	98,559.67	9,969.92	108,529.59

Latency

	Read latency (ms)	Write latency (ms)
Dell EMC PowerEdge R740xd with Toshiba HK4R Series SSDs	1.890	2.243
Dell EMC PowerEdge R730 with older SSDs	2.202	3.625

System configuration information

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

Server configuration information	Dell EMC PowerEdge R740xd	Dell EMC PowerEdge R730
BIOS name and version	Dell 1.3.7	Dell 2.7.1
Operating system name and version/build number	Oracle® Linux® 7.4	Oracle Linux 7.4
Date of last OS updates/patches applied	10/18/2018	10/18/2018
Power management policy	Performance	Performance
Processor		
Number of processors	2	2
Vendor and model	Intel® Xeon® Gold 6130	Intel Xeon E5-2640 v4
Core count (per processor)	16	10
Core frequency (GHz)	2.10	2.40
Stepping	4	1
Memory module(s)		
Total memory in system (GB)	128	128
Number of memory modules	8	16
Vendor and model	Hynix® HMA82GR7AFR8N-VK	Samsung® M393A1G43DB0-CPB
Size (GB)	16	8
Type	PC4-2666	PC4-2133
Speed (GHz)	2.66	2133
Speed running in the server (GHz)	2.66	2133
Storage controller		
Vendor and model	Dell PERC H740p	Dell PERC H730p Mini
Cache size	4 GB	2 GB
Firmware version	50.0.3-0962	25.5.4.0006
Local storage 1		
Number of drives	2	2
Drive vendor and model	Intel SSDSCKJB120G7R	Seagate® ST300MM0006
Drive size (GB)	120	300
Drive information (speed, interface, type)	m.2 SSD	6 Gb/s, SAS, HDD
Local storage 2		
Number of drives	6	6
Drive vendor and model	Toshiba THNSF8960CCSE	Intel SSDSC2BB960G7R
Drive size (GB)	960	960
Drive information (speed, interface, type)	6 Gbps, SATA, SSD	6Gb/s, SATA, SSD

Server configuration information	Dell EMC PowerEdge R740xd	Dell EMC PowerEdge R730
Network adapter		
Vendor and model	Broadcom® BCM5720-T rNDC	Intel Gigabit 4p X520/i350
Number and type of ports	4 x 1GbE	2 x 1GbE, 2 x 10GbE
Driver version	20.6.52	18.3.6
Cooling fans		
Vendor and model	Delta Electronics® PFR0612DHE-C	Dell CW51C
Number of cooling fans	6	6
Power supplies		
Vendor and model	Dell 0Y26KXA02	Dell 0HTR4A01
Number of power supplies	2	2
Wattage of each (W)	1100	750

How we tested

Our testing environment consisted of two servers; a Dell EMC PowerEdge R740xd and a Dell EMC PowerEdge R730. Each server was configured with 128 GB of RAM and six SATA SSDs. We installed our OS on the m.2 SSDs in a RAID 1 pair. We then created three sets of RAID 1 pairs on the SATA SSDs through the on-board controller, which we then presented to the OS for our OracleASM disk groups. We installed the Oracle Grid Infrastructure and Oracle Database 12cR2, created an Oracle instance, and populated the database with SLOB. We then ran SLOB three times and took the median score. For our test environment, we used a 1TB database and a 90/10 read/write workload.

We used the following steps to configure each server and our Oracle environment.

Installing Oracle Enterprise Linux 7.4

1. Insert an Oracle Enterprise Linux 7.4 bootable USB stick to the server, and boot to it.
2. Select Install or upgrade an existing system.
3. Choose the language you wish to use, and click Continue.
4. Select Installation Destination.
5. Select the desired disk for the OS.
6. Under Other Storage Options, select I will configure partitioning.
7. Click Done.
8. Select Click here to create them automatically.
9. Remove the /home partition.
10. Expand the swap partition to 16GB.
11. Assign all remaining free space to the / partition.
12. Click Done.
13. Click Accept Changes.
14. Select Kdump.
15. Uncheck Enable kdump, and click Done.
16. Select Network & Hostname.
17. Enter the desired hostname for the VM.
18. Turn on the desired network port, and click Configure.
19. On the General tab, select Automatically connect to this network when it is available.
20. On the IPv4 Settings tab, select Manual under Method.
21. Under Addresses, click Add, and enter the desired static IP information for the server.
22. Enter the desired DNS information.
23. Click Save, and click Done.
24. Select Date & Time, and ensure the correct date, time, and time zone is set.
25. Click the cog next to the Network Time On/Off switch to add your NTP server.
26. Add the IP address of your NTP server, and click +.
27. Uncheck all other NTP servers.
28. Click OK.
29. Click Done.
30. Click Begin Installation.
31. Select Root Password.
32. Enter the desired root password, and click Done.
33. When the installation completes, select Reboot to restart the server.

Configuring OEL 7.4 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. Install the Oracle 12c preinstall RPM:

   ```
   yum install oracle-database-server-12cR2-preinstall
   ```

5. Update OEL 7.4

   ```
   yum update
   ```

6. 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
   ```

7. Disable auditd:

   ```
   systemctl disable auditd
   ```

8. 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
   ```

9. Create passwords for the oracle account with Passwd.
10. 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/
    ```

11. 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
    ```

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

    ```
    vm.nr_hugepages = 51200
    vm.hugetlb_shm_group = 54321
    ```

13. 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'
```

14. 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
```

15. Install the oracleasmlib packages:

```
   yum install -y oracleasm-support-*
```

16. Create a partition on all R1 pairs using fdisk

17. 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
```

18. Run the following command to initialize oracleasm:

```
   oracleasm init
```

19. 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 LOG /dev/sdd1
```

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.
9. Change the path to /dev/oracleasm/disks, select the two disks that you are planning to use for the database, and click Next.
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. Click Next at the Management Options screen.
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. Follow the instructions to run the scripts.
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), select the disk for redo logs.
23. Click Advanced Options.
24. Set the database compatibility level to 12.2.0.1.0, and click OK.
25. Click OK.
26. In the ASM Configuration Assistant, click Create.
27. Edit the data disk group to set the compatibility level to 12.2.0.1.0 as well.
28. 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. Type `db_env` to set the Oracle database environment.
4. Run ./runInstaller.sh.
5. Wait for the GUI installer loads.
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. Type dbca, and press enter to open the Database configuration assistant.
3. At the Database Operation screen, select Create Database, and click Next.
4. Under Creation Mode select Advanced Mode, and click Next.
5. At the Deployment Type screen, select General Purpose or Transaction Processing. Click Next.
6. Enter a Global database name and the appropriate SID, and uncheck Create as Container database. Click Next.
7. At the storage option screen, select Use following for the database storage attributes.
8. From the drop-down menu, select Automatic Storage Management (ASM), and select +DATA for the file location.
9. At the Network Configuration screen, select the listener, and click Next.
10. At the Data Vault Option screen, leaves default, and click Next.
11. At the Configuration Options screen, set the SGA size to 38400 and the PGA size to 12800, and click Next.
12. At the Management Options screen select Configure Enterprise Manager (EM) Database Express, and click Next.
13. At the User Credentials screen, select Use the same administrative password for all accounts, enter and confirm the desired password, and click Next.
14. At the Creation Options, select Create Database, and click Next.
15. At the summary screen click Finish.
16. Close the Database Configuration Assistant.
17. In a Web browser, browse to https://host.ip.address:5500/em to open the database manager.
18. Log in as system with the password you specified.
19. Go to Storage→Tablespaces.
20. Click Create.
21. Enter SLOB as the Name, and check the Set As Default box.
22. Add 48 Oracle-Managed files sized at 30G. Click OK.
23. Go to Storage→Redo Log Groups.
24. Click Actions→Switch file… until you get one of the groups to go inactive.
25. Highlight the inactive group, and click Actions→Drop group.
26. Create two redo log groups, each with a single 10GB file on the +LOG ASM volume.
27. Repeat steps 24 and 25, removing the remaining default redo logs.

Installing SLOB and populating the database

1. Download the SLOB kit from http://kevinclosson.net/slob/
2. Copy and untar the files to /home/oracle/SLOB.
3. Edit the slob.conf file to match the contents of Benchmark parameters.
4. Type ./setup.sh SLOB 128 to start the data population to the SLOB tablespace we created earlier.
5. The database is populated when the setup is complete.

Running SLOB

1. Log in as the oracle user.
2. Type db_env to set the database environment.
3. Navigate to /home/oracle/SLOB.
4. Type ./runit.sh 64 to start the test.
5. When the test is complete, copy all output files to another location, and repeat steps 1 through 4 two more times.

Oracle spfile

Database: ORCL

```
orcl.__data_transfer_cache_size=0
orcl.__db_cache_size=30467424256
orcl.__inmemory_ext_roarea=0
orcl.__inmemory_ext_rwarea=0
orcl.__java_pool_size=939524096
orcl.__large_pool_size=4429185024
orcl.__oracle_base='/u01/app/oracle'#ORACLE_BASE set from environment
orcl.__pga_aggregate_target=13421772800
orcl.__sga_target=40265318400
orcl.__shared_io_pool_size=536870912
orcl.__shared_pool_size=3758096384
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.261.971213129'
*.db_block_size=8192
*.db_cache_size=134217728
*.db_create_file_dest='+DATA'
*.db_domain='test.local'
*.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=12800m
*.processes=5120
*.remote_login_passwordfile='EXCLUSIVE'
*.sga_target=38400m
*.undo_tablespace='UNDOTBS1'
*.use_large_pages='only'
```

Benchmark parameters

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

UPDATE_PCT=10
SCAN_PCT=0
RUN_TIME=7200
WORK_LOOP=0
SCALE=8G
SCAN_TABLE_SZ=1M
WORK_UNIT=64
REDO_STRESS=LITE
LOAD_PARALLEL_DEGREE=8

THREADS_PER_SCHEMA=4

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=.05
THINK_TM_MAX=.05
```

This project was commissioned by Dell Technologies.

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