The science behind the report:

Process 84% more MySQL database activity with the latest-gen Dell PowerEdge R760 server running VMware vSphere 8.0

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 Process 84% more MySQL database activity with the latest-gen Dell PowerEdge R760 server running VMware vSphere 8.0.

We concluded our hands-on testing on April 25, 2023. During testing, we determined the appropriate hardware and software configurations and applied updates as they became available. The results in this report reflect configurations that we finalized on April 24, 2023 or earlier. Unavoidably, these configurations may not represent the latest versions available when this report appears.

Our results

To learn more about how we have calculated the wins in this report, go to http://facts.pt/calculating-and-highlighting-wins. Unless we state otherwise, we have followed the rules and principles we outline in that document.

Table 1: Results of our testing.

	Dell™ PowerEdge™ R760	Dell PowerEdge R750
New orders per minute	3,881,239	2,103,020
Average CPU utilization percentage	79.9	69.3

System configuration information

Table 2: Detailed information on the systems we tested.

Server configuration information	Dell PowerEdge R760	Dell PowerEdge R750
Tested by	Principled Technologies	Principled Technologies
Test date	4/25/2023	4/25/2023
Workload & version	HammerDB TPROC-C 4.7	HammerDB TPROC-C 4.7
Workload-specific parameters	750 warehouses, 16 virtual users, all_warehouse=true	750 warehouses, 16 virtual users, all_warehouse=true
Iterations and result choice	3 runs, median	3 runs, median
Server platform	Dell PowerEdge R760	Dell PowerEdge R750
BIOS name and version	1.2.1	1.9.2
Operating system name and version/ build number	VMware® vSphere® 8.0 Red Hat® Enterprise Linux® 9.1 5.14.0-162.22.2.el9_1.x86_64	VMware vSphere 7.0 Red Hat Enterprise Linux 9.1 5.14.0-162.22.2.el9_1.x86_64
Date of last OS updates/patches applied	4/24/2023	4/24/2023
Processor		
Number of processors	2	2
Vendor and model	Intel® Xeon® Platinum 8452Y	Intel Xeon Gold 6348
Core count (per processor)	36	28
Core frequency (GHz)	2.00	2.60
Model, Stepping	143, 6	106, 6
SMT	Yes	Yes
Turbo	Yes (3.20)	Yes (3.50)
Memory module(s)		
Total memory in system (GB)	1,024	512
NVMe® memory present?	No	No
Total memory (DDR+NVMe RAM) (GB)	1,024	512
General HW		
Storage: NW or Direct Att / Controller	Direct Att PERC H965i	Direct Att PERC H755N
Local storage – OS		
Number of drives	2	2
Drive size (GB)	480	480
Drive information (speed, interface, type)	8 GT/s NVMe M.2 SSD	6 Gbps SATA M.2 SSD
Local storage – Data drive		
Number of drives	8	8
Drive size (TB)	1.6	1.6
Drive information (speed, interface, type)	16 GT/s NVMe SSD	16 GT/s NVMe SSD

How we tested

We compared the following dual-socket solutions:

- Dell PowerEdge R760 with Intel Xeon Platinum 8452Y 36-core processors and 1024GB DDR5 memory
    - PERC 12 storage controller (PERC H965i)
- Dell PowerEdge R750 with Intel Gold 6348 28-core processors and 512GB DDR4 memory
    - PERC 11 storage controller (PERC H755N)

We chose to use additional RAM in the Dell PowerEdge R760 to alleviate disk controller contention that we observed in the PowerEdge R750, to optimize our database sizing, and to take advantage of the server's additional cores.

Both servers used eight SSDs in a RAID10 configuration to host the MySQL data and logs. We used VMware vSphere 8.0 as our hypervisor for the PowerEdge R760 and VMware vSphere 7.0 as our hypervisor for the PowerEdge R750. We created 10 VMs on each server so we could divide each server into medium-sized database VMs equally while leaving some cores and memory for hypervisor overhead. The VMs on the PowerEdge R760 each had 12 virtual CPUs (vCPUs) and 96 GB of vRAM, and the VMs on the PowerEdge R750 each had 10 vCPUs and 48 GB of vRAM. We installed Red Hat Enterprise Linux 9.1 and MySQL 8.0. We ran the HammerDB 4.7 TPROC-C workload and measured the new orders per minute (NOPM) that each VM achieved.

Installing VMware vSphere 8.0 or 7.0

1. Boot to the VMware vSphere 8.0 or 7.0 installation media.
2. To continue, press Enter.
3. To accept the license agreement, press F11.
4. Select the BOSS M-2 installation location.
5. Select a language, and create the root password.
6. To install, press F11.

Creating the base VM

1. Use a web browser to connect and log into the vSphere instance.
2. Right-click the host, and click New VM.
3. Assign the VM the following properties:

    - 10 or 12 vCPUs
    - 48 or 96 GB of memory
    - 60GB VMDK on SCSI controller 0 (for operating system)
    - 100GB VMDK on SCSI controller 1 (for MySQL data and logs)
    - VMware Paravirtual controller
    - Thick-provisioned eager-zeroed

4. Click Finish.

Installing Red Hat Enterprise Linux 9.1

1. Boot the VM to the Red Hat Enterprise Linux 9.1 installation media.
2. Select Install or upgrade an existing system.
3. Choose English, and click Continue.
4. To install the OS, under Installation Destination, select the OS VMDK.
5. Click Done.
6. Click Accept Changes.
7. Select Kdump.
8. Uncheck Enable kdump, and click Done.
9. Select Network & Hostname.
10. Enter the desired hostname for the system.
11. Turn on the desired network ports, and click Configure.
12. On the General tab, select Automatically connect to this network when it is available.
13. On the IPv4 Settings tab, choose the Method drop-down menu, and select Manual.
14. Under Addresses, click Add, and enter the desired static IP information for the server.
15. Enter the desired DNS information.

16. Click Save, and click Done.
17. Select Date & Time, and ensure the correct date, time, and time zone are set.
18. To add your NTP server, click the cog next to the Network Time On/Off switch.
19. Add the IP address of your NTP server, and click +.
20. Uncheck all other NTP servers.
21. Click OK.
22. Click Done.
23. Click Software Selection.
24. Choose the Base Environment of Minimal Install.
25. Click Done.
26. Click Begin Installation.
27. Select Root Password.
28. Enter the desired root password, and click Done.
29. When the installation completes, select Reboot to restart the server.

Configuring Red Hat Enterprise Linux 9.1 for MySQL

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. Register your Red Hat Enterprise Linux subscription:

```
subscription-manager register --username <RHEL_USERNAME> --password <RHEL_PASSWORD> --auto-attach
```

5. Install wget, sysstat, and gdisk:

```
yum install -y sysstat wget gdisk
```

6. Update Red Hat Enterprise Linux 9.1:

```
yum update -y
```

7. Disable auditd:

```
systemctl disable auditd
```

8. Format the data disk:

```
mkfs.xfs /dev/sdb
```

9. Create the data directory:

```
mkdir -p /mnt/mysqldata
```

10. Mount the data disk:

```
mount /dev/sdb /mnt/mysqldata
```

11. Edit `/etc/fstab` to include the following line:

```
/dev/sdb  /mnt/mysqldata  xfs  defaults,nofail,x-systemd.device-timeout=5  0 2
```

12. Reboot the VM.
13. Download the MySQL 8.0 RPM bundle:

```
wget https://dev.mysql.com/get/Downloads/MySQL-8.0/mysql-8.0.33-1.el9.x86_64.rpm-bundle.tar
```

14. Extract the files and install all RPMs:

```
yum localinstall -y *.rpm
```

15. Stop the MySQL service:

```
systemctl stop mysqld.service
```

16. Move the MySQL directory to the data disk:

```
cp -r /var/lib/mysql /mnt/mysqldata/mysql
```

17. Replace the MySQL configuration file with the `my.cnf` file in the Scripts section below:

```
cp my-750.cnf /etc/my.cnf
```

18. Start the MySQL service:

```
systemctl start mysqld.service
```

19. Log into the database instance:

```
mysql -u root
```

20. Enter the following commands:

```
CREATE USER 'mysql'@'localhost' IDENTIFIED BY '[password]';
GRANT ALL PRIVILEGES ON *.* TO 'mysql'@'localhost'
->  WITH GRANT OPTION;
CREATE USER 'mysql'@'%' IDENTIFIED BY '[password]';
GRANT ALL PRIVILEGES ON *.* TO 'mysql'@'%'
->  WITH GRANT OPTION;
ALTER USER 'mysql'@'localhost' IDENTIFIED WITH mysql_native_password BY '[password]';
ALTER USER 'mysql'@'%' IDENTIFIED WITH mysql_native_password BY '[password]';
FLUSH PRIVILEGES;
EXIT
```

21. Reboot the VM.

Creating the client VM

We created the client VMs on a separate infrastructure server and connected them via a 25Gb network. We used VMware vSphere 8.0 for the infrastructure hypervisor and Red Hat Enterprise Linux 9.1 for the guest operating system.

1. Complete the steps from the previous sections to install the hypervisor and guest OS, and to configure the guest OS up to and including installing the MySQL RPMs.
2. Download and extract the HammerDB-4.7 package:

```
wget https://github.com/TPC-Council/HammerDB/releases/download/v4.7/HammerDB-4.7-Linux.tar.gz
tar -xf HammerDB-4.7-Linux.tar.gz
```

3. Inside the HammerDB directory, create the `build.tcl` and `run.tcl` scripts from the Scripts section below.

Building and backing up the database

1. Inside each client VM, navigate to the HammerDB directory, and run the `build.tcl` script:

```
cd HammerDB-4.7
./hammerdbcli auto build.tcl
```

2. Once the database has finished building, log onto the target VM, and back up the database:

```
systemctl stop mysqld.service
cd /mnt/mysqldata
tar -cf- data/ | pigz -9 -c > mysql_tpcc750warehouses_data.tar.gz
```

3. Reboot the target VM.

Running the tests

1. Inside each target VM, start the nmon process to capture performance data during the run:

```
nmon -F /root/<host>_<run>.nmon -s 10 -c 270 -J -t
```

2. From each client VM, kick off the HammerDB test by running the `run.tcl` script:

```
./hammerdbcli auto run.tcl
```

3. After each test run, collect the nmon and HammerDB logs, perform the steps in the next section to reset the database, and allow the VM to idle for 10 minutes.
4. Complete 1 through 3 two more times, and report the median result.

Resetting the database

1. Inside each target VM, reset the database:

```
systemctl stop mysqld.service
cd /mnt/mysqldata
tar -xf mysql_tpcc750warehouses_data.tar.gz
reboot
```

Scripts

In this section, we provide the scripts we mentioned in the methodology steps.

my-750.cnf:

```
[mysqld]
datadir=/mnt/mysqldata/mysql
default_authentication_plugin=mysql_native_password
socket=/mnt/mysqldata/mysql/mysqld.sock
log-error=/var/log/mysql/mysqld.log
pid-file=/var/run/mysqld/mysqld.pid
port=3306
bind_address=0.0.0.0
# general
max_connections=4000
table_open_cache=8000
table_open_cache_instances=16
back_log=1500
default_password_lifetime=0
ssl=0
performance_schema=OFF
max_prepared_stmt_count=128000
skip_log_bin=1
character_set_server=latin1
collation_server=latin1_swedish_ci
transaction_isolation=REPEATABLE-READ
# files
innodb_file_per_table
innodb_log_file_size=1024M
innodb_log_files_in_group=12 / 24 #scale depending on R750 or R760
innodb_open_files=4000
# buffers
innodb_buffer_pool_size=36000M / 72000M #scale depending on R750 or R760
innodb_buffer_pool_instances=16
innodb_log_buffer_size=64M
# tune
innodb_doublewrite=0
innodb_thread_concurrency=0
innodb_flush_log_at_trx_commit=0
innodb_max_dirty_pages_pct=90
innodb_max_dirty_pages_pct_lwm=10
join_buffer_size=32K
sort_buffer_size=32K
innodb_use_native_aio=1
innodb_stats_persistent=1
innodb_spin_wait_delay=6
innodb_max_purge_lag_delay=300000
innodb_max_purge_lag=0
innodb_flush_method=O_DIRECT_NO_FSYNC
innodb_checksum_algorithm=none
innodb_io_capacity=2000
innodb_io_capacity_max=4000
innodb_lru_scan_depth=9000
innodb_change_buffering=none
innodb_read_only=0
innodb_page_cleaners=4
innodb_undo_log_truncate=off
# perf special
innodb_adaptive_flushing=1
innodb_flush_neighbors=0
innodb_read_io_threads=16
innodb_write_io_threads=16
innodb_purge_threads=4
innodb_adaptive_hash_index=0
# monitoring
innodb_monitor_enable='%'
[client]
socket=/mnt/mysqldata/mysql/mysqld.sock
```

build.tcl:

```
dbset db mysql
diset connection mysql_host <IP_ADDRESS>
diset tpcc mysql_user mysql
diset tpcc mysql_pass <Password>
diset tpcc mysql_count_ware 750
diset tpcc mysql_partition true
diset tpcc mysql_num_vu 16
diset tpcc mysql_storage_engine innodb
buildschema
```

run.tcl

```
dbset db mysql
diset connection mysql_host <IP_ADDRESS>
diset tpcc mysql_user mysql
diset tpcc mysql_pass <Password>
diset tpcc mysql_count_ware 750
diset tpcc mysql_partition true
diset tpcc mysql_num_vu 16
diset tpcc mysql_storage_engine innodb
diset tpcc mysql_allwarehouse true
diset tpcc rampup 10
diset tpcc duration 30
vucreate
vurun
```

Read the report at https://facts.pt/2fT60bz ▶

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