



The science behind the report:

# Get insight from document-based distributed MongoDB databases sooner and have CPU headroom for additional data analysis workloads

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 [Get insight from document-based distributed MongoDB databases sooner and have CPU headroom for additional data analysis workloads](#).

We concluded our hands-on testing on October 1, 2019. 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 September 11, 2019 or earlier. Unavoidably, these configurations may not represent the latest versions available when this report appears.

## Our results

The table below presents our findings in detail.

	Dell EMC PowerEdge R640	Dell EMC PowerEdge R630
YCSB operations per second	100,678.76	73,668.72
Percentage win	N/A	36.66%
Average CPU %	43.06%	63.49%

## System configuration information

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

Server configuration information	Dell EMC PowerEdge R640	Dell EMC PowerEdge R630
BIOS name and version	2.2.11	2.9.1
Non-default BIOS settings	Performance per watt (OS)	Performance per watt (OS)
Operating system name and version/build number	VMware ESXi™ 6.7.0, 14320388	VMware ESXi 6.7.0, 13981272
Date of last OS updates/patches applied	09/04/2019	09/19/2019
Power management policy	Performance per watt (OS)	Performance per watt (OS)
Processor		
Number of processors	2	2
Vendor and model	Intel® Xeon® Gold 6230	Intel Xeon E5-2690 v3
Core count (per processor)	20	12
Core frequency (GHz)	2.10	2.60
Stepping	6	2
Memory module(s)		
Total memory in system (GB)	256	256
Number of memory modules	16	16
Vendor and model	Hynix® Semiconductor HMA82GR7CJR8N-WM	Samsung® M393A2G40DB0-CPB
Size (GB)	16	16
Type	PC4-2933	PC4-2133
Speed (MHz)	2,933	2,133
Speed running in the server (MHz)	2,933	2,133
Storage controller		
Vendor and model	PERC H740P Mini	PERC H730 Mini
Cache size (GB)	8	1
Firmware version	50.5.1-2818	25.5.5.0005
Driver version	7.708.07.00	7.708.07.00
SATA SSD storage		
Number of drives	8	8
Drive vendor and model	Intel SSDSC2KB019T8R	Intel SSDSC2KB019T8R
Drive size (TB)	1.92	1.92
Drive information (speed, interface, type)	6Gbps SATA SSD	6Gbps SATA SSD
NVMe SSD storage		
Number of drives	2	N/A

Server configuration information	Dell EMC PowerEdge R640	Dell EMC PowerEdge R630
Drive vendor and model	Dell EMC Express Flash NVMe P4610	N/A
Drive size (TB)	1.6	N/A
Drive information (speed, interface, type)	PCIe SSD	N/A
Network adapter		
Vendor and model	Intel XXV710	QLogic BCM57800
Number and type of ports	2 x 25Gb	4 x 10Gb
Driver version	1.8.1.9	1.0.77.2
Cooling fans		
Vendor and model	Dell 384-BBQE	Dell TGC4J
Number of cooling fans	8	7
Power supplies		
Vendor and model	Dell 0PJMDN	Dell 0Y9VFC
Number of power supplies	2	2
Wattage of each (W)	750	750

# How we tested

## Configuring the ESXi servers

We installed ESXi 6.7 (VMware-VMvisor-Installer-6.7.0.update02-13981272.x86\_64-DellEMC\_Customized-A02.iso) onto each Dell EMC PowerEdge R630 and Dell EMC PowerEdge R640 server. Then we performed the following steps on each physical ESXi server:

1. Attach the installation media.
2. Boot the server.
3. At the VMware Installer screen, press Enter.
4. At the EULA screen, to Accept and Continue, press F11.
5. Under Storage Devices, select the appropriate virtual disk, and press Enter.
6. As the keyboard layout, select US, and press Enter.
7. Enter the root password twice, and press Enter.
8. To start installation, press F11.
9. After the server reboots, press F2, and enter root credentials
10. Select Configure Management Network, and press Enter.
11. Select the appropriate network adapter, and select OK.
12. Select IPv4 settings, and enter the desired IP address, subnet mask, and gateway for the server.
13. Select OK, and restart the management network.
14. Use the table below to create six Mongod Servers, one Config Server, and one Mongos server for each ESXi host.

## Configuring of the VMs for testing

We used the following configurations for VMs on the PowerEdge R630 servers we tested.

VM type	Number of VMs	Number of vCPUs	vRAM	HDDs
Config Server	3	2	8 GB	1 x 50 GB (OS) 1 x 200 GB (DB)
Mongos Server	3	6	28 GB	1 x 50 GB (OS)
Mongod Server	6	6	32 GB	1 x 50 GB (OS) 1 x 400 GB (DB)

We used the following configurations for VMs on the PowerEdge R640 servers we tested.

VM type	Number of VMs	Number of vCPUs	vRAM	HDDs
Config Server	3	2	8 GB	1 x 50 GB (OS) 1 x 200 GB (DB)
Mongos Server	3	10	28 GB	1 x 50 GB (OS)
Mongod Server	6	10	32 GB	1 x 50 GB (OS) 1 x 400 GB (DB)

## Installing and configuring MongoDB on the Config Server VMs

We installed CentOS 7 onto each VM, and then performed the following steps on each Config Server VM:

1. Log into the VM you want to configure.
2. Type the following commands to stop and disable the firewall service:

```
systemctl stop firewalld
systemctl disable firewalld
```
3. Type the following commands to enter the SELinux configuration file:

```
vim /etc/sysconfig/selinux
```
4. Once inside the SELinux configuration file, change its configuration from enabled to disabled.
5. Type the following commands to create a new tuned config file that disables Transparent HugePages within a virtual guest machine:

```
sudo mkdir /etc/tuned/no-thp
vim /etc/tuned/no-thp/tuned.conf
```
6. With the blank tuned.conf file open, write the following into the file, and save:

```
[main]
include=virtual-guest

[vm]
transparent_hugepages=never
```
7. Follow the procedure on MongoDB's website to disable Transparent HugePages on the OS:  
<https://docs.mongodb.com/manual/tutorial/transparent-huge-pages/>
8. Add all host information for all systems into the /etc/hosts file.
9. Reboot the server.
10. Update the system:

```
sudo yum update -y
```
11. Create the mongodb-org.repo file:

```
touch /etc/yum.repos.d/mongodb-org.repo
```
12. Populate the mongodb-org.repo file:

```
vim /etc/yum.repos.d/mongodb-org.repo
```

  - a. Add the following:

```
[mongodb-org-4.0]
name=MongoDB Repository
baseurl=https://repo.mongodb.org/yum/redhat/$releasever/mongodb-org/4.0/x86_64/
gpgcheck=1
enabled=1
gpgkey=https://www.mongodb.org/static/pgp/server-4.0.asc
```
13. Install MongoDB:

```
yum install -y mongodb-org
```
14. Type the following command to make mongod start with the operating system:

```
echo "mongod --config=/etc/mongod.conf" >> /etc/rc.d/rc.local
```

Type the following command to add the database drive to the VM and create the database folders for MongoDB:

```
mkfs.xfs /dev/sdb
mount /dev/sdb /mnt
echo '/dev/sdb /mnt xfs defaults 0 0' >> /etc/fstab
mkdir -p /mnt/var/lib/mongo
chown mongod /mnt/var/lib/mongo
chgrp mongod /mnt/var/lib/mongo
```

15. Type the following command to open the mongod configuration file:

```
vim /etc/mongod.conf
```

16. Inside the mongod configuration file, make the following changes:

```
storage:
  dbPath: /mnt/var/lib/mongo
  journal:
    enabled: true
    engine: "wiredTiger"
net:
  port: 27017
  bindIp: 0.0.0.0 #0.0.0.0 binds all
replication:
  replSetName: config-replica-set
sharding:
  clusterRole: configsvr
```

17. Save the mongod configuration file.
18. Type the following command to start your mongod server:

```
mongod --config=/etc/mongod.conf
```

19. Reboot the server, and verify that the daemons loaded properly:

```
systemctl status mongod
```

20. Complete steps 1 through 20 on the remaining two Config Server VMs.

## Creating the Config Server replica set on the Config Server VMs

1. Log into all three Config Servers, and verify that all three are "active (running)."
2. To enter the MongoDB console on all three Config Servers, type `mongo`.
3. In the MongoDB console of only one Config Server, type the following command to create the replica set:

```
rs.initiate(
  {
    _id : "config-replica-set",
    members: [
      { _id : 0, host : "config-server-1:27017" },
      { _id : 1, host : "config-server-2:27017" },
      { _id : 2, host : "config-server-3:27017" }
    ]
  }
)
```

4. To verify that the config-replica-set was created, press the enter key several times on all three Config Servers by. The command line should change to one of the following:

```
config-replica-set:PRIMARY>
config-replica-set:SECONDARY> (2 of these will be present)
```

## Installing and configuring MongoDB on the Mongos Server VMs

We installed CentOS 7 onto each VM, and then performed the following steps on each Mongos Server VM:

1. Log into the VM you want to configure.
2. Type the following commands to stop and disable the firewall service:

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

3. Type the following commands to enter the SELinux configuration file:

```
vim /etc/sysconfig/selinux
```

4. Once inside the SELinux configuration file, change its configuration from enabled to disabled.

5. Type the following commands to create a new tuned config file that disables Transparent HugePages within a virtual guest machine:

```
sudo mkdir /etc/tuned/no-thp
vim /etc/tuned/no-thp/tuned.conf
```

6. With the blank tuned.conf file open, write the following into the file, and save:

```
[main]
include=virtual-guest

[vm]
transparent_hugepages=never
```

7. Follow the procedure on MongoDB's website to disable Transparent HugePages:

<https://docs.mongodb.com/manual/tutorial/transparent-huge-pages/>

8. Add all host information for all systems into the /etc/hosts file.

9. Reboot the server.

10. Perform system updates:

```
sudo yum update -y
```

11. Create the mongodb-org.repo file:

```
touch /etc/yum.repos.d/mongodb-org.repo
```

12. Populate the mongodb-org.repo file:

```
vim /etc/yum.repos.d/mongodb-org.repo
Add the following:
[mongodb-org-4.0]
name=MongoDB Repository
baseurl=https://repo.mongodb.org/yum/redhat/$releasever/mongodb-org/4.0/x86_64/
gpgcheck=1
enabled=1
gpgkey=https://www.mongodb.org/static/pgp/server-4.0.asc
```

13. Install MongoDB:

```
yum install -y mongodb-org
```

14. Type the following command to make mongod start with the operating system:

```
echo "mongos --config=/etc/mongod.conf" >> /etc/rc.d/rc.local
```

15. Type the following command to open the mongod configuration file:

```
vim /etc/mongod.conf
```

16. Inside the mongod configuration file, make the following changes:

```
#storage:
#dbPath: /var/lib/mongo
#journal:
#enabled: true
net:
port: 27017
bindIp: 0.0.0.0 #0.0.0.0 binds all
sharding:
configDB: config-replica-set/config-server-1:27017,config-server-2:27017,config-server-3:27017
```

17. Save the mongod configuration file.

18. Type the following command to start the mongod server:

```
mongos --config=/etc/mongod.conf
```

19. To enter the MongoDB console on the Mongos Server, type mongo.

20. Verify that the MongoDB console starts in the mongos console. The command line should look like the following:

```
mongos>
```

21. Complete steps 1 through 20 on the remaining two Mongos Server VMs.

## Installing and configuring MongoDB on the Mongod Server VMs

We installed CentOS 7 onto each VM, and then performed the following steps on each Mongod Server VM:

1. Log into the VM you want to configure.
2. Type the following commands to stop and disable the firewall service:

```
systemctl stop firewalld
systemctl disable firewalld
```
3. Type the following command to enter the SELinux configuration file:

```
vim /etc/sysconfig/selinux
```
4. Once inside the SELinux configuration file, change its configuration from enabled to disabled.
5. Type the following commands to create a new tuned config file that disables Transparent HugePages within a virtual guest machine:

```
sudo mkdir /etc/tuned/no-thp
vim /etc/tuned/no-thp/tuned.conf
```
6. With the blank tuned.conf file open, write the following into the file, and save:

```
[main]
include=virtual-guest

[vm]
transparent_hugepages=never
```
7. Follow the procedure on MongoDB's website to disable Transparent HugePages on the OS:  
<https://docs.mongodb.com/manual/tutorial/transparent-huge-pages/>
8. Add all host information for all systems into the /etc/hosts file.
9. Reboot the server.
10. Perform system updates:

```
sudo yum update -y
```
11. Create the mongodb-org.repo file:

```
touch /etc/yum.repos.d/mongodb-org.repo
```
12. Populate the mongodb-org.repo file:

```
vim /etc/yum.repos.d/mongodb-org.repo
Add the following:
[mongodb-org-4.0]
name=MongoDB Repository
baseurl=https://repo.mongodb.org/yum/redhat/$releasever/mongodb-org/4.0/x86_64/
gpgcheck=1
enabled=1
gpgkey=https://www.mongodb.org/static/pgp/server-4.0.asc
```
13. Install MongoDB:

```
yum install -y mongodb-org
```
14. Type the following command to make mongod start with the operating system:

```
echo "mongod --config=/etc/mongod.conf" >> /etc/rc.d/rc.local
```
15. Type the following commands to add the database drive to the VM and create the database folders for MongoDB:

```
mkfs.xfs /dev/sdb
mount /dev/sdb /mnt
echo '\dev/sdb /mnt xfs defaults 0 0' >> /etc/fstab
mkdir -p /mnt/var/lib/mongo
chown mongod /mnt/var/lib/mongo
chgrp mongod /mnt/var/lib/mongo
```
16. Type the following command to open the mongod configuration file:

```
vim /etc/mongod.conf
```



17. Inside the mongod configuration file, make the following changes:

```
storage:
dbPath: /mnt/var/lib/mongo
journal:
enabled: true
engine: "wiredTiger"
net:
port: 27017
bindIp: [your server's IP],localhost
replication:
replSetName: shard-replica-set-#
sharding:
clusterRole: shardsvr
```

18. Save the mongod configuration file.
19. Type the following command to start your mongod server:

```
mongod --config=/etc/mongod.conf
```

20. Reboot the server, and verify that the daemons load properly:

```
systemctl status mongod
```

21. Complete steps 1 through 20 on the remaining five Mongod Server VMs.

## Creating the mongod replica sets on the Mongod Server VMs

1. Log into the three Mongod Servers that will make up a the three-node replica set, and verify that all three are "active (running)."
2. To enter the MongoDB console on all three Mongod Servers, type `mongo`.
3. In the MongoDB console of only one Mongod Server, type the following command to create the shard-replica-set (where # represents the shard-replica-set number and where ## represents the hostname number):

```
rs.initiate(
  {
    _id : "shard-replica-set-#",
    members: [
      { _id : 0, host : "mongod-server-##:27017" },
      { _id : 1, host : "mongod-server-##:27017" },
      { _id : 2, host : "mongod-server-##:27017" }
    ]
  }
)
```

4. Press the enter key several times on all three Config Servers to verify that the config-replica-set was created. The command line should change to one of the following:

```
shard-replica-set-#:PRIMARY>
shard-replica-set-#:SECONDARY> (2 of these will be present)
```

5. Complete steps 1 through 4 until all 18 servers are configured, using three Mongod Servers per shard-server-set for a total six shard-server-sets.

## Enable sharding operations on the Mongos Server VMs

Prior to building the database, sharding must be enabled on the Mongos Server(s).

1. Log into the Mongos Server VMs you want to configure.
2. Type the following command to start the mongod server:

```
mongos --config=/etc/mongod.conf
```

3. To enter the MongoDB console on the Mongos Server, type `mongo`.
4. Type the following to configure two shards on the first Mongos Server:

```
sh.addShard("shard-replica-set-1/<Mongod-Svr-01a:27017, Mongod-Svr-02a:27017, Mongod-Svr-03a:27017")
sh.addShard("shard-replica-set-4/<Mongod-Svr-01d:27017, Mongod-Svr-02d:27017, Mongod-Svr-03d:27017")
```

5. Type the following to configure two shards on the second Mongos Server:

```
sh.addShard("shard-replica-set-2/<Mongod-Svr-01b:27017, Mongod-Svr-02b:27017, Mongod-Svr-03b:27017")
sh.addShard("shard-replica-set-5/<Mongod-Svr-01e:27017, Mongod-Svr-02e:27017, Mongod-Svr-03e:27017")
```

6. Type the following to configure two shards on the third Mongos Server:

```
sh.addShard("shard-replica-set-3/<Mongod-Svr-01c:27017, Mongod-Svr-02c:27017, Mongod-Svr-03c:27017")
sh.addShard("shard-replica-set-6/<Mongod-Svr-01f:27017, Mongod-Svr-02f:27017, Mongod-Svr-03f:27017")
```

7. Type the following command to verify the shards are setup correctly:

```
sh.status()
```

## Installing the YCSB Driver VMs

We installed CentOS 7 onto each VM, and then performed the following steps on each YCSB Driver VM:

1. Log into the VM you want to configure.
2. Type the following commands to stop and disable the firewall service:

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

3. Type the following command to enter the SELinux configuration file:

```
vim /etc/sysconfig/selinux
```

4. Once inside the SELinux configuration file, change its configuration from enabled to disabled.

5. Type the following commands to create a new tuned config file that disables Transparent HugePages within a virtual guest machine:

```
sudo mkdir /etc/tuned/no-thp
vim /etc/tuned/no-thp/tuned.conf
```

6. With the blank tuned.conf file open, write the following into the file, and save:

```
[main]
include=virtual-guest

[vm]
transparent_hugepages=never
```

7. Follow the procedure on MongoDB's website to disable Transparent HugePages on the OS.

<https://docs.mongodb.com/manual/tutorial/transparent-huge-pages/>

8. Add all host information for all systems into the /etc/hosts file.

9. Reboot the server.

10. Perform system updates:

```
sudo yum update -y
```

11. Create the mongodb-org.repo file:

```
touch /etc/yum.repos.d/mongodb-org.repo
```

12. Populate the mongodb-org.repo file:

```
vim /etc/yum.repos.d/mongodb-org.repo
Add the following:
[mongodb-org-4.0]
name=MongoDB Repository
baseurl=https://repo.mongodb.org/yum/redhat/$releasever/mongodb-org/4.0/x86_64/
gpgcheck=1
enabled=1
gpgkey=https://www.mongodb.org/static/pgp/server-4.0.asc
```

13. Install MongoDB:

```
yum install -y mongodb-org
```

14. Type the following command to make mongod start with the operating system:
 

```
echo "mongod --config=/etc/mongod.conf" >> /etc/rc.d/rc.local
```
15. Type the following command to install Java:
 

```
sudo yum install java-devel
```
16. Type the following commands to install Maven:
 

```
wget "http://http://apache.cs.utah.edu/maven/maven-3/3.6.1/binaries/apache-maven-3.6.1-bin.tar.gz"
sudo tar xzf apache-maven-*-bin.tar.gz -C /usr/local
cd /usr/local
sudo ln -s apache-maven-* maven
echo export M2_HOME=/usr/local/maven >> /etc/profile.d/maven.sh
echo export PATH=${M2_HOME}/bin:${PATH} >> /etc/profile.d/maven.sh
```
17. Type the following commands to download and unpack YCSB into your driver:
 

```
run("curl -O --location https://github.com/brianfrankcooper/YCSB/releases/download/0.15.0/ycsb-0.15.0.tar.gz")
run("tar xfvz ycsb-0.15.0.tar.gz")
```
18. Complete steps 1 through 17 on the remaining two YCSB Driver VMs.

## Creating the YCSB database

1. Log into one YCSB Driver VM.
2. To create a roughly 600GB database for MongoDB, run the following command:
 

```
<install-dir>ycsb-0.15.0/bin/ycsb load mongodb -s -P <install-dir>ycsb-0.15.0/workloads/workloadb -threads 64 -p mongodb.url=mongodb://<mongos-server>:27017/ycsb?w=1 -p recordcount=500000000
```
3. As the database is being created, log into one of your Mongos Server VMs.
4. Type the following command to enter the MongoDB mongos console:
 

```
mongo
```
5. Type the following commands to shard and chunk your MongoDB database:
 

```
use ycsb
sh.enableSharding("ycsb")
sh.shardCollection("ycsb.usertable", { _id: 1 }, true )
```
6. The database will build for several hours. After the database is finished building, run the following command to check on the progress of the shard distribution:
 

```
sh.status()
```
7. The tests can begin once all shards have an equivalent number of distributed chunks.
8. To eliminate possible data collisions while updating, edit the <install-dir>ycsb-0.15.0/workloads/workloadb file on each YCSB Driver VM.
9. On YCSB Driver 1, type the following:
 

```
insertstart=0
insertcount=160000000
```
10. On YCSB Driver 2, type the following:
 

```
insertstart=160000000
insertcount=160000000
```
11. On YCSB Driver 3, type the following:
 

```
insertstart=320000000
insertcount=160000000
```

## Running the YCSB test

1. To clear all caches on each mongod VM, run the following command:

```
echo 3 > /proc/sys/vm/drop_caches
```

2. Log into the three YCSB drivers.
3. To start the test on all three drivers, run the following command:

```
<install-dir>/ycsb-0.15.0/bin/ycsb run mongod -s -P <install-dir>ycsb-0.15.0/workloads/workloadb  
-threads 64 -p mongod.url=mongod://<MONGOS-SERVER-01>:27017/ycsb?w=1 -p operationcount 3000000 -p  
mongod.upsert=true >> <install-dir>/ycsbttest-64threads-3000000ops-workloadb-<hostname>-<date>.txt
```

4. Record the results from the test.

Read the report at <http://facts.pt/e9lsh58> ►

This project was commissioned by Dell EMC.



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