Converged Database Continuous Availability Workshop

Part III - Database sharding

Contents

Initial requirements

- SSH private key to Access the database servers in the cloud. This private key is provided along with this manual.
- SSH client app, to login to the database servers
- Database servers public IP

Database sharding

Check environment

For additional details about this lab, especially about sharding concepts, please check " https://apexapps.oracle.com/pls/apex/dbpm/r/livelabs/workshop-attendee-2?p210_workshop_id=835&p210_type=3&session=4182485884819".

In the following workshop, you will:

- Deploy a shard database with two shards using system managed sharding
- Migrate an application to the shard database
- Work with the sharded database
- Extend the sharded database with a third shard

Your environment is made of 4 servers. You have been provided with the public IP of each of the servers, along with the private key to ssh them. The servers are:

- Shard catalog
- Shard 1
- Shard 2
- Shard 3

To start-up with the lab, connect to the 4 servers and check that a database is up and running on each of them, as well as a listener:

```
## Connect to the shard catalog

ssh -i privateKey opc@<public ip of shard catalog>

## Connect as "oracle" user and connect to the database

sudo su - oracle

[oracle@cata ~]$ sqlplus / as sysdba

SQL*Plus: Release 19.0.0.0.0 - Production on Tue Nov 9 11:36:07 2021
Version 19.11.0.0.0

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Connected to:
Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
Version 19.11.0.0.0

SQL>
SQL> show pdbs
```

```
    CON_ID CON_NAME                        OPEN MODE  RESTRICTED
---------- ------------------------------ ---------- ----------
         2 PDB$SEED                       READ ONLY  NO
         3 CATAPDB                        READ WRITE NO
SQL> exit

lsnrctl status LISTENER

## Connect to shard 1
ssh -i privateKey opc@<public ip of shard 1>

## Connect as "oracle" user and connect to the database

sudo su - oracle

[oracle@shd1 ~]$ sqlplus / as sysdba

SQL*Plus: Release 19.0.0.0.0 - Production on Tue Nov 9 11:37:10 2021
Version 19.11.0.0.0

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Connected to:
Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
Version 19.11.0.0.0

SQL> show pdbs

    CON_ID CON_NAME                        OPEN MODE  RESTRICTED
---------- ------------------------------ ---------- ----------
         2 PDB$SEED                       READ ONLY  NO
         3 SHDPDB1                        READ WRITE NO

exit

lsnrctl status LISTENER

## Connect to shard 2
ssh -i privateKey opc@<public ip of shard 2>

## Connect as "oracle" user and connect to the database

sudo su - oracle

[oracle@shd2 ~]$ sqlplus / as sysdba

SQL*Plus: Release 19.0.0.0.0 - Production on Tue Nov 9 11:37:10 2021
Version 19.11.0.0.0

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Connected to:
Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
Version 19.11.0.0.0

SQL> show pdbs
```

```
    CON_ID CON_NAME                        OPEN MODE  RESTRICTED
---------- ------------------------------ ---------- ----------
         2 PDB$SEED                       READ ONLY  NO
         3 SHDPDB2                        READ WRITE NO

exit

lsnrctl status LISTENER

## Connect to shard 3
ssh -i privateKey opc@<public ip of shard 3>

## Connect as "oracle" user and connect to the database

sudo su - oracle

[oracle@shd3 ~]$ sqlplus / as sysdba

SQL*Plus: Release 19.0.0.0.0 - Production on Tue Nov 9 11:37:10 2021
Version 19.11.0.0.0

Copyright (c) 1982, 2020, Oracle.  All rights reserved.


Connected to:
Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
Version 19.11.0.0.0

SQL> show pdbs

    CON_ID CON_NAME                        OPEN MODE  RESTRICTED
---------- ------------------------------ ---------- ----------
         2 PDB$SEED                       READ ONLY  NO
         3 SHDPDB3                        READ WRITE NO

exit

lsnrctl status LISTENER
```

Deploy a sharded database

In the following section, we will deploy a sharded database. Let's sum-up what we've done so far, and how we will use the components in the coming steps.

So far, we have 4 databases instances, and their unique names are:

- cata: we will use it as the catalog database
- shd1: will be database shard 1
- shd2: will be database shard 2
- shd3: will be used as database shard 3, added to the first two shards at the end of the lab, to illustrate sharding horizontal scalability

Before going further, review the public and private IP of your 4 servers, and complete a table like the one given as an example below:

Public IP	Private IP	CDB name	PDB name
130.61.33.169	10.0.1.125	cata	catapdb
130.61.238.152	10.0.1.75	shd1	shdpdb1
130.61.102.103	10.0.1.98	shd2	shdpdb2
130.61.112.37	10.0.1.131	shd3	shdpdb3

Replace all the IP by your own values.

Configure the shard hosts: Connect to the catalog host and each of the shard hosts with root user, then edit the /etc/hosts file:

```
ssh -i privateKey opc@<catalog host public IP>

## Sudo to root user
sudo -i

## Modify the /etc/hosts file, with the name and private IP of the 4 machines:

10.0.1.125 cata
10.0.1.75 shd1
10.0.1.98 shd2
10.0.1.131 shd3

## Substitute the values by your own IPs
## Do this step on cata, shd1, shad2 and shd3 !!!
```

For each of the shard host (shard1, shard2, shard3), open 1521 port:

```
ssh -i privateKey opc@<shd1 host public IP>
## Use sudo and firewall command to open port 1521

[opc@shd1 ~]$ sudo firewall-cmd --add-port=1521/tcp --permanent
success
[opc@shd1 ~]$ sudo firewall-cmd --reload
success
[opc@shd1 ~]$ sudo firewall-cmd --list-all
public (active)
  target: default
  icmp-block-inversion: no
  interfaces: ens3
```

```
  sources:
  services: dhcpv6-client ssh
  ports: 1521/tcp
  protocols:
  masquerade: no
  forward-ports:
  source-ports:
  icmp-blocks:
  rich rules:

## Repeat this steps on shd2 and shd3 servers !!!
```

On the catalog host (cata), we will install GSM (Global Service Manager). GSM is a component of Oracle Global Data Services solution (GDS), that acts as a global listener on top of all the shards of the sharded database.

As the catalog host will also be the shard director, we need to open port 1522 (shard director default listener port), along with port 1521. For the demo application we will use in this lab, we need to open port 8081 as well.

Connect to the catalog host (cata) as "opc", and open the required ports:

```
## Connect to cata host as opc

ssh -i privateKey opc@<cata host public IP>

## Open the required ports

[opc@cata ~]$ sudo firewall-cmd --add-port=1521/tcp --permanent
success
[opc@cata ~]$ sudo firewall-cmd --add-port=1522/tcp --permanent
success
[opc@cata ~]$ sudo firewall-cmd --add-port=8081/tcp --permanent
success
[opc@cata ~]$ sudo firewall-cmd --reload
success
[opc@cata ~]$ sudo firewall-cmd --list-all
public (active)
  target: default
  icmp-block-inversion: no
  interfaces: ens3
  sources:
  services: dhcpv6-client ssh
  ports: 1521/tcp 1522/tcp 8081/tcp
  protocols:
  masquerade: no
  forward-ports:
  source-ports:
  icmp-blocks:
  rich rules:
```

On the catalog host, install the shard director software.

```
## Connect to the cata server and gain access to "oracle" user:

[opc@cata ~]$ sudo -i
[root@cata ~]# su - oracle
Last login: Tue Nov  9 11:36:00 GMT 2021 on pts/0

## Create a file named gsm.sh
## This file will be used further to load the GSM environment variables

cat /home/oracle/gsm.sh

export ORACLE_BASE=/u01/app/oracle
export ORACLE_HOME=/u01/app/oracle/product/19c/gsmhome_1
export LD_LIBRARY_PATH=$ORACLE_HOME/lib
export PATH=$ORACLE_HOME/bin:$PATH

## Create a file named cata.sh
## This file will be used further to load the catalog database environment variables

cat /home/oracle/cata.sh

export ORACLE_BASE=/u01/app/oracle
export ORACLE_HOME=/u01/app/oracle/product/19c/dbhome_1
export LD_LIBRARY_PATH=$ORACLE_HOME/lib
export PATH=$ORACLE_HOME/bin:$PATH

## Load GSM environment and install GSM software:

. ./gsm.sh

## Download GSM distribution

wget https://objectstorage.eu-frankfurt-
1.oraclecloud.com/p/Z4i3zvZqp2X1ElEcfaJxe8pCjaR0a6tJ75SxBYC6m675Awct4um4BPKU5DPbT2k1/n/o
ractdemeabdmautodb/b/DISTRIBS/o/GSM.19.3.V982067-01.zip

[oracle@cata ~]$ ls -ltr
total 937408
drwxr-xr-x. 12 oracle oinstall      4096 Jul 23  2020 swingbench
-rw-r--r--.  1 oracle oinstall       166 Nov 10 10:20 cata.sh
-rw-r--r--.  1 oracle oinstall       167 Nov 10 16:56 gsm.sh
-rw-r--r--.  1 oracle oinstall 959891519 Nov 11 08:48 GSM.19.3.V982067-01.zip

## Unzip the distribution in /home/oracle

unzip GSM.19.3.V982067-01.zip

[oracle@cata ~]$ ls -ltr
total 937408
drwxr-xr-x.  5 oracle oinstall        90 Apr 17  2019 gsm
drwxr-xr-x. 12 oracle oinstall      4096 Jul 23  2020 swingbench
-rw-r--r--.  1 oracle oinstall       166 Nov 10 10:20 cata.sh
-rw-r--r--.  1 oracle oinstall       167 Nov 10 16:56 gsm.sh
-rw-r--r--.  1 oracle oinstall 959891519 Nov 11 08:48 GSM.19.3.V982067-01.zip

## Edit the ./gsm/response/gsm_install.rsp file. Specify the variables like following.
```

```
    UNIX_GROUP_NAME=oinstall
    INVENTORY_LOCATION=/u01/app/oraInventory
    ORACLE_HOME=/u01/app/oracle/product/19c/gsmhome_1
    ORACLE_BASE=/u01/app/oracle

## Create the gsm home directory

mkdir -p /u01/app/oracle/product/19c/gsmhome_1

## Install the GSM software in silent mode

./gsm/runInstaller -silent -responseFile /home/oracle/gsm/response/gsm_install.rsp -
showProgress -ignorePrereq

Starting Oracle Universal Installer...

Checking Temp space: must be greater than 551 MB.   Actual 32844 MB    Passed
Preparing to launch Oracle Universal Installer from /tmp/OraInstall2021-11-11_08-55-
36AM. Please wait ...[oracle@cata ~]$
[oracle@cata ~]$ [WARNING] [INS-13014] Target environment does not meet some optional
requirements.
   CAUSE: Some of the optional prerequisites are not met. See logs for details.
/u01/app/oraInventory/logs/installActions2021-11-11_08-55-36AM.log
   ACTION: Identify the list of failed prerequisite checks from the log:
/u01/app/oraInventory/logs/installActions2021-11-11_08-55-36AM.log. Then either from the
log file or from installation manual find the appropriate configuration to meet the
prerequisites and fix it manually.
The response file for this session can be found at:
 /u01/app/oracle/product/19c/gsmhome_1/install/response/gsm_2021-11-11_08-55-36AM.rsp

You can find the log of this install session at:
 /u01/app/oraInventory/logs/installActions2021-11-11_08-55-36AM.log

Prepare in progress.
.................................................   8% Done.

Prepare successful.

Copy files in progress.
.................................................   13% Done.
.................................................   19% Done.
.................................................   27% Done.
.................................................   33% Done.
.................................................   38% Done.
.................................................   43% Done.
.................................................   48% Done.
.................................................   53% Done.
.................................................   58% Done.
.................................................   64% Done.
.................................................   69% Done.
.................................................   74% Done.
.................................................   79% Done.

Copy files successful.

Link binaries in progress.
```

```
Link binaries successful.

Setup files in progress.
.....................................
Setup files successful.

Setup Inventory in progress.

Setup Inventory successful.
.........
Finish Setup in progress.
.............................................   84% Done.

Finish Setup successful.
The installation of Oracle Distributed Service and Load Management was successful.
Please check '/u01/app/oraInventory/logs/silentInstall2021-11-11_08-55-36AM.log' for
more details.

Setup Oracle Base in progress.

Setup Oracle Base successful.
.............................................   95% Done.

As a root user, execute the following script(s):
      1. /u01/app/oracle/product/19c/gsmhome_1/root.sh



Successfully Setup Software with warning(s).
.............................................   100% Done.

## As root, execute the root.sh script

[root@cata ~]# /u01/app/oracle/product/19c/gsmhome_1/root.sh
Check /u01/app/oracle/product/19c/gsmhome_1/install/root_cata_2021-11-11_08-58-23-
323548564.log for the output of root script

## Check the logfile

[root@cata ~]$ cat /u01/app/oracle/product/19c/gsmhome_1/install/root_cata_2021-11-
11_08-58-23-323548564.log
Performing root user operation.

The following environment variables are set as:
    ORACLE_OWNER= oracle
    ORACLE_HOME=  /u01/app/oracle/product/19c/gsmhome_1
   Copying dbhome to /usr/local/bin ...
   Copying oraenv to /usr/local/bin ...
   Copying coraenv to /usr/local/bin ...

Entries will be added to the /etc/oratab file as needed by
Database Configuration Assistant when a database is created
Finished running generic part of root script.
Now product-specific root actions will be performed.
```

Now we will setup the catalog database. Connect back to "oracle" on cata server, and perform the following steps:

```
[root@cata ~]# su - oracle
Last login: Wed Nov 10 10:18:34 GMT 2021 on pts/0

## Load the catalog database environment

[oracle@cata ~]$ . ./cata.sh

## Because the shard catalog database can run multi-shard queries which connect to
shards over database links, the OPEN_LINKS and OPEN_LINKS_PER_INSTANCE database
initialization parameter values must be greater than or equal to the number of shards
that will be part of the sharded database configuration.

## Review and change some instance parameters

sqlplus / as sysdba

SQL> alter system set open_links=20 scope=spfile;

System altered.

SQL> alter system set open_links_per_instance=20 scope=spfile;

System altered.

SQL> alter system set db_files=1024 scope=spfile;

System altered.

SQL> alter system set db_create_file_dest='/u01/app/oracle/oradata' scope=spfile;

System altered.

## Unlock the catalog user schema, and change its password

SQL> alter user gsmcatuser account unlock;

User altered.

SQL> alter user gsmcatuser identified by Ora_DB4U;

User altered.

## Connect to the catalog pdb, Unlock the gsmcatalog user and create a shard catalog
administrator account

SQL> show pdbs

    CON_ID CON_NAME                       OPEN MODE  RESTRICTED
---------- ------------------------------ ---------- ----------
         2 PDB$SEED                       READ ONLY  NO
         3 CATAPDB                        READ WRITE NO

SQL> alter session set container=catapdb;

Session altered.
```

```
SQL> alter user gsmcatuser account unlock;

User altered.

SQL> create user mysdbadmin identified by Ora_DB4U;

User created.

SQL> grant gsmadmin_role to mysdbadmin;

Grant succeeded.

## Connect as sysdba. Check the database archivelog mode and flashback mode

SQL> connect / as sysdba
Connected.
SQL> archive log list
Database log mode          No Archive Mode
Automatic archival         Disabled
Archive destination        /u01/app/oracle/product/19c/dbhome_1/dbs/arch
Oldest online log sequence     16
Current log sequence             18

SQL> select flashback_on from v$database;

FLASHBACK_ON
------------------
NO

SQL> show parameter db_recovery_file

NAME                                 TYPE      VALUE
------------------------------------ ----------- ------------------------------
db_recovery_file_dest                       string
db_recovery_file_dest_size           big integer 0
SQL>

## Enable archivelog and flashback

SQL> !mkdir -p /u01/app/oracle/fast_recovery_area

SQL> alter system set db_recovery_file_dest_size=50G scope=both;

System altered.

SQL> alter system set db_recovery_file_dest='/u01/app/oracle/fast_recovery_area'
scope=both;

System altered.

SQL> shutdown immediate
Database closed.
Database dismounted.
ORACLE instance shut down.
SQL>
SQL>
SQL>
```

```
SQL> startup mount
ORACLE instance started.

Total System Global Area 4630509232 bytes
Fixed Size                  9143984 bytes
Variable Size             855638016 bytes
Database Buffers         3758096384 bytes
Redo Buffers                7630848 bytes
Database mounted.

SQL> alter database archivelog;

Database altered.

SQL> alter database flashback on;

Database altered.

SQL> alter database open;

Database altered.
```

In the following steps, we are going to setup the shards of the sharded database. **These steps need to be performed on shd1, shd2 and shd3**.

```
## Gain access to shd1 as "oracle", and run the following steps
ssh -i privateKey opc@<shd1 public IP>

sudo su - oracle

[oracle@shd1 ~]$ sqlplus / as sysdba

SQL*Plus: Release 19.0.0.0.0 - Production on Wed Nov 10 11:44:28 2021
Version 19.11.0.0.0

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Connected to:
Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
Version 19.11.0.0.0

SQL> alter user gsmrootuser account unlock;

User altered.

SQL> alter user gsmrootuser identified by Ora_DB4U;

User altered.

SQL> grant SYSDG, SYSBACKUP to gsmrootuser;

Grant succeeded.

## A directory object named DATA_PUMP_DIR must be created and accessible in the shard
database from the GSMADMIN_INTERNAL account
```

```
SQL> select directory_path from dba_directories where directory_name='DATA_PUMP_DIR';

DIRECTORY_PATH
--------------------------------------------------------------------------------
/u01/app/oracle/admin/shd1/dpdump/

SQL> grant read, write on directory DATA_PUMP_DIR to gsmadmin_internal;

Grant succeeded.

## Unlock schema gsmuser

SQL> alter user gsmuser account unlock;

User altered.

SQL> alter user gsmuser identified by Ora_DB4U;

User altered.

SQL> grant SYSDG, SYSBACKUP to gsmuser;

Grant succeeded.

SQL> alter system set db_files=1024 scope=spfile;

System altered.

SQL> alter system set dg_broker_start=true scope=both;

System altered.

SQL> alter system set db_file_name_convert='/SHDSTB1/','/SHD1/' scope=spfile;

System altered.

SQL> show pdbs

    CON_ID CON_NAME                       OPEN MODE  RESTRICTED
---------- ------------------------------ ---------- ----------
         2 PDB$SEED                       READ ONLY  NO
         3 SHDPDB1                        READ WRITE NO

SQL> alter session set container=shdpdb1;

Session altered.

SQL> alter user gsmuser account unlock;

User altered.

SQL> grant SYSDG, SYSBACKUP to gsmuser;

Grant succeeded.

SQL> show parameter db_create_file_dest
```

```
NAME                                 TYPE        VALUE
------------------------------------ ----------- ------------------------------
db_create_file_dest                  string
SQL> alter system set db_create_file_dest='/u01/app/oracle/oradata' scope=both;

System altered.

SQL> grant read, write on directory DATA_PUMP_DIR to gsmadmin_internal;

Grant succeeded.

## Connect to the CDB and enable archivelog and flashback

SQL> connect / as sysdba
Connected.
SQL> !mkdir -p /u01/app/oracle/fast_recovery_area

SQL> alter system set db_recovery_file_dest_size=50G scope=both;

System altered.

SQL> alter system set db_recovery_file_dest='/u01/app/oracle/fast_recovery_area'
scope=both;

System altered.

SQL> shutdown immediate
Database closed.
Database dismounted.
ORACLE instance shut down.
SQL> startup mount
ORACLE instance started.

Total System Global Area 4630509232 bytes
Fixed Size                  9143984 bytes
Variable Size             855638016 bytes
Database Buffers         3758096384 bytes
Redo Buffers                7630848 bytes
Database mounted.

SQL> alter database archivelog;

Database altered.

SQL> alter database flashback on;

Database altered.

SQL> alter database open;

Database altered.

## (Optional) If your shard database will use standby shard databases, you must enable
the FORCE LOGGING mode.
## In this lab we won't setup Data Guard on the shards, so the next step can be skipped.

SQL> alter database force logging;
```

```
Database altered.

## Connect to the shard pdb and validate the shard.
The validateShard procedure can and should be run against primary, mounted (unopened)
standby, and Active Data Guard standby databases that are part of the sharded database
configuration.

SQL> alter session set container=shdpdb1;

Session altered.

SQL> set serveroutput on
SQL> execute dbms_gsm_fix.validateShard
INFO: Data Guard shard validation requested.
INFO: Database role is PRIMARY.
INFO: Database name is SHD1.
INFO: Database unique name is shd1.
INFO: Database ID is 785208895.
INFO: Database open mode is READ WRITE.
INFO: Database in archivelog mode.
INFO: Flashback is on.
INFO: Force logging is on.
INFO: Database platform is Linux x86 64-bit.
INFO: Database character set is AL32UTF8. This value must match the character
set of the catalog database.
INFO: 'compatible' initialization parameter validated successfully.
INFO: Database is a multitenant container database.
INFO: Current container is SHDPDB1.
INFO: Database is using a server parameter file (spfile).
INFO: db_create_file_dest set to: '/u01/app/oracle/oradata'
INFO: db_recovery_file_dest set to: '/u01/app/oracle/fast_recovery_area'
INFO: db_files=1024. Must be greater than the number of chunks and/or
tablespaces to be created in the shard.
INFO: dg_broker_start set to TRUE.
INFO: remote_login_passwordfile set to EXCLUSIVE.
INFO: db_file_name_convert set to: '/SHDSTB1/, /SHD1/'
INFO: GSMUSER account validated successfully.
INFO: DATA_PUMP_DIR is
'/u01/app/oracle/admin/shd1/dpdump/D04B91BB4408489EE055000017074120'.

PL/SQL procedure successfully completed.
```

Repeat these configuration steps on shd2 and shd3 !!!

Once we have configured shd1, shd2 and shd3, we are ready to configure the sharded database topology. Connect to the catalog host (cata), and gain access to the "oracle" user:

```
sudo su - oracle

## Switch to the GSM environment

[oracle@cata ~]$ . ./gsm.sh

## Enter the GSM command line interface.

[oracle@cata ~]$ gdsctl
```

```
GDSCTL: Version 19.0.0.0.0 - Production on Thu Nov 11 09:18:26 GMT 2021

Copyright (c) 2011, 2019, Oracle.  All rights reserved.

Welcome to GDSCTL, type "help" for information.

Warning:  GSM  is not set automatically because gsm.ora does not contain GSM entries.
Use "set  gsm" command to set GSM for the session.
Current GSM is set to GSMORA
GDSCTL>

## Create the shard catalog using the System-Managed sharding method. In this workshop,
we have no data guard environment, so just set one region.
## In this workshop, we set the chunks to 12, the default value is 120 for each of the
shard database.

GDSCTL> create shardcatalog -database cata:1521/catapdb -user mysdbadmin/Ora_DB4U -
chunks 12 -region region1 -SHARDING system

Catalog is created

## Add and start the shard director

GDSCTL> connect mysdbadmin/Ora_DB4U@cata:1521/catapdb
Catalog connection is established

GDSCTL> add gsm -gsm sharddirector1 -catalog cata:1521/catapdb -pwd Ora_DB4U -region
region1
GSM successfully added
GDSCTL> start gsm -gsm sharddirector1
GSM is started successfully
GDSCTL> set gsm -gsm sharddirector1

## Add shard group, each shardspace must contain at least one primary shardgroup and may
contain any number or type of standby shardgroups.
## In this workshop, we have only one primary shardgroup.

GDSCTL> add shardgroup -shardgroup shardgroup_primary -deploy_as primary -region region1
The operation completed successfully

## Verify the Sharding Topology.
## Before adding information about your shard databases to the catalog,
verify that your sharding topology is correct by using some GDSCTL CONFIG commands.

GDSCTL> config

Regions
------------------------
region1

GSMs
------------------------
sharddirector1

Sharded Database
------------------------
orasdb
```


```
Databases
------------------------

Shard Groups
------------------------
shardgroup_primary

Shard spaces
------------------------
shardspaceora

Services
------------------------

GDSCTL pending requests
------------------------
Command                       Object                        Status
-------                       ------                        ------

Global properties
------------------------
Name: oradbcloud
Master GSM: sharddirector1
DDL sequence #: 0

## Add shard CDB. Repeat the ADD CDB command for all of the CDBs that contain a shard
PDB in the configuration. for now, we only add shd1 and shd2.

GDSCTL> add cdb -connect shd1:1521/shd1 -pwd Ora_DB4U
DB Unique Name: shd1
The operation completed successfully

GDSCTL> add cdb -connect shd2:1521/shd2 -pwd Ora_DB4U
DB Unique Name: shd2
The operation completed successfully

GDSCTL> config cdb
shd1
shd2

## Add the primary shard information to the shard catalog. The shard group is
shardgroup_primary.

GDSCTL> add shard -connect shd1:1521/shdpdb1 -pwd Ora_DB4U -shardgroup
shardgroup_primary -cdb shd1
INFO: Data Guard shard validation requested.
INFO: Database role is PRIMARY.
INFO: Database name is SHD1.
INFO: Database unique name is shd1.
INFO: Database ID is 785208895.
INFO: Database open mode is READ WRITE.
INFO: Database in archivelog mode.
INFO: Flashback is on.
INFO: Force logging is on.
INFO: Database platform is Linux x86 64-bit.
INFO: Database character set is AL32UTF8. This value must match the character set of the
catalog database.
INFO: 'compatible' initialization parameter validated successfully.
```

```
INFO: Database is a multitenant container database.
INFO: Current container is SHDPDB1.
INFO: Database is using a server parameter file (spfile).
INFO: db_create_file_dest set to: '/u01/app/oracle/oradata'
INFO: db_recovery_file_dest set to: '/u01/app/oracle/fast_recovery_area'
INFO: db_files=1024. Must be greater than the number of chunks and/or tablespaces to be
created in the shard.
INFO: dg_broker_start set to TRUE.
INFO: remote_login_passwordfile set to EXCLUSIVE.
INFO: db_file_name_convert set to: '/SHDSTB1/, /SHD1/'
INFO: GSMUSER account validated successfully.
INFO: DATA_PUMP_DIR is
'/u01/app/oracle/admin/shd1/dpdump/D04B91BB4408489EE055000017074120'.
DB Unique Name: shd1_shdpdb1
The operation completed successfully

GDSCTL> add shard -connect shd2:1521/shdpdb2 -pwd Ora_DB4U -shardgroup
shardgroup_primary -cdb shd2
INFO: Data Guard shard validation requested.
INFO: Database role is PRIMARY.
INFO: Database name is SHD2.
INFO: Database unique name is shd2.
INFO: Database ID is 1343741747.
INFO: Database open mode is READ WRITE.
INFO: Database in archivelog mode.
INFO: Flashback is on.
INFO: Force logging is on.
INFO: Database platform is Linux x86 64-bit.
INFO: Database character set is AL32UTF8. This value must match the character set of the
catalog database.
INFO: 'compatible' initialization parameter validated successfully.
INFO: Database is a multitenant container database.
INFO: Current container is SHDPDB2.
INFO: Database is using a server parameter file (spfile).
INFO: db_create_file_dest set to: '/u01/app/oracle/oradata'
INFO: db_recovery_file_dest set to: '/u01/app/oracle/fast_recovery_area'
INFO: db_files=1024. Must be greater than the number of chunks and/or tablespaces to be
created in the shard.
INFO: dg_broker_start set to TRUE.
INFO: remote_login_passwordfile set to EXCLUSIVE.
INFO: db_file_name_convert set to: '/SHDSTB2/, /SHD2/'
INFO: GSMUSER account validated successfully.
INFO: DATA_PUMP_DIR is
'/u01/app/oracle/admin/shd2/dpdump/D04B984A766F48D6E055000017017509'.
DB Unique Name: shd2_shdpdb2
The operation completed successfully


## Run CONFIG SHARD to view the shard metadata on the shard catalog.

GDSCTL> config shard
Name                Shard Group         Status    State       Region    Availability
----                -----------         ------    -----       ------    ------------
shd1_shdpdb1        shardgroup_primary  U         none        region1   -
shd2_shdpdb2        shardgroup_primary  U         none        region1   -
```

```
## Add all of the host names and IP addresses of your shard hosts to the shard catalog.
First, View a list of trusted hosts.

GDSCTL> config vncr
Name                            Group ID
----                            --------
10.0.1.125
shd1
shd2

## Run the ADD INVITEDNODE command to manually add all host names and IP addresses of
your shard hosts to the shard catalog metadata.

GDSCTL> add invitednode 127.0.0.1
GDSCTL> add invitednode cata
GDSCTL> add invitednode 10.0.1.75 <======= Substitute by private IP of shd1
GDSCTL> add invitednode 10.0.1.98 <======= Substitute by private IP of shd2
GDSCTL>

GDSCTL> config vncr
Name                            Group ID
----                            --------
10.0.1.125
10.0.1.75
10.0.1.98
127.0.0.1
cata
shd1
shd2

## Deploy the sharding configuration

## When the sharded database topology has been fully configured, run the GDSCTL DEPLOY
command to deploy the sharded database configuration

GDSCTL> deploy
deploy: examining configuration...
deploy: requesting Data Guard configuration on shards via GSM
deploy: shards configured successfully
The operation completed successfully

## Check the shard status, It may look similar to the following.

GDSCTL> config shard
Name                Shard Group          Status    State       Region    Availability
----                -----------          ------    -----       ------    ------------
shd1_shdpdb1        shardgroup_primary   Ok        Deployed    region1   ONLINE
shd2_shdpdb2        shardgroup_primary   Ok        Deployed    region1   ONLINE

## Observe all shard are registered.

GDSCTL> databases
Database: "shd1_shdpdb1" Registered: Y State: Ok ONS: N. Role: PRIMARY Instances: 1
Region: region1
   Registered instances:
     orasdb%1
Database: "shd2_shdpdb2" Registered: Y State: Ok ONS: N. Role: PRIMARY Instances: 1
Region: region1
```

```
   Registered instances:
     orasdb%11

## Create and start a global service named oltp_rw_srvc that a client can use to connect
to the sharded database.
## The oltp_rw_srvc service runs read/write transactions on the primary shards.

GDSCTL> add service -service oltp_rw_srvc -role primary
The operation completed successfully

GDSCTL> start service -service oltp_rw_srvc
The operation completed successfully

Check the status of the service.

GDSCTL> config service


Name           Network name                  Pool           Started Preferred all
----           ------------                  ----           ------- -------------
oltp_rw_srvc   oltp_rw_srvc.orasdb.oradbclou orasdb         Yes     Yes
               d


Exit the GDSCTL.

GDSCTL> exit
[oracle@cata ~]$
```

Check the shard director listener status. You can see listening on 1522 port there is a service named oltp_rw_srvc.orasdb.oradbcloud which we create previously and a service named GDS$CATALOG.oradbcloud which connects to the catalog instance.

```
[oracle@cata ~]$ lsnrctl status SHARDDIRECTOR1

LSNRCTL for Linux: Version 19.0.0.0.0 - Production on 11-NOV-2021 10:24:26

Copyright (c) 1991, 2019, Oracle.  All rights reserved.

Connecting to
(DESCRIPTION=(ADDRESS=(HOST=cata)(PORT=1522)(PROTOCOL=tcp))(CONNECT_DATA=(SERVICE_NAME=G
DS$CATALOG.oradbcloud)))
STATUS of the LISTENER
------------------------
Alias                     SHARDDIRECTOR1
Version                   TNSLSNR for Linux: Version 19.0.0.0.0 - Production
Start Date                11-NOV-2021 10:05:22
Uptime                    0 days 0 hr. 19 min. 4 sec
Trace Level               off
Security                  ON: Local OS Authentication
SNMP                      OFF
Listener Parameter File   /u01/app/oracle/product/19c/gsmhome_1/network/admin/gsm.ora
Listener Log File         /u01/app/oracle/diag/gsm/cata/sharddirector1/alert/log.xml
Listening Endpoints Summary...
  (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=cata)(PORT=1522)))
Services Summary...
Service "GDS$CATALOG.oradbcloud" has 1 instance(s).
```

```
  Instance "cata", status READY, has 1 handler(s) for this service...
Service "GDS$COORDINATOR.oradbcloud" has 1 instance(s).
  Instance "cata", status READY, has 1 handler(s) for this service...
Service "_MONITOR" has 1 instance(s).
  Instance "SHARDDIRECTOR1", status READY, has 1 handler(s) for this service...
Service "_PINGER" has 1 instance(s).
  Instance "SHARDDIRECTOR1", status READY, has 1 handler(s) for this service...
Service "oltp_rw_srvc.orasdb.oradbcloud" has 2 instance(s).
  Instance "orasdb%1", status READY, has 1 handler(s) for this service...
  Instance "orasdb%11", status READY, has 1 handler(s) for this service...
The command completed successfully
```

Create a non sharded application

In the following steps, we will create a non sharded application on shd3. Then we will convert that application to a sharded application, to illustrate the conversion steps. This might be a pretty common situation to start from a non-sharded existing application, and convert it to sharded to gain scalability.

Connect to the shard3 host, switch to the oracle user:

```
ssh -i privateKey opc@<shard3 public IP>

## Gain access to "oracle" user

sudo su - oracle

## Create a new PDB named NSPDB

[oracle@shd3 ~]$ sqlplus / as sysdba

SQL*Plus: Release 19.0.0.0.0 - Production on Thu Nov 11 11:39:19 2021
Version 19.11.0.0.0

Copyright (c) 1982, 2020, Oracle.  All rights reserved.


Connected to:
Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
Version 19.11.0.0.0

SQL>
SQL>
SQL> CREATE PLUGGABLE DATABASE nspdb ADMIN USER admin IDENTIFIED BY Ora_DB4U
  DEFAULT TABLESPACE users DATAFILE '/u01/app/oracle/oradata/SHD3/nspdb/users01.dbf'
  SIZE 10G AUTOEXTEND ON
  FILE_NAME_CONVERT = ('/pdbseed/', '/nspdb/');

Pluggable database created.

SQL> alter pluggable database NSPDB open;

Pluggable database altered.
```

```
SQL> show pdbs

    CON_ID CON_NAME                       OPEN MODE  RESTRICTED
---------- ------------------------------ ---------- ----------
         2 PDB$SEED                       READ ONLY  NO
         3 SHDPDB3                        READ WRITE NO
         4 NSPDB                          READ WRITE NO

## Create a service named GDS$CATALOG.ORADBCLOUD and start it in order to run the demo
application correctly
SQL> alter session set container = nspdb;

Session altered.

SQL> BEGIN
  DBMS_SERVICE.create_service(
    service_name => 'GDS$CATALOG.ORADBCLOUD',
    network_name => 'GDS$CATALOG.ORADBCLOUD'
  );
END;
/

PL/SQL procedure successfully completed.

SQL> BEGIN
  DBMS_SERVICE.start_service(
    service_name => 'GDS$CATALOG.ORADBCLOUD'
  );
END;
/

PL/SQL procedure successfully completed.
```

Create the demo schema.
Still in the shard3 host with oracle user. Download the SQL script nonshard-app-schema.sql

```
cd /home/oracle

wget https://objectstorage.us-ashburn-
1.oraclecloud.com/p/_wAzMJHX9Kz8sFn3kd12KMov3HxTPiAyX0winrn7sbh9T7RXYSsR6f_tyAxIdYhi/n/c
4u04/b/data-management-library-files/o/Oracle%20Sharding/nonshard-app-schema.sql

--2021-11-11 16:40:26--  https://objectstorage.us-ashburn-
1.oraclecloud.com/p/_wAzMJHX9Kz8sFn3kd12KMov3HxTPiAyX0winrn7sbh9T7RXYSsR6f_tyAxIdYhi/n/c
4u04/b/data-management-library-files/o/Oracle%20Sharding/nonshard-app-schema.sql
Resolving objectstorage.us-ashburn-1.oraclecloud.com (objectstorage.us-ashburn-
1.oraclecloud.com)... 134.70.28.1, 134.70.24.1, 134.70.32.1
Connecting to objectstorage.us-ashburn-1.oraclecloud.com (objectstorage.us-ashburn-
1.oraclecloud.com)|134.70.28.1|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 2938 (2.9K) [application/octet-stream]
Saving to: ‘nonshard-app-schema.sql’

100%[=================================================================================
===========>] 2,938       --.-K/s   in 0s
```

```
2021-11-11 16:40:26 (28.2 MB/s) - ‘nonshard-app-schema.sql’ saved [2938/2938]

[oracle@shd3 ~]$ ls -ltr
total 8
drwxr-xr-x. 12 oracle oinstall 4096 Jul 23  2020 swingbench
-rw-r--r--.  1 oracle oinstall 2938 Jul  2 19:51 nonshard-app-schema.sql

## Use Sql*Plus to run the script

sqlplus /nolog
@nonshard-app-schema.sql
```

Setup and Run the Demo Application: connect to the catalog host, switch to the oracle user.

```
ssh -i privateKey opc@<cata public IP>
sudo su - oracle

## Download the sdb_demo_app.zip file

wget https://objectstorage.us-ashburn-
1.oraclecloud.com/p/iQr8DVOvWtGnYnrFdRqiPxuUuTQz_BbEIQpDY4HHxeCDJ1qSD6ccX-
vYc6J1d71w/n/c4u04/b/data-management-library-files/o/Oracle%20Sharding/sdb_demo_app.zip

## Unzip the file. This will create sdb_demo_app directory under the /home/oracle

unzip sdb_demo_app.zip

## View the content of the nonshard_demo_app_ext.sql. Make sure the connect string is
correct to the non-sharded instance pdb

cd sdb_demo_app/sql
cat nonshard_demo_app_ext.sql

-- Create catalog monitor packages
connect sys/Ora_DB4U@shd3:1521/nspdb as sysdba;

@catalog_monitor.sql

connect app_schema/app_schema@shd3:1521/nspdb;

alter session enable shard ddl;

CREATE OR REPLACE VIEW SAMPLE_ORDERS AS
  SELECT OrderId, CustId, OrderDate, SumTotal FROM
    (SELECT * FROM ORDERS ORDER BY OrderId DESC)
      WHERE ROWNUM < 10;

alter session disable shard ddl;

-- Allow a special query for dbaview
connect sys/Ora_DB4U@shd3:1521/nspdb as sysdba;

-- For demo app purposes
grant shard_monitor_role, gsmadmin_role to app_schema;
```

```
alter session enable shard ddl;

create user dbmonuser identified by TEZiPP4MsLLL;
grant connect, alter session, shard_monitor_role, gsmadmin_role to dbmonuser;

grant all privileges on app_schema.products to dbmonuser;
grant read on app_schema.sample_orders to dbmonuser;

alter session disable shard ddl;
-- End workaround

exec dbms_global_views.create_any_view('SAMPLE_ORDERS', 'APP_SCHEMA.SAMPLE_ORDERS',
'GLOBAL_SAMPLE_ORDERS', 0, 1);

## Use Sql*Plus to run the script

sqlplus /nolog

SQL*Plus: Release 19.0.0.0.0 - Production on Tue Nov 16 16:41:37 2021
Version 19.11.0.0.0

Copyright (c) 1982, 2020, Oracle.  All rights reserved.

SQL> @nonshard_demo_app_ext.sql

## The result screen like the following. Ignore the ORA-02521 error because it''s not a
shard database.

Connected.
ERROR:
ORA-02521: attempted to enable shard DDL in a non-shard database



Role created.


Grant succeeded.


Grant succeeded.


Grant succeeded.


Grant succeeded.


Session altered.


Package created.

No errors.

Package body created.
```


```
No errors.

PL/SQL procedure successfully completed.


Type created.


Type created.


Package created.

No errors.

Package body created.

No errors.

Package body created.

No errors.

Grant succeeded.


Grant succeeded.


Grant succeeded.


PL/SQL procedure successfully completed.


PL/SQL procedure successfully completed.


PL/SQL procedure successfully completed.


PL/SQL procedure successfully completed.


PL/SQL procedure successfully completed.

Connected.
ERROR:
ORA-02521: attempted to enable shard DDL in a non-shard database


View created.


Session altered.
```

```
Connected.

Grant succeeded.

ERROR:
ORA-02521: attempted to enable shard DDL in a non-shard database



User created.


Grant succeeded.


Grant succeeded.


Grant succeeded.


Session altered.


PL/SQL procedure successfully completed.

## Exit the sqlplus. Then change directory to the sdb_demo_app.
exit

cd /home/oracle/sdb_demo_app

## Review the nonsharddemo.properties file content. Make sure the connect_string and
service name is correct

[oracle@cata sdb_demo_app]$ cat nonsharddemo.properties
name=demo
connect_string=(ADDRESS_LIST=(LOAD_BALANCE=off)(FAILOVER=on)(ADDRESS=(HOST=shd3)(PORT=15
21)(PROTOCOL=tcp)))
monitor.user=dbmonuser
monitor.pass=TEZiPP4MsLLL
app.service.write=nspdb
app.service.readonly=nspdb
app.user=app_schema
app.pass=app_schema
app.threads=7

## Start the workload by executing command: ./run.sh demo nonsharddemo.properties

./run.sh demo nonsharddemo.properties

RO Queries | RW Queries | RO Failed  | RW Failed  | APS
     133194        22428            0            0          819
     135368        22801            0            0          794
     137639        23162            0            0          816
     139983        23514            0            0          857
     142154        23923            0            0          791
     144423        24326            0            0          821
     146604        24720            0            0          790
```

```
     148820        25111           0           0         812
     151074        25509           0           0         809
     153302        25899           0           0         793
     155798        26347           0           0         913
     158566        26841           0           0        1013
     161386        27335           0           0        1019
     164235        27820           0           0        1031
     167050        28272           0           0        1008
     169731        28729           0           0         976
     172676        29238           0           0        1078
     175631        29737           0           0        1083
     178483        30231           0           0        1043
     181422        30730           0           0        1074
[...]

## Wait the application run several minutes and press Ctrl-C to exit the application.
Remember the values of the APS(transaction per second).
```

Export the demo data and copy the DMP file.

In this step, you will export the demo application data and copy the dmp file to the catalog and each of the shard hosts. You will import the data to the shard database in the next lab.

Connect to the shard3 host, switch to the oracle user.

```
--- Connect to the shard3 host, switch to the oracle user.

ssh -i privateKey opc@<shd3 public IP>

[opc@shd3 ~]$ sudo su - oracle
Last login: Tue Nov 23 16:10:11 GMT 2021 on pts/0

## Connect to the non-sharded database as app_schema user with SQLPLUS.
## Create a DIRECTORY

sqlplus app_schema/app_schema@shd3:1521/nspdb

create directory demo_pump_dir as '/home/oracle';
exit

## Run the following command to export the demo data
## GROUP_PARTITION_TABLE_DATA: Unloads all partitions as a single operation producing a
single partition of data in the dump file.
## Subsequent imports will not know this was originally made up of multiple partitions.

expdp app_schema/app_schema@shd3:1521/nspdb directory=demo_pump_dir \
  dumpfile=original.dmp logfile=original.log \
  schemas=app_schema data_options=group_partition_table_data

[...]
Dump file set for APP_SCHEMA.SYS_EXPORT_SCHEMA_01 is:
  /home/oracle/original.dmp
```

```
Job "APP_SCHEMA"."SYS_EXPORT_SCHEMA_01" successfully completed at Tue Nov 16 17:06:36
2021 elapsed 0 00:01:27
```

Now we will copy the DMP file to cata, shd1 and shd2. First we generate a RSA key pair:

```
## From the shard3 host, create a ssh key pair. Press Enter to accept all the default
values.

[oracle@shd3 sdb_demo_app]$ ssh-keygen -t rsa
Generating public/private rsa key pair.
Enter file in which to save the key (/home/oracle/.ssh/id_rsa):
Created directory '/home/oracle/.ssh'.
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/oracle/.ssh/id_rsa.
Your public key has been saved in /home/oracle/.ssh/id_rsa.pub.
The key fingerprint is:
SHA256:BakV9l9zcUn/FuS8evQKNoE7WhrEsFc9/74QxUGVfmE oracle@shd3
The key''s randomart image is:
+---[RSA 2048]----+
|        +o    o**|
|       .oo .  =E=|
|      .o  + o =*+|
|      .+ o o +.+=|
|      . S . o..o+|
|       o   . .+o.|
|         . + +o .o|
|          = o ooo |
|        o     ..o|
+----[SHA256]-----+

[oracle@shd3 sdb_demo_app]$ cat /home/oracle/.ssh/id_rsa.pub
ssh-rsa
AAAAB3NzaC1yc2EAAAADAQABAAABAQDC2EjG8bsTKnvQpjlnDtbDKFUb9X0ik3PRnW99BbDfR0vAiYp2rojcBMCe
d2YKzcZr5UX8x7p8HpB3u8Bp/J1wJxW/OVuww3oaSkQ8QRL60tX6KdyTbwVGwxK0YoUaCbgYemXVHGa/TjuRY/cs
SesTBIRuCSL1SPYBBGLCOpOnl84+PDhVsf+TxfeIFK+b0zcevr3y++1Yz96+EwS66h1RSs9d6QQ/Uf0dx4WQnbxW
M5lyXdwyJKInDoBxRgoDgv/+Zo+RCOk2n0SCqqaXwTb6cA8Vimup7dmd+9e8wPX9Wo0rDIlCfdEjBStBhK2sDTtq
+8ju9tXDhguiTZ53LD4f oracle@shd3
```

Now we will copy the public key to cata, shd1 and shd2:

```
--- Connect to cata host and gain access to "oracle" user
ssh -i privateKey opc@<cata public IP>
sudo su - oracle

## Make a .ssh directory and edit the authorized_keys file.

[oracle@cata ~]$ mkdir .ssh
[oracle@cata ~]$ vi .ssh/authorized_keys

## Copy and paste the public key from shd3
## Save and chmod the file

[oracle@cata ~]$ chmod 600 .ssh/authorized_keys
```

```
## Repeat this steps on shd1 and shd2 !!!
```

Now we are ready to copy the DMP file on each host, using scp and the generated private key: go back to your shd3 session and scp the DMP file to the other hosts.

```
 [oracle@shd3 ~]$ scp original.dmp oracle@cata:/home/oracle
original.dmp
100%   12MB  47.6MB/s   00:00
[oracle@shd3 ~]$ scp original.dmp oracle@shd1:/home/oracle
original.dmp
100%   12MB  49.5MB/s   00:00
[oracle@shd3 ~]$ scp original.dmp oracle@shd2:/home/oracle
original.dmp
100%   12MB  51.4MB/s   00:00
```

Migrate to sharded database

Before the existing database can be migrated to the sharded database, you must decide how to organize the sharded database.

You must decide which tables in the application are sharded and which tables are duplicated tables. In this lab, we have already created a scripts for the sharded demo schema.
It creates a sharded table family: "Customers-->Orders-->LineItems" using the sharding key CustId, and Products is the duplicated table.
Next we will create a sharded schema, and then load the exported data into that sharded schema.
Login to the catalog database host, switch to oracle user.

```
ssh -i privateKey opc@<cata public IP>
sudo su - oracle

## Download the sharded demo schema SQL scripts sdb-app-schema.sql

[oracle@cata ~]$ wget https://objectstorage.us-ashburn-
1.oraclecloud.com/p/ZkoZi3PVSwYGZAscZNDRzOLlqdKypfJEnM15czI6ud6nM5POU8MHkcXHXnp1NJ27/n/c
4u04/b/data-management-library-files/o/Oracle%20Sharding/sdb-app-schema.sql
--2021-11-17 09:57:44--  https://objectstorage.us-ashburn-
1.oraclecloud.com/p/ZkoZi3PVSwYGZAscZNDRzOLlqdKypfJEnM15czI6ud6nM5POU8MHkcXHXnp1NJ27/n/c
4u04/b/data-management-library-files/o/Oracle%20Sharding/sdb-app-schema.sql
Resolving objectstorage.us-ashburn-1.oraclecloud.com (objectstorage.us-ashburn-
1.oraclecloud.com)... 134.70.24.1, 134.70.28.1, 134.70.32.1
Connecting to objectstorage.us-ashburn-1.oraclecloud.com (objectstorage.us-ashburn-
1.oraclecloud.com)|134.70.24.1|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 3554 (3.5K) [application/octet-stream]
Saving to: ‘sdb-app-schema.sql’

100%[=============================================================================
=========>] 3,554       --.-K/s   in 0s

2021-11-17 09:57:44 (29.6 MB/s) - ‘sdb-app-schema.sql’ saved [3554/3554]
```

```
[oracle@cata ~]$ ls -ltr
total 955464
drwxr-xr-x.  5 oracle oinstall        90 Apr 17  2019 gsm
drwxr-xr-x. 12 oracle oinstall      4096 Jul 23  2020 swingbench
-rw-r--r--.  1 oracle oinstall      3554 Jul  2 19:51 sdb-app-schema.sql
-rw-r--r--.  1 oracle oinstall   5897389 Jul  6 19:04 sdb_demo_app.zip
-rw-r--r--.  1 oracle oinstall       166 Nov 10 10:20 cata.sh
-rw-r--r--.  1 oracle oinstall 959891519 Nov 11 08:48 GSM.19.3.V982067-01.zip
-rw-r--r--.  1 oracle oinstall       167 Nov 11 09:18 gsm.sh
drwxr-xr-x.  3 oracle oinstall        26 Nov 16 16:39 __MACOSX
drwxr-xr-x.  9 oracle oinstall      4096 Nov 16 16:46 sdb_demo_app
-rw-r-----.  1 oracle oinstall  12582912 Nov 16 17:28 original.dmp

## Use SQLPLUS to run this sql scripts
## First load the cata database environment

. ./cata.sh

[oracle@cata ~]$ sqlplus /nolog

SQL*Plus: Release 19.0.0.0.0 - Production on Wed Nov 17 09:59:48 2021
Version 19.11.0.0.0

Copyright (c) 1982, 2020, Oracle.  All rights reserved.

SQL> @sdb-app-schema.sql
SQL> set termout on
SQL> set time on
10:00:00 SQL> spool /home/oracle/sdb_app_schema.lst
10:00:00 SQL> REM
10:00:00 SQL> REM Connect to the Shard Catalog and Create Schema
10:00:00 SQL> REM
10:00:00 SQL> connect / as sysdba
Connected.
10:00:00 SQL> alter session set container=catapdb;

Session altered.

10:00:00 SQL> alter session enable shard ddl;

Session altered.

10:00:00 SQL> create user app_schema identified by app_schema;

User created.

10:00:01 SQL> grant connect, resource, alter session to app_schema;

Grant succeeded.

10:00:01 SQL> grant execute on dbms_crypto to app_schema;

Grant succeeded.

10:00:01 SQL> grant create table, create procedure, create tablespace, create
materialized view to app_schema;

Grant succeeded.
```

```
10:00:01 SQL> grant unlimited tablespace to app_schema;

Grant succeeded.

10:00:01 SQL> grant select_catalog_role to app_schema;

Grant succeeded.

10:00:01 SQL> grant all privileges to app_schema;

Grant succeeded.

10:00:01 SQL> grant gsmadmin_role to app_schema;

Grant succeeded.

10:00:01 SQL> grant dba to app_schema;

Grant succeeded.

10:00:01 SQL>
10:00:01 SQL>
10:00:01 SQL> REM
10:00:01 SQL> REM Create a tablespace set for SHARDED tables
10:00:01 SQL> REM
10:00:01 SQL> CREATE TABLESPACE SET  TSP_SET_1 using template (datafile size 100m
autoextend on next 10M maxsize unlimited extent management local segment space
management auto );

Tablespace created.

10:00:02 SQL>
10:00:02 SQL> REM
10:00:02 SQL> REM Create a tablespace for DUPLICATED tables
10:00:02 SQL> REM
10:00:02 SQL> CREATE TABLESPACE products_tsp datafile size 100m autoextend on next 10M
maxsize unlimited extent management local uniform size 1m;

Tablespace created.

10:00:03 SQL>
10:00:03 SQL> REM
10:00:03 SQL> REM Create Sharded and Duplicated tables
10:00:03 SQL> REM
10:00:03 SQL> connect app_schema/app_schema@catapdb
Connected.
10:00:03 SQL> alter session enable shard ddl;

Session altered.

10:00:03 SQL> REM
10:00:03 SQL> REM Create a Sharded table for Customers     (Root table)
10:00:03 SQL> REM
10:00:03 SQL> CREATE SHARDED TABLE Customers
10:00:03   2  (
10:00:03   3        CustId     VARCHAR2(60) NOT NULL,
10:00:03   4        FirstName   VARCHAR2(60),
```

```
10:00:03   5        LastName    VARCHAR2(60),
10:00:03   6        Class      VARCHAR2(10),
10:00:03   7        Geo        VARCHAR2(8),
10:00:03   8        CustProfile VARCHAR2(4000),
10:00:03   9        Passwd     RAW(60),
10:00:03  10        CONSTRAINT pk_customers PRIMARY KEY (CustId),
10:00:03  11        CONSTRAINT json_customers CHECK (CustProfile IS JSON)
10:00:03  12  ) TABLESPACE SET TSP_SET_1
10:00:03  13  PARTITION BY CONSISTENT HASH (CustId) PARTITIONS AUTO;

Table created.

10:00:04 SQL>
10:00:04 SQL> REM
10:00:04 SQL> REM Create a Sharded table for Orders
10:00:04 SQL> REM
10:00:04 SQL> CREATE SHARDED TABLE Orders
10:00:04   2  (
10:00:04   3        OrderId     INTEGER NOT NULL,
10:00:04   4        CustId     VARCHAR2(60) NOT NULL,
10:00:04   5        OrderDate   TIMESTAMP NOT NULL,
10:00:04   6        SumTotal    NUMBER(19,4),
10:00:04   7        Status     CHAR(4),
10:00:04   8        constraint  pk_orders primary key (CustId, OrderId),
10:00:04   9        constraint  fk_orders_parent foreign key (CustId)
10:00:04  10          references Customers on delete cascade
10:00:04  11  ) partition by reference (fk_orders_parent);

Table created.

10:00:04 SQL>
10:00:04 SQL> REM
10:00:04 SQL> REM Create the sequence used for the OrderId column
10:00:04 SQL> REM
10:00:04 SQL> CREATE SEQUENCE Orders_Seq;

Sequence created.

10:00:04 SQL>
10:00:04 SQL> REM
10:00:04 SQL> REM Create a Sharded table for LineItems
10:00:04 SQL> REM
10:00:04 SQL> CREATE SHARDED TABLE LineItems
10:00:04   2  (
10:00:04   3        OrderId     INTEGER NOT NULL,
10:00:04   4        CustId     VARCHAR2(60) NOT NULL,
10:00:04   5        ProductId   INTEGER NOT NULL,
10:00:04   6        Price      NUMBER(19,4),
10:00:04   7        Qty        NUMBER,
10:00:04   8        constraint  pk_items primary key (CustId, OrderId, ProductId),
10:00:04   9        constraint  fk_items_parent foreign key (CustId, OrderId)
10:00:04  10          references Orders on delete cascade
10:00:04  11  ) partition by reference (fk_items_parent);

Table created.

10:00:04 SQL>
10:00:04 SQL> REM
```

```
10:00:04 SQL> REM Create Duplicated table for Products
10:00:04 SQL> REM
10:00:04 SQL> CREATE DUPLICATED TABLE Products
10:00:04   2  (
10:00:04   3        ProductId  INTEGER GENERATED BY DEFAULT AS IDENTITY PRIMARY KEY,
10:00:04   4        Name      VARCHAR2(128),
10:00:04   5        DescrUri   VARCHAR2(128),
10:00:04   6        LastPrice  NUMBER(19,4)
10:00:04   7  ) TABLESPACE products_tsp;

Table created.

10:00:05 SQL>
10:00:05 SQL> REM
10:00:05 SQL> REM Create functions for Password creation and checking – used by the REM
demo loader application
10:00:05 SQL> REM
10:00:05 SQL>
10:00:05 SQL> CREATE OR REPLACE FUNCTION PasswCreate(PASSW IN RAW)
10:00:05   2        RETURN RAW
10:00:05   3  IS
10:00:05   4        Salt RAW(8);
10:00:05   5  BEGIN
10:00:05   6        Salt := DBMS_CRYPTO.RANDOMBYTES(8);
10:00:05   7        RETURN UTL_RAW.CONCAT(Salt, DBMS_CRYPTO.HASH(UTL_RAW.CONCAT(Salt,
PASSW), DBMS_CRYPTO.HASH_SH256));
10:00:05   8  END;
10:00:05   9  /

Function created.

10:00:05 SQL>
10:00:05 SQL> CREATE OR REPLACE FUNCTION PasswCheck(PASSW IN RAW, PHASH IN RAW)
10:00:05   2        RETURN INTEGER IS
10:00:05   3  BEGIN
10:00:05   4        RETURN UTL_RAW.COMPARE(
10:00:05   5            DBMS_CRYPTO.HASH(UTL_RAW.CONCAT(UTL_RAW.SUBSTR(PHASH, 1, 8),
PASSW), DBMS_CRYPTO.HASH_SH256),
10:00:05   6            UTL_RAW.SUBSTR(PHASH, 9));
10:00:05   7  END;
10:00:05   8  /

Function created.

10:00:05 SQL>
10:00:05 SQL> REM
10:00:05 SQL> REM
10:00:05 SQL> select table_name from user_tables;

TABLE_NAME
--------------------------------------------------------------------------------
CUSTOMERS
ORDERS
LINEITEMS
PRODUCTS
MLOG$_PRODUCTS
RUPD$_PRODUCTS
```

```
6 rows selected.

10:00:05 SQL> REM
10:00:05 SQL> REM
10:00:05 SQL> spool off
10:00:05 SQL>
```

Once we have created the sharded demo schema, we will connect to GSM and perform some checking steps. On cata host, as "oracle", load the GSM environment:

```
[oracle@cata ~]$ . ./gsm.sh
[oracle@cata ~]$
[oracle@cata ~]$
[oracle@cata ~]$ gdsctl
GDSCTL: Version 19.0.0.0.0 - Production on Wed Nov 17 11:17:51 GMT 2021

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Welcome to GDSCTL, type "help" for information.

Current GSM is set to SHARDDIRECTOR1

## Rn the "show ddl" command to see the last DDL executed on the sharded DB

GDSCTL> show ddl
Catalog connection is established
id      DDL Text                                 Failed shards
--      --------                                 -------------
9       grant dba to app_schema
10      CREATE TABLESPACE SET  TSP_SET_1 usin...
11      CREATE TABLESPACE products_tsp datafi...
12      CREATE SHARDED TABLE Customers (   Cu...
13      CREATE SHARDED TABLE Orders (   Order...
14      CREATE SEQUENCE Orders_Seq
15      CREATE SHARDED TABLE LineItems (   Or...
16      CREATE MATERIALIZED VIEW "APP_SCHEMA"...
17      CREATE OR REPLACE FUNCTION PasswCreat...
18      CREATE OR REPLACE FUNCTION PasswCheck...

GDSCTL>


## Run the config commands as shown below for each of the shards and verify if there are
any DDL error.

GDSCTL> config shard -shard shd1_shdpdb1
Name: shd1_shdpdb1
Shard Group: shardgroup_primary
Status: Ok
State: Deployed
Region: region1
Connection string: shd1:1521/shdpdb1
SCAN address:
ONS remote port: 0
Disk Threshold, ms: 20
CPU Threshold, %: 75
Version: 19.0.0.0
```

```
Failed DDL:
DDL Error: ---
Failed DDL id:
Availability: ONLINE
Rack:


Supported services
------------------------
Name                                                             Preferred Status
----                                                             --------- ------
oltp_rw_srvc                                                     Yes       Enabled


## Show the created chunks.

GDSCTL> config chunks
Chunks
------------------------
Database                       From      To
--------                       ----      --
shd1_shdpdb1                   1         6
shd2_shdpdb2                   7         12
```

With Sql*plus, connect to shdpdb1 and check the created tablespaces:

```
 [oracle@cata ~]$ . ./cata.sh

[oracle@cata ~]$  sqlplus sys/Ora_DB4U@shd1:1521/shdpdb1 as sysdba

SQL*Plus: Release 19.0.0.0.0 - Production on Wed Nov 17 13:02:08 2021
Version 19.3.0.0.0

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Connected to:
Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
Version 19.11.0.0.0

SQL> select TABLESPACE_NAME, BYTES/1024/1024 MB from sys.dba_data_files order by
tablespace_name;

TABLESPACE_NAME                  MB
------------------------------ ----------
C001TSP_SET_1                   100
C002TSP_SET_1                   100
C003TSP_SET_1                   100
C004TSP_SET_1                   100
C005TSP_SET_1                   100
C006TSP_SET_1                   100
PRODUCTS_TSP                    100
SYSAUX                          520
SYSTEM                          350
TSP_SET_1                       100
UNDOTBS1                        215
USERS                            5
```

```
12 rows selected.

## Verify that the chunks and chunk tablespaces are created.

set linesize 140
column table_name format a20
column tablespace_name format a20
column partition_name format a20
select table_name, partition_name, tablespace_name from dba_tab_partitions where
tablespace_name like 'C%TSP_SET_1' order by tablespace_name;

TABLE_NAME         PARTITION_NAME   TABLESPACE_NAME
------------------- -------------------- --------------------
LINEITEMS          CUSTOMERS_P1     C001TSP_SET_1
CUSTOMERS          CUSTOMERS_P1     C001TSP_SET_1
ORDERS             CUSTOMERS_P1     C001TSP_SET_1
CUSTOMERS          CUSTOMERS_P2     C002TSP_SET_1
ORDERS             CUSTOMERS_P2     C002TSP_SET_1
LINEITEMS          CUSTOMERS_P2     C002TSP_SET_1
CUSTOMERS          CUSTOMERS_P3     C003TSP_SET_1
LINEITEMS          CUSTOMERS_P3     C003TSP_SET_1
ORDERS             CUSTOMERS_P3     C003TSP_SET_1
LINEITEMS          CUSTOMERS_P4     C004TSP_SET_1
CUSTOMERS          CUSTOMERS_P4     C004TSP_SET_1

TABLE_NAME         PARTITION_NAME   TABLESPACE_NAME
------------------- -------------------- --------------------
ORDERS             CUSTOMERS_P4     C004TSP_SET_1
CUSTOMERS          CUSTOMERS_P5     C005TSP_SET_1
ORDERS             CUSTOMERS_P5     C005TSP_SET_1
LINEITEMS          CUSTOMERS_P5     C005TSP_SET_1
CUSTOMERS          CUSTOMERS_P6     C006TSP_SET_1
ORDERS             CUSTOMERS_P6     C006TSP_SET_1
LINEITEMS          CUSTOMERS_P6     C006TSP_SET_1

18 rows selected.

## Connect to shdpdb2 with Sql*Plus

SQL> connect sys/Ora_DB4U@shd2:1521/shdpdb2 as sysdba
Connected.
SQL> select TABLESPACE_NAME, BYTES/1024/1024 MB from sys.dba_data_files order by
tablespace_name;

TABLESPACE_NAME          MB
------------------- ----------
C007TSP_SET_1           100
C008TSP_SET_1           100
C009TSP_SET_1           100
C00ATSP_SET_1           100
C00BTSP_SET_1           100
C00CTSP_SET_1           100
PRODUCTS_TSP            100
SYSAUX                  530
SYSTEM                  350
TSP_SET_1               100
UNDOTBS1                215
```

```
TABLESPACE_NAME          MB
-------------------- ----------
USERS                     5

12 rows selected.

SQL> select table_name, partition_name, tablespace_name from dba_tab_partitions where
tablespace_name like 'C%TSP_SET_1' order by tablespace_name;

TABLE_NAME         PARTITION_NAME    TABLESPACE_NAME
------------------- -------------------- --------------------
ORDERS             CUSTOMERS_P7      C007TSP_SET_1
LINEITEMS          CUSTOMERS_P7      C007TSP_SET_1
CUSTOMERS          CUSTOMERS_P7      C007TSP_SET_1
ORDERS             CUSTOMERS_P8      C008TSP_SET_1
CUSTOMERS          CUSTOMERS_P8      C008TSP_SET_1
LINEITEMS          CUSTOMERS_P8      C008TSP_SET_1
LINEITEMS          CUSTOMERS_P9      C009TSP_SET_1
ORDERS             CUSTOMERS_P9      C009TSP_SET_1
CUSTOMERS          CUSTOMERS_P9      C009TSP_SET_1
LINEITEMS          CUSTOMERS_P10     C00ATSP_SET_1
ORDERS             CUSTOMERS_P10     C00ATSP_SET_1

TABLE_NAME         PARTITION_NAME    TABLESPACE_NAME
------------------- -------------------- --------------------
CUSTOMERS          CUSTOMERS_P10     C00ATSP_SET_1
ORDERS             CUSTOMERS_P11     C00BTSP_SET_1
LINEITEMS          CUSTOMERS_P11     C00BTSP_SET_1
CUSTOMERS          CUSTOMERS_P11     C00BTSP_SET_1
LINEITEMS          CUSTOMERS_P12     C00CTSP_SET_1
CUSTOMERS          CUSTOMERS_P12     C00CTSP_SET_1
ORDERS             CUSTOMERS_P12     C00CTSP_SET_1

18 rows selected.

## Connect to the shardcatalog database
## Query the gsmadmin_internal.chunk_loc table to observe that the chunks are uniformly
distributed between shards

SQL> connect sys/Ora_DB4U@cata:1521/catapdb as sysdba

column shard format a40

select a.name Shard,count( b.chunk_number) Number_of_Chunks from
gsmadmin_internal.database a, gsmadmin_internal.chunk_loc b where
a.database_num=b.database_num group by a.name;

SHARD                                    NUMBER_OF_CHUNKS
---------------------------------------- ----------------
shd1_shdpdb1                                        6
shd2_shdpdb2                                        6

## Connect into the appschema/appschema on the catadb, shard1, shard2 databases and
verify that the sharded and duplicated tables were created.

SQL> connect app_schema/app_schema@cata:1521/catapdb
Connected.
```

```
SQL> select table_name from user_tables;

TABLE_NAME
--------------------
CUSTOMERS
ORDERS
LINEITEMS
PRODUCTS
MLOG$_PRODUCTS
RUPD$_PRODUCTS

6 rows selected.

SQL> connect app_schema/app_schema@shd1:1521/shdpdb1
Connected.
SQL> select table_name from user_tables;

TABLE_NAME
--------------------
CUSTOMERS
ORDERS
LINEITEMS
PRODUCTS
USLOG$_PRODUCTS

SQL> connect app_schema/app_schema@shd2:1521/shdpdb2
Connected.
SQL> select table_name from user_tables;

TABLE_NAME
--------------------
CUSTOMERS
ORDERS
LINEITEMS
PRODUCTS
USLOG$_PRODUCTS
```

Now, we will load data into sharded database using the dump file which created in the previous lab.

The duplicated tables reside in the shard catalog, they are always loaded into the shard catalog database using any of available data loading utilities, or plain SQL.

When loading a sharded table, each database shard accommodates a distinct subset of the data set, so the data in each table must be split (partitioned) across shards during the load.

You can use the Oracle Data Pump utility to load the data across database shards in subsets.
Data from the source database can be exported into a Data Pump dump file. Then Data Pump import can be run on each shard concurrently by using the same dump file.

Loading the data directly into the database shards is much faster, because each shard is loaded separately.

The Data Pump Import detects that you are importing into a shard and only load rows that belong to that shard.

Use SQLPLUS, connect to the catalog pdb with app_schema user:

```
ssh -i privateKey opc@<cata public IP>
sudo su - oracle
. ./cata.sh

## Create a directory
## When shard ddl is enabled, it will be created in catalog db and each of the sharded
db

sqlplus app_schema/app_schema@cata:1521/catapdb

alter session enable shard ddl;
create directory demo_pump_dir as '/home/oracle';
exit

## From the catalog host, run the following command to import the duplicated table data

[oracle@cata ~]$ impdp app_schema/app_schema@cata:1521/catapdb directory=demo_pump_dir \
dumpfile=original.dmp logfile=imp.log \
tables=Products \
content=DATA_ONLY

Import: Release 19.0.0.0.0 - Production on Thu Nov 18 10:27:58 2021
Version 19.11.0.0.0

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Connected to: Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
Master table "APP_SCHEMA"."SYS_IMPORT_TABLE_01" successfully loaded/unloaded
Starting "APP_SCHEMA"."SYS_IMPORT_TABLE_01":  app_schema/********@cata:1521/catapdb
directory=demo_pump_dir dumpfile=original.dmp logfile=imp.log tables=Products
content=DATA_ONLY
*/
Processing object type SCHEMA_EXPORT/TABLE/TABLE_DATA
. . imported "APP_SCHEMA"."PRODUCTS"                     27.25 KB     480 rows
Job "APP_SCHEMA"."SYS_IMPORT_TABLE_01" successfully completed at Thu Nov 18 10:28:13
2021 elapsed 0 00:00:10

## The data was imported in duplicated table PRODUCTS

## Run the following command to import data into the shard1 tables

impdp app_schema/app_schema@shd1:1521/shdpdb1 directory=demo_pump_dir \
      dumpfile=original.dmp logfile=imp.log \
      tables=Customers, Orders, LineItems \
      content=DATA_ONLY

Import: Release 19.0.0.0.0 - Production on Thu Nov 18 10:29:46 2021
Version 19.11.0.0.0

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Connected to: Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
Master table "APP_SCHEMA"."SYS_IMPORT_TABLE_01" successfully loaded/unloaded
```

```
Starting "APP_SCHEMA"."SYS_IMPORT_TABLE_01":  app_schema/********@shd1:1521/shdpdb1
directory=demo_pump_dir dumpfile=original.dmp logfile=imp.log tables=Customers, Orders,
LineItems content=DATA_ONLY
*/
Processing object type SCHEMA_EXPORT/TABLE/TABLE_DATA
. . imported "APP_SCHEMA"."CUSTOMERS"                    6.169 MB   13717 out of 27430
rows   <====== Roughly half of the rows are loaded into shard1
. . imported "APP_SCHEMA"."ORDERS"                       2.118 MB   21188 out of 42386
rows
. . imported "APP_SCHEMA"."LINEITEMS"                    3.027 MB   38011 out of 76034
rows
Job "APP_SCHEMA"."SYS_IMPORT_TABLE_01" successfully completed at Thu Nov 18 10:30:19
2021 elapsed 0 00:00:28

## Run the following command to load data into shard2 tables.

[oracle@cata ~]$ impdp app_schema/app_schema@shd2:1521/shdpdb2 directory=demo_pump_dir \
dumpfile=original.dmp logfile=imp.log \
tables=Customers, Orders, LineItems \
content=DATA_ONLY

Import: Release 19.0.0.0.0 - Production on Thu Nov 18 10:31:03 2021
Version 19.11.0.0.0

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Connected to: Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
Master table "APP_SCHEMA"."SYS_IMPORT_TABLE_01" successfully loaded/unloaded
Starting "APP_SCHEMA"."SYS_IMPORT_TABLE_01":  app_schema/********@shd2:1521/shdpdb2
directory=demo_pump_dir dumpfile=original.dmp logfile=imp.log tables=Customers, Orders,
LineItems content=DATA_ONLY
*/
Processing object type SCHEMA_EXPORT/TABLE/TABLE_DATA
. . imported "APP_SCHEMA"."CUSTOMERS"                    6.169 MB   13713 out of 27430
rows   <====== Roughly half of the rows are loaded into shard2
. . imported "APP_SCHEMA"."ORDERS"                       2.118 MB   21198 out of 42386
rows
. . imported "APP_SCHEMA"."LINEITEMS"                    3.027 MB   38023 out of 76034
rows
Job "APP_SCHEMA"."SYS_IMPORT_TABLE_01" successfully completed at Thu Nov 18 10:31:37
2021 elapsed 0 00:00:30
```

Setup and Run the Demo Application

Migrate application to the sharded database requires a slight change to the application code. This will be illustrated in a further chapter.
In this workshop, the demo application is designed for sharded database. You need to create additional objects needed by the demo application.

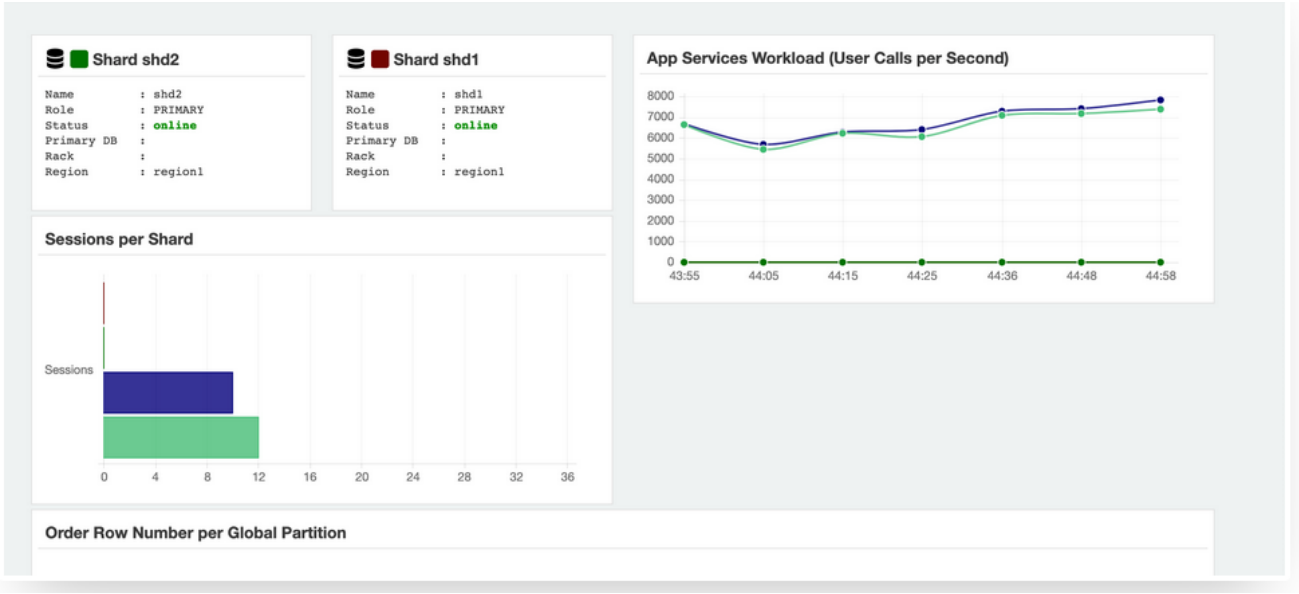
```
## From the catalog host, as "oracle" user, make sure your are in the catalog
environment.

cd ~/sdb_demo_app/sql
```

```
## View the content of the sdb_demo_app_ext.sql. Make sure the connect string is
correct.

cat sdb_demo_app_ext.sql

-- Create catalog monitor packages
connect / as sysdba
alter session set container=catapdb;

@catalog_monitor.sql

connect app_schema/app_schema@cata:1521/catapdb;

alter session enable shard ddl;

CREATE OR REPLACE VIEW SAMPLE_ORDERS AS
  SELECT OrderId, CustId, OrderDate, SumTotal FROM
    (SELECT * FROM ORDERS ORDER BY OrderId DESC)
      WHERE ROWNUM < 10;

alter session disable shard ddl;

-- Allow a special query for dbaview
connect / as sysdba
alter session set container=catapdb;

-- For demo app purposes
grant shard_monitor_role, gsmadmin_role to app_schema;

alter session enable shard ddl;

create user dbmonuser identified by TEZiPP4MsLLL;
grant connect, alter session, shard_monitor_role, gsmadmin_role to dbmonuser;

grant all privileges on app_schema.products to dbmonuser;
grant read on app_schema.sample_orders to dbmonuser;

alter session disable shard ddl;
-- End workaround

exec dbms_global_views.create_any_view('SAMPLE_ORDERS', 'APP_SCHEMA.SAMPLE_ORDERS',
'GLOBAL_SAMPLE_ORDERS', 0, 1);

## Connect to Sql*Plus and run the script

sqlplus /nolog
@sdb_demo_app_ext.sql
exit

## Change directory to the sdb_demo_app and review sdbdemo.properties file

cd ~/sdb_demo_app

[oracle@cata sdb_demo_app]$ cat sdbdemo.properties
name=demo
connect_string=(ADDRESS_LIST=(LOAD_BALANCE=off)(FAILOVER=on)(ADDRESS=(HOST=localhost)(PO
RT=1522)(PROTOCOL=tcp)))
monitor.user=dbmonuser
```

```
monitor.pass=TEZiPP4MsLLL
#app.service.write=oltp_rw_srvc.cust_sdb.oradbcloud
app.service.write=oltp_rw_srvc.orasdb.oradbcloud
#app.service.readonly=oltp_rw_srvc.cust_sdb.oradbcloud
app.service.readonly=oltp_rw_srvc.orasdb.oradbcloud
app.user=app_schema
app.pass=app_schema
app.threads=7

## Start the workload by executing the command:

./run.sh demo sdbdemo.properties

RO Queries | RW Queries | RO Failed  | RW Failed  | APS
     217471        37038            0            0         1338
     221685        37782            0            0         1573
     226016        38510            0            0         1620
     230522        39264            0            0         1697
     235169        39980            0            0         1749
     239513        40703            0            0         1653
     243503        41472            0            0         1488
     247781        42238            0            0         1617
     252090        43001            0            0         1628
     256371        43791            0            0         1635
     260649        44523            0            0         1604
     264750        45230            0            0         1540
     268903        45943            0            0         1587
     273267        46659            0            0         1689
     277461        47343            0            0         1591
     281727        48096            0            0         1619
     286116        48777            0            0         1651

## Compare the APS values with the ones obtained with the non-sharded application.

## Open another terminal, connect to the catalog host, switch to oracle user. Change the
directory to sdb_demo_app.

## Start the monitoring tool via the following command. Ignore the FileNotFoundException
message.
(Note: due to the resource limit, start monitor may impact the demo application
performance).

./run.sh monitor sdbdemo.properties
```

Now you can access to the monitor application through the URL: http://<cata host public IP>:8081/

This allows you to monitor the shards, for example:



Database requests routing to shards

In the following chapter, we will see how to route SQL statements directly to shards.
For clarity, we will use Sql*Plus, but the same kind of concepts apply for any application working with a sharded database.

Connect to cata host and gain access to "oracle" user. Load the catalog database environment:

```
ssh -i privateKey opc@<cata public IP>
sudo su - oracle

. ./cata.sh

## Connect to the sharded database with a known sharding key
## Observer the "SHARDING_KEY" clause at the end of the connection string

[oracle@cata ~]$ sqlplus
app_schema/app_schema@'(description=(address=(protocol=tcp)(host=cata)(port=1522))(conne
ct_data=(service_name=oltp_rw_srvc.orasdb.oradbcloud)(region=region1)(SHARDING_KEY=tom.e
dwards@y.bogus)))'

SQL*Plus: Release 19.0.0.0.0 - Production on Thu Nov 18 11:10:43 2021
Version 19.11.0.0.0

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Last Successful login time: Thu Nov 18 2021 10:45:45 +00:00

Connected to:
Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
Version 19.11.0.0.0

SQL> select instance_name from v$instance;

INSTANCE_NAME
```

```
----------------
shd1

## You have been connected to shard1: this is because tom.edwards@y.bogus hash value
corresponds to shard1 !!!

SQL> INSERT INTO Customers (CustId, FirstName, LastName, CustProfile, Class, Geo,
Passwd) VALUES ('tom.edwards@y.bogus', 'Tom', 'Edwards', NULL, 'Gold', 'east',
hextoraw('8d1c00e'));

1 row created.

SQL> commit;

Commit complete.

## Select from the customer table. You can see there is one record which you just insert
in the table

SQL> select * from customers where custid like '%y.bogus';

CUSTID
------------------------------------------------------------
FIRSTNAME
------------------------------------------------------------
LASTNAME                                                 CLASS    GEO
-------------------------------------------------------------- ---------- --------
CUSTPROFILE
--------------------------------------------------------------------------------
PASSWD
--------------------------------------------------------------------------------
tom.edwards@y.bogus
Tom
Edwards                                                  Gold     east

CUSTID
------------------------------------------------------------
FIRSTNAME
------------------------------------------------------------
LASTNAME                                                 CLASS    GEO
-------------------------------------------------------------- ---------- --------
CUSTPROFILE
--------------------------------------------------------------------------------
PASSWD
--------------------------------------------------------------------------------

08D1C00E

## Exit and connect to a shard with another shard key.

[oracle@cata ~]$ sqlplus
app_schema/app_schema@'(description=(address=(protocol=tcp)(host=cata)(port=1522))(conne
ct_data=(service_name=oltp_rw_srvc.orasdb.oradbcloud)(region=region1)(SHARDING_KEY=james
.parker@y.bogus)))'

SQL*Plus: Release 19.0.0.0.0 - Production on Thu Nov 18 11:13:58 2021
Version 19.11.0.0.0
```

```
Copyright (c) 1982, 2020, Oracle.  All rights reserved.

Last Successful login time: Thu Nov 18 2021 10:45:45 +00:00

Connected to:
Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
Version 19.11.0.0.0

SQL> select instance_name from v$instance;

INSTANCE_NAME
----------------
shd2

SQL> INSERT INTO Customers (CustId, FirstName, LastName, CustProfile, Class, Geo,
Passwd) VALUES ('james.parker@y.bogus', 'James', 'Parker', NULL, 'Gold', 'west',
hextoraw('9a3b00c'));

1 row created.

SQL> commit;

Commit complete.

SQL> select * from customers where custid like '%y.bogus';

CUSTID
--------------------------------------------------------------
FIRSTNAME
--------------------------------------------------------------
LASTNAME                                                 CLASS    GEO
-------------------------------------------------------------- ---------- --------
CUSTPROFILE
--------------------------------------------------------------------------------
PASSWD
--------------------------------------------------------------------------------
james.parker@y.bogus
James
Parker                                                   Gold     west

CUSTID
--------------------------------------------------------------
FIRSTNAME
--------------------------------------------------------------
LASTNAME                                                 CLASS    GEO
-------------------------------------------------------------- ---------- --------
CUSTPROFILE
--------------------------------------------------------------------------------
PASSWD
--------------------------------------------------------------------------------

09A3B00C
```

Depending on the value of your sharding key, you are routed to a shard or another by the shard director.

In the next steps, we will illustrate Routing Queries and DMLs by Proxy: connect to the shardcatalog (coordinator database) using the GDS$CATALOG service (from catalog or any shard host):

```
[oracle@cata ~]$ sqlplus app_schema/app_schema@cata:1522/GDS\$CATALOG.oradbcloud

SQL*Plus: Release 19.0.0.0.0 - Production on Thu Nov 18 11:22:30 2021
Version 19.11.0.0.0

Copyright (c) 1982, 2020, Oracle.  All rights reserved.

Last Successful login time: Thu Nov 18 2021 11:22:24 +00:00

Connected to:
Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
Version 19.11.0.0.0

SQL> select instance_name from v$instance;

INSTANCE_NAME
----------------
cata

SQL> select custid from customers where custid like '%y.bogus';

CUSTID
------------------------------------------------------------
tom.edwards@y.bogus
james.parker@y.bogus

## The query returns a consolidated set of rows, one row in each shard.
```

Now we will illustrate a multi-shard query use case. A multi-shard query is a query that must scan data from more than one shard, and the processing on each shard is independent of any other shard.

A multi-shard query maps to more than one shard and the coordinator might need to do some processing before sending the result to the client.

The inline query block is mapped to every shard just as a remote mapped query block.
The coordinator performs further aggregation and GROUP BY on top of the result set from all shards.
The unit of execution on every shard is the inline query block.

From the catalog host, connect to the catalog database:

```
## Let's run a multi-shard query which joins sharded and duplicated table (join on non
sharding key) to get the fast moving products (qty sold > 10).
The output that you will observe will be different (due to data load randomization).

sqlplus app_schema/app_schema@catapdb

set echo on
column name format a40
```

```
explain plan for SELECT name, SUM(qty) qtysold FROM lineitems l, products p WHERE
l.productid = p.productid GROUP BY name HAVING sum(qty) > 10 ORDER BY qtysold desc;

SQL> set echo off
SQL> select * from table(dbms_xplan.display());

PLAN_TABLE_OUTPUT
--------------------------------------------------------------------------------
Plan hash value: 2044377012

--------------------------------------------------------------------------------
------------------------

| Id  | Operation      | Name           | Rows  | Bytes | Cost (%CPU)| Ti
me     | Inst|IN-OUT|

--------------------------------------------------------------------------------
------------------------


PLAN_TABLE_OUTPUT
--------------------------------------------------------------------------------
|   0 | SELECT STATEMENT   |                 |     1 |    79 |     4   (50)| 00
:00:01 |      |      |

|   1 |  SORT ORDER BY       |                 |     1 |    79 |     4   (50)| 00
:00:01 |      |      |

|*  2 |   HASH GROUP BY    |                 |     1 |    79 |     4   (50)| 00
:00:01 |      |      |

|   3 |    VIEW        | VW_SHARD_372F2D25 |     1 |    79 |     4       (50)| 00
:00:01 |      |      |

PLAN_TABLE_OUTPUT
--------------------------------------------------------------------------------

|   4 |     SHARD ITERATOR |                 |       |       |       |      |
       |      |      |

|   5 |      REMOTE    |                 |       |       |       |
       | ORA_S~ | R->S |

--------------------------------------------------------------------------------
------------------------


PLAN_TABLE_OUTPUT
--------------------------------------------------------------------------------
Predicate Information (identified by operation id):
---------------------------------------------------

   2 - filter(SUM("ITEM_1")>10)

Remote SQL Information (identified by operation id):
----------------------------------------------------
```

```
   5 - EXPLAIN PLAN INTO PLAN_TABLE@! FOR SELECT SUM("A2"."QTY"),"A1"."NAME" FRO
M "LINEITEMS"


PLAN_TABLE_OUTPUT
--------------------------------------------------------------------------------
       "A2","PRODUCTS" "A1" WHERE "A2"."PRODUCTID"="A1"."PRODUCTID" GROUP BY "A1
"."NAME" /*

       coord_sql_id=g415vyfr9rg2a */  (accessing 'ORA_SHARD_POOL@ORA_MULTI_TARGE
T' )



25 rows selected.

SQL> SELECT name, SUM(qty) qtysold FROM lineitems l, products p WHERE l.productid =
p.productid GROUP BY name HAVING sum(qty) > 10 ORDER BY qtysold desc;

NAME                                QTYSOLD
----------------------------------- ----------
Fuel tank                             1823
Thermostat                            1772
Distributor                           1734
Radiator                              1718
Fastener                              1704
Center console                              1698
Master cylinder                       1685
seal                                  1677
Starter motor                         1672
Battery                               1607
Engine block                          1558
[...]
NAME                                QTYSOLD
----------------------------------- ----------
Pinion bearing                              722
Ammeter                               721
Power steering                              717
Oil pump                              715
Suspension link and bolt              705
Engine shake damper and vibration absorb      691
er

Coil wire                             685

469 rows selected.

## Let's run a multi-shard query which runs an IN subquery to get orders that includes
product with price > 900000.

set echo on
column name format a20
explain plan for SELECT COUNT(orderid) FROM orders o WHERE orderid IN (SELECT orderid
FROM lineitems l, products p WHERE l.productid = p.productid AND o.custid = l.custid AND
p.lastprice > 900000);

set echo off lines 120
select * from table(dbms_xplan.display());
```

```
PLAN_TABLE_OUTPUT
--------------------------------------------------------------------------------
--------------------------------
Plan hash value: 2403723386

--------------------------------------------------------------------------------
---------------
| Id  | Operation     | Name           | Rows  | Bytes | Cost (%CPU)| Time     | Inst
|IN-OUT|
--------------------------------------------------------------------------------
---------------
|   0 | SELECT STATEMENT  |                |     1 |    13 |     2    (0)| 00:00:01 |
|      |
|   1 |  SORT AGGREGATE   |                |     1 |    13 |      |         |        |
|
|   2 |   VIEW              | VW_SHARD_72AE2D8F |     1 |    13 |     2 (0)| 00:00:01 |
|      |
|   3 |    SHARD ITERATOR |                |       |       |      |         |        |
|
|   4 |     REMOTE    |                |       |       |      |         | ORA_S~ | R->S |
--------------------------------------------------------------------------------
---------------

PLAN_TABLE_OUTPUT
--------------------------------------------------------------------------------
--------------------------------

Remote SQL Information (identified by operation id):
----------------------------------------------------

   4 - EXPLAIN PLAN INTO PLAN_TABLE@! FOR SELECT COUNT(*) FROM "ORDERS" "A1" WHERE
       "A1"."ORDERID"=ANY (SELECT "A3"."ORDERID" FROM "LINEITEMS" "A3","PRODUCTS" "A2"
WHERE
       "A3"."PRODUCTID"="A2"."PRODUCTID" AND "A1"."CUSTID"="A3"."CUSTID" AND
"A2"."LASTPRICE">900000)
       /* coord_sql_id=ff5nrpzr2ddnf */  (accessing 'ORA_SHARD_POOL@ORA_MULTI_TARGET' )


20 rows selected.

SQL> SELECT COUNT(orderid) FROM orders o WHERE orderid IN (SELECT orderid FROM lineitems
l, products p WHERE l.productid = p.productid AND o.custid = l.custid AND p.lastprice >
900000);

COUNT(ORDERID)
--------------
         7860
## Let’s run a multi-shard query that calculates customer distribution based on the
number of orders placed. Please wait several minutes for the results return.

set echo off
column name format a40
explain plan for SELECT ordercount, COUNT(*) as custdist
    FROM (SELECT c.custid, COUNT(orderid) ordercount
           FROM customers c LEFT OUTER JOIN orders o
           ON c.custid = o.custid AND
           orderdate BETWEEN sysdate-4 AND sysdate GROUP BY c.custid)
```

```
    GROUP BY ordercount
    ORDER BY custdist desc, ordercount desc;

select * from table(dbms_xplan.display());


PLAN_TABLE_OUTPUT
------------------------------------------------------------------------------------------------
--------------------------------
Plan hash value: 313106859

------------------------------------------------------------------------------------------------
------------------
| Id  | Operation        | Name          | Rows  | Bytes | Cost (%CPU)| Time     | Inst
|IN-OUT|
------------------------------------------------------------------------------------------------
------------------
|   0 | SELECT STATEMENT     |                |     1 |    13 |     5  (20)| 00:00:01 |
        |     |
|   1 |  SORT ORDER BY         |              |     1 |    13 |     5  (20)| 00:00:01 |
        |     |
|   2 |   HASH GROUP BY      |                |     1 |    13 |     5  (20)| 00:00:01 |
        |     |
|   3 |    VIEW          |              |     1 |    13 |     5  (20)| 00:00:01 |      |
      |
|   4 |     HASH GROUP BY    |                |     1 |    45 |     5  (20)| 00:00:01 |
        |     |
|   5 |      VIEW        | VW_SHARD_28C476E6 |     1 |    45 |     5  (20)| 00:00:01 |
        |     |

PLAN_TABLE_OUTPUT
------------------------------------------------------------------------------------------------
--------------------------------
|   6 |       SHARD ITERATOR |                |     |     |          |       |      |
      |
|   7 |        REMOTE          |              |     |     |          |       | ORA_S~
| R->S |
------------------------------------------------------------------------------------------------
------------------

Remote SQL Information (identified by operation id):
----------------------------------------------------

   7 - EXPLAIN PLAN INTO PLAN_TABLE@! FOR SELECT COUNT("A1"."ORDERID"),"A2"."CUSTID"
FROM
       "CUSTOMERS" "A2","ORDERS" "A1" WHERE "A2"."CUSTID"="A1"."CUSTID"(+) AND
       "A1"."ORDERDATE"(+)>=CAST(SYSDATE@!-4 AS TIMESTAMP) AND
"A1"."ORDERDATE"(+)<=CAST(SYSDATE@! AS
       TIMESTAMP) GROUP BY "A2"."CUSTID" /* coord_sql_id=972ysbafqgcav */  (accessing

PLAN_TABLE_OUTPUT
------------------------------------------------------------------------------------------------
--------------------------------
       'ORA_SHARD_POOL@ORA_MULTI_TARGET' )


Note
-----
```

```
   - dynamic statistics used: dynamic sampling (level=2)

28 rows selected.

SQL> SELECT ordercount, COUNT(*) as custdist
    FROM (SELECT c.custid, COUNT(orderid) ordercount
           FROM customers c LEFT OUTER JOIN orders o
           ON c.custid = o.custid AND
           orderdate BETWEEN sysdate-4 AND sysdate GROUP BY c.custid)
    GROUP BY ordercount
    ORDER BY custdist desc, ordercount desc;  2    3    4    5    6    7

ORDERCOUNT   CUSTDIST
---------- ----------
         1      58516
         2      21298
         3       8151
         4       3335
         5       1468
         6        752
         7        417
         8        242
         9        160
        10        120
        11         69

ORDERCOUNT   CUSTDIST
---------- ----------
        12         67
        13         50
        16         27
        15         27
        14         18
        18         16
        17         13
        19         11
        20         10
        21          7
        32          6

ORDERCOUNT   CUSTDIST
---------- ----------
         0          6
        22          5
        24          4
        38          3
        27          3
        26          3
        25          3
        47          2
        42          2
        40          2
        37          2

ORDERCOUNT   CUSTDIST
---------- ----------
        28          2
        23          2
```

```
       59         1
       58         1
       54         1
       51         1
       46         1
       41         1
       39         1
       36         1
       35         1

ORDERCOUNT   CUSTDIST
---------- ----------
       33         1
       30         1
       29         1

47 rows selected.
```

Sharded database dynamic scaling

Now, we will add the shard (on shd3) to the Shard Database and thus elastically scale the sharded database.

We will see that we can add a new shard to the database without downtime. The chunks and data will be dynamically re-balanced on the new shards, to achieve even data distribution.

To add a new shard to the sharded database, connect to the catalog database host. Switch to oracle user.

```
ssh -i privateKey opc@<cata public IP>
sudo su - oracle
## Load the GSM environment, and connect to gdsctl

. ./gsm.sh
[oracle@cata ~]$ gdsctl
GDSCTL: Version 19.0.0.0.0 - Production on Thu Nov 18 11:39:03 GMT 2021

Copyright (c) 2011, 2019, Oracle.  All rights reserved.

Welcome to GDSCTL, type "help" for information.

Current GSM is set to SHARDDIRECTOR1

GDSCTL> config shard
Catalog connection is established
Name                Shard Group         Status    State       Region    Availability
----                -----------         ------    -----       ------    ------------
shd1_shdpdb1        shardgroup_primary  Ok        Deployed    region1   ONLINE
shd2_shdpdb2        shardgroup_primary  Ok        Deployed    region1   ONLINE

## Add the new shard CDB

GDSCTL> add cdb -connect shd3:1521/shd3 -pwd Ora_DB4U
DB Unique Name: shd3
The operation completed successfully
```

```
GDSCTL> config cdb
shd1
shd2
shd3

## Add the new shard PDB

GDSCTL> add shard -connect shd3:1521/shdpdb3 -pwd Ora_DB4U -shardgroup
shardgroup_primary -cdb shd3
INFO: Data Guard shard validation requested.
INFO: Database role is PRIMARY.
INFO: Database name is SHD3.
INFO: Database unique name is shd3.
INFO: Database ID is 1393551348.
INFO: Database open mode is READ WRITE.
INFO: Database in archivelog mode.
INFO: Flashback is on.
INFO: Force logging is on.
INFO: Database platform is Linux x86 64-bit.
INFO: Database character set is AL32UTF8. This value must match the character set of the
catalog database.
INFO: 'compatible' initialization parameter validated successfully.
INFO: Database is a multitenant container database.
INFO: Current container is SHDPDB3.
INFO: Database is using a server parameter file (spfile).
INFO: db_create_file_dest set to: '/u01/app/oracle/oradata'
INFO: db_recovery_file_dest set to: '/u01/app/oracle/fast_recovery_area'
INFO: db_files=1024. Must be greater than the number of chunks and/or tablespaces to be
created in the shard.
INFO: dg_broker_start set to TRUE.
INFO: remote_login_passwordfile set to EXCLUSIVE.
INFO: db_file_name_convert set to: '/SHDSTB3/, /SHD3/'
INFO: GSMUSER account validated successfully.
INFO: DATA_PUMP_DIR is
'/u01/app/oracle/admin/shd3/dpdump/D04B9ECB98A14919E05502001701C873'.
DB Unique Name: shd3_shdpdb3
The operation completed successfully

GDSCTL> config shard
Name                Shard Group         Status    State       Region    Availability
----                -----------         ------    -----       ------    ------------
shd1_shdpdb1        shardgroup_primary  Ok        Deployed    region1   ONLINE
shd2_shdpdb2        shardgroup_primary  Ok        Deployed    region1   ONLINE
shd3_shdpdb3        shardgroup_primary  U         none        region1   -

## View a list of trusted hosts.

GDSCTL> config vncr
Name                          Group ID
----                          --------
10.0.1.125
10.0.1.75
10.0.1.98
127.0.0.1
cata
shd1
shd2
shd3
```

```
## The host name of shard3 is already there. Manually add shard3 private IP addresses to
the shard catalog metadata.

GDSCTL> add invitednode 10.0.1.131 <======= substitute by your shd3 private IP
GDSCTL>
GDSCTL>
GDSCTL> config vncr
Name                          Group ID
----                          --------
10.0.1.125
10.0.1.131
10.0.1.75
10.0.1.98
127.0.0.1
cata
shd1
shd2
shd3

## Deploy and Verify the New Shard.
GDSCTL> deploy
Catalog connection is established
deploy: examining configuration...
deploy: requesting Data Guard configuration on shards via GSM
deploy: shards configured; background operations in progress
The operation completed successfully
GDSCTL>

GDSCTL> config shard
Name                Shard Group          Status    State       Region    Availability
----                -----------          ------    -----       ------    ------------
shd1_shdpdb1        shardgroup_primary   Ok        Deployed    region1   ONLINE
shd2_shdpdb2        shardgroup_primary   Ok        Deployed    region1   ONLINE
shd3_shdpdb3        shardgroup_primary   Ok        Deployed    region1   ONLINE

## Run the following command every minute or two to see the progress of automatic
rebalancing of chunks. You can see there are 4 chunks need to move to the third shard.

GDSCTL> config chunks -show_reshard
Chunks
------------------------
Database                      From      To
--------                      ----      --
shd1_shdpdb1                  1         5
shd2_shdpdb2                  7         12
shd3_shdpdb3                  6         6

Ongoing chunk movement
------------------------
Chunk     Source                      Target                      status
-----     ------                      ------                      ------
5         shd1_shdpdb1                shd3_shdpdb3                scheduled
6         shd1_shdpdb1                shd3_shdpdb3                Running
11        shd2_shdpdb2                shd3_shdpdb3                scheduled
12        shd2_shdpdb2                shd3_shdpdb3                scheduled

GDSCTL> config chunks -show_reshard
```

```
Chunks
------------------------
Database                        From      To
--------                        ----      --
shd1_shdpdb1                    1         5
shd2_shdpdb2                    7         12
shd3_shdpdb3                    6         6

Ongoing chunk movement
------------------------
Chunk     Source                        Target                        status
-----     ------                        ------                        ------
5         shd1_shdpdb1                  shd3_shdpdb3                  Running
11        shd2_shdpdb2                  shd3_shdpdb3                  scheduled
12        shd2_shdpdb2                  shd3_shdpdb3                  scheduled

GDSCTL> config chunks -show_reshard
Chunks
------------------------
Database                        From      To
--------                        ----      --
shd1_shdpdb1                    1         4
shd2_shdpdb2                    7         12
shd3_shdpdb3                    5         6

Ongoing chunk movement
------------------------
Chunk     Source                        Target                        status
-----     ------                        ------                        ------
11        shd2_shdpdb2                  shd3_shdpdb3                  scheduled
12        shd2_shdpdb2                  shd3_shdpdb3                  Running

GDSCTL> config chunks -show_reshard
Chunks
------------------------
Database                        From      To
--------                        ----      --
shd1_shdpdb1                    1         4
shd2_shdpdb2                    7         11
shd3_shdpdb3                    5         6
shd3_shdpdb3                    12        12

Ongoing chunk movement
------------------------
Chunk     Source                        Target                        status
-----     ------                        ------                        ------
11        shd2_shdpdb2                  shd3_shdpdb3                  Running

## After a few minutes, chunks end up rebalanced on the new shard !!!

GDSCTL> config chunks -show_reshard
Chunks
------------------------
Database                        From      To
--------                        ----      --
shd1_shdpdb1                    1         4
shd2_shdpdb2                    7         10
shd3_shdpdb3                    5         6
```

```
shd3_shdpdb                    11        12

Ongoing chunk movement
------------------------
Chunk     Source                         Target                         status
-----     ------                         ------                         ------

## Observe that the “databases” are automatically registered.

GDSCTL> databases
Database: "shd1_shdpdb1" Registered: Y State: Ok ONS: N. Role: PRIMARY Instances: 1
Region: region1
   Service: "oltp_rw_srvc" Globally started: Y Started: Y
            Scan: N Enabled: Y Preferred: Y
   Registered instances:
     orasdb%1
Database: "shd2_shdpdb2" Registered: Y State: Ok ONS: N. Role: PRIMARY Instances: 1
Region: region1
   Service: "oltp_rw_srvc" Globally started: Y Started: Y
            Scan: N Enabled: Y Preferred: Y
   Registered instances:
     orasdb%11
Database: "shd3_shdpdb3" Registered: Y State: Ok ONS: N. Role: PRIMARY Instances: 1
Region: region1
   Service: "oltp_rw_srvc" Globally started: Y Started: Y
            Scan: N Enabled: Y Preferred: Y
   Registered instances:
     orasdb%21

## Observe that the “services” are automatically brought up on the newly added shard.

GDSCTL> services
Service "oltp_rw_srvc.orasdb.oradbcloud" has 3 instance(s). Affinity: ANYWHERE
   Instance "orasdb%1", name: "shd1", db: "shd1_shdpdb1", region: "region1", status:
ready.
   Instance "orasdb%11", name: "shd2", db: "shd2_shdpdb2", region: "region1", status:
ready.
   Instance "orasdb%21", name: "shd3", db: "shd3_shdpdb3", region: "region1", status:
ready.
```

Now, run the demo application again and observe.
Manually update the monitored shard list. The package dbms_global_views is used by the monitor tools to monitor the status of shards.
It will create a public shard_dblinks_view and a public dblink to each shard. If you skip this step, the monitor tools will not show the status of the latest added shard database.

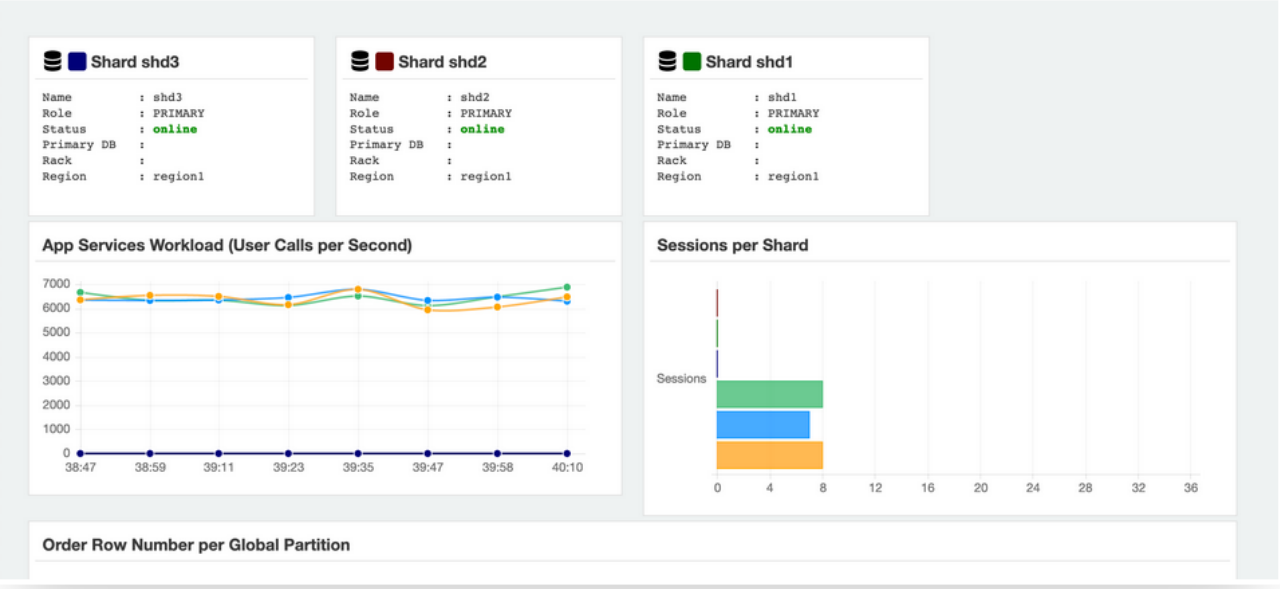
```
## From the cata host, as "oracle"

. ./cata.sh

[oracle@cata ~]$ sqlplus / as sysdba

SQL*Plus: Release 19.0.0.0.0 - Production on Thu Nov 18 13:06:58 2021
Version 19.11.0.0.0
```

```
Copyright (c) 1982, 2020, Oracle.  All rights reserved.


Connected to:
Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
Version 19.11.0.0.0

SQL> alter session set container=catapdb;

Session altered.

SQL> exec dbms_global_views.create_all_database_links();

PL/SQL procedure successfully completed.
```

Now run the demo app and compare the APS results with the previous runs, without shards and with two shards.

```
cd sdb_demo_app
[oracle@cata sdb_demo_app]$ ./run.sh demo sdbdemo.properties
 RO Queries | RW Queries | RO Failed  | RW Failed  | APS
     195539        34027            0            0        1601
     199379        34670            0            0        1587
     203113        35358            0            0        1524
     206903        36066            0            0        1548
     210737        36786            0            0        1595
     214500        37493            0            0        1544
     218492        38189            0            0        1639
     222401        38859            0            0        1613
     226386        39517            0            0        1635
     230349        40210            0            0        1614
     234115        40891            0            0        1560
     237785        41507            0            0        1536
     241644        42146            0            0        1567
     245335        42785            0            0        1556
```

Connect to the monitor tool with the URL: http://<cata host public IP>:8081/



You can see the new shard in the monitor tool. The sharded database scaled up horizontally without any downtime.

This concludes the Sharding workshop.