# PROTECTING ORACLE VLDB WITH DATA DOMAIN BOOSTFS
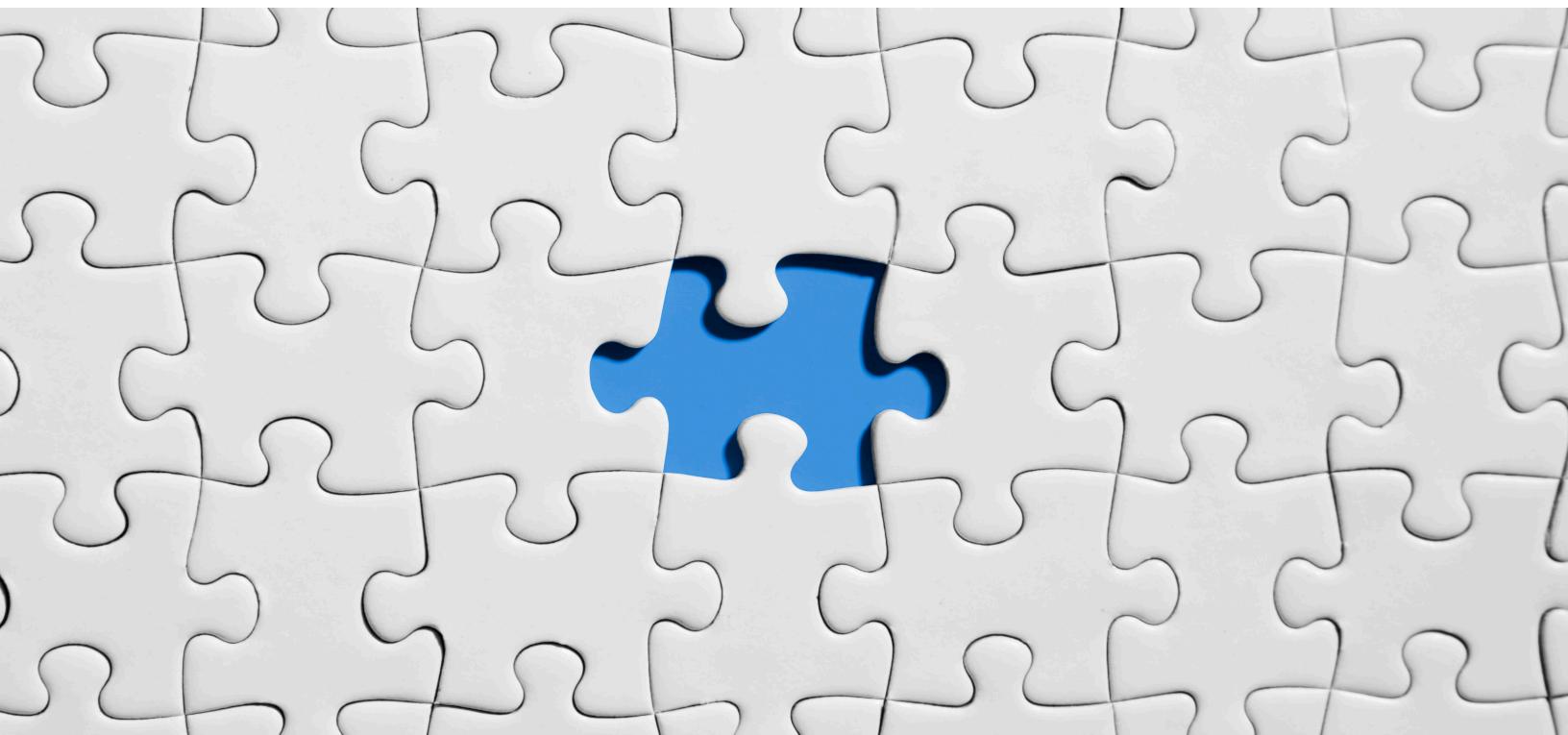
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Introduction

Dell EMC has pioneered data protection for databases using Data Domain Boost API to provide full backup via incremental backup using source de-duplication and compression. When a database grows beyond a certain size (e.g. >50TB), alternative methods may be required. Storage Direct (Dell EMC ProtectPoint) provides that capability and is available on Dell EMC VMAX and XtremIO storage arrays that allow moving backup data directly from Storage to Data Domain backup appliance without impacting host performance and near instant restores.

When a Very Large DataBase (VLDB) resides on a storage that is not capable of providing Storage Direct capability (e.g. HCI, non-Dell EMC), data protection remains a challenge. Thus, Database Administrators seek alternative methods, including the use of Oracle Incremental Merge (OIM). OIM requires NFS or dNFS that do not provide source de-duplication and do not preserve previous backup points.

This Knowledge Sharing article examines a more efficient architecture to perform OIM with Dell EMC Data Domain BoostFS. Specifically, using an Oracle Incremental forever approach, the solution provides source de-duplication, compression, and preserves previous backups efficiently using Data Domain Snapshots, a live mount allowing instant database access with the ability to perform table level restore.

Oracle Incremental Merge

OIM backups create a Full (level 0) image copy backup of database data files in a disk location with a unique Tag name. Oracle Block Change Tracking feature (supported from Oracle 10g onwards and requires Oracle Enterprise Edition license) can then be used to back up fast Incremental (level 1) backup that can then be used to merge with the previous full backup creating a full restore point after every incrementally merged backup without the need for another full backup.

OIM feature is therefore well suited for backing up very large Oracle databases using the Incremental forever approach.
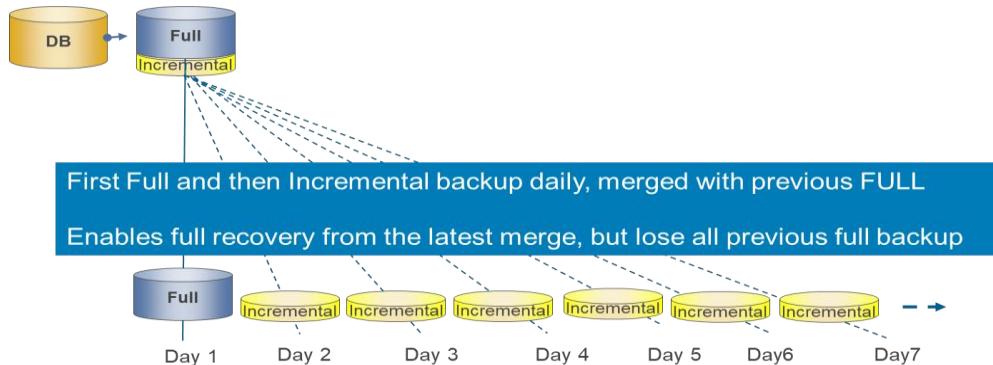
**Figure 1 Oracle Incremental Merge Backups**

However, OIM backups come with some challenges, These include:

- Only last full backup is kept, requiring that previous full backups be copied to a secondary location to preserve previous backups
- Storage Capacity required to preserve previous full backups without a proper de-duplicated appliance
- Occasional Full backup may be required and could take a very long time

OIM feature requires that backups be performed as type DISK that requires block storage. Traditionally, NFS mounts are used to perform such backup but due to the poor performance associated with NFS, Oracle introduced direct-NFS (dNFS) that improves NFS performance. Still, large bandwidth is needed to send backups to a purpose built backup appliance that could take a long time to complete.

Dell EMC Data Domain BoostFS

Dell EMC Data Domain Boost API provides source de-duplication and compression and helps run daily full backup at the cost of incremental to a Data Domain backup appliance. This capability is used by many large organizations to simplify to daily full backup, reduce network traffic and store only unique blocks providing a simple, fast and efficient backup strategy. Data Domain Boost API is available for use with backup application (e.g. NetWorker, NetBackup) as well as integrated with native backup tools such as Oracle RMAN, SQL Server, DB2, SAP and SAP HANA. Dell EMC has extended this capability by providing a simple file system interface allowing any application or database to take advantage of the Data Domain boost capabilities via a simple file system interface.
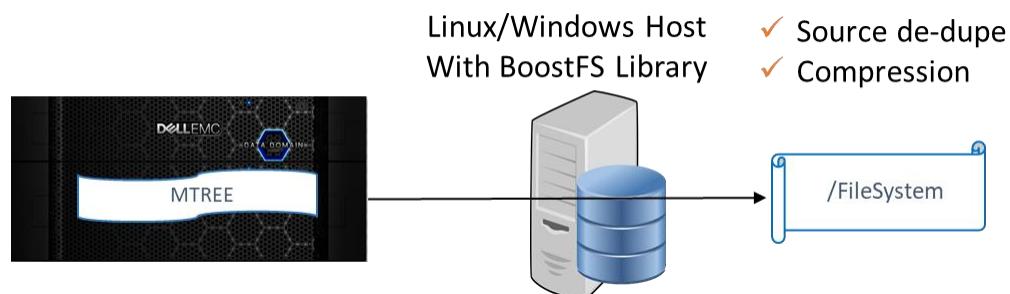
Figure 2 Dell EMC Data Domain BoostFS

BoostFS uses DD Boost technology that helps reduce bandwidth, resulting in faster backups, load balancing across multiple networks, in-flight encryption and supported with physical and virtual data domain and can be deployed in private or public clouds.

While similar to NFS, BoostFS leverages Data Domain Boost protocol and therefore helps remove the OIM implementation challenges discussed previously..

NFS mount generally requires "root" privileges, however, BoostFS mount can be mounted by Oracle user and the ability to mount is controlled via "FUSE" utility. This is in addition to the Data Domain security required to write to the MTREE associated with the BoostFS file system. The BoostFS Configuration Guide provides details on how to set up BoostFS.

Dell EMC Data Domain fastcopy

Data Domain fastcopy is a key feature of Data Domain backup appliance that helps preserve various point in time copies of OIM backup. Fastcopy creates a snapshot of a directory within the MTREE (mounted as a file system) to enable preservation of every full or incrementally merged backup. Because fastcopy is pointer-based snapshot, it is not only fast to create one, but also does not consume capacity on the Data Domain appliance. Using the fastcopy feature, one can preserve every backup performed with OIM, eliminating the challenge of losing previous full backup with the traditional OIM backup discussed earlier.

Oracle Incremental Backup with BoostFS

The following section demonstrates OIM backup with BoostFS and the benefits.

Setup for OIM Backups

To demonstrate the OIM with BoostFS, a Data Domain Virtual Edition (ddt.local) along with a Virtual Linux host (cora1) is used. An MTREE named boostfsu is mounted onto the Linux host as /boostfs. Oracle OIM backups are performed against an Oracle 12.1 database called "BOOST".

Since Data Domain fastcopy will be used to preserve various points in time, it is important to have a directory structure so copies of backups can be preserved. The following structure is used to showcase the OIM with BoostFS:
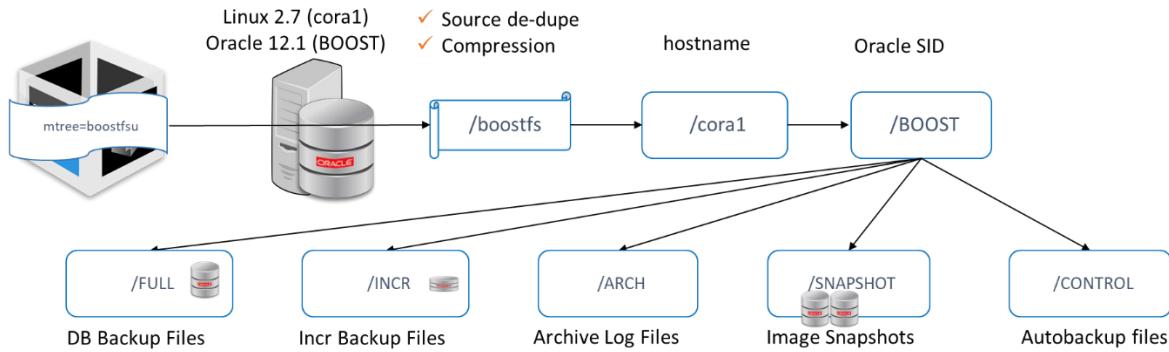
Figure 3 BoostFS OIM Directory Structure

An initial full backup (L0) done to /FULL directory with tag "INCR_MERGE" and a snapshot of the backup using Data Domain Fastcopy is performed to the /SNAPSHOT directory to preserve the initial backup.

Incremental backups (L1) are only required after the first full backup and the incremental backup data is stored in /INCR directory and then merged to the previous full backup in /FULL directory. After every Incrementally merged backup, a snapshot is created in the /SNAPSHOT directory. Note: While a FULL backup is no longer required after first full, should the forever incremental sequence get broken, a new FULL backup can always be created again and BoostFS – with its source de-dupe capability – will only back up unique blocks that do not exist on the Data Domain, thus reducing the time required to perform such full backups.

In order to perform a standard restore using RMAN, it is important to let Oracle know that a backup copy is available in the /SNAPSHOT directory. The RMAN Catalog command is used to catalog the backup snapshot that has been created outside Oracle with a unique tag name.

When a live mount of backup is required, a new snapshot named "TEST" is created using one of the previous backup snapshots and database started directly. By doing this, we do not make any changes to backup snapshots and the "TEST" snapshot can be removed upon completion of the live mount.

Finally, Archive Logs and Autobackup Control Files are stored in their respective directories and their retention can be kept to a different retention to the full backups.

Step 1. Mounting BoostFS

The DDVE that will be used to demonstrate OIM with BoostFS is empty to demonstrate the benefits. The boostfsu MTREE will be used to mount the /boostfs filesystem on the linux host:

```
Using username "sysadmin".
EMC Data Domain Virtual Edition

Welcome to Data Domain OS 6.1.2.10-603959
-----------------------------------------

sysadmin@ddt# mtree list
Name                  Pre-Comp (GiB)    Status
--------------------  --------------    ------
/data/col1/backup                0.0    RW
/data/col1/boostfsu              0.0    RW
/data/col1/boostfsw              0.0    RW
/data/col1/hadoop                0.0    RW
/data/col1/oracle                0.0    RW
/data/col1/sqlboost              0.0    RW
/data/col1/sqlserver             0.0    RW
--------------------  --------------    ------
 D    : Deleted
 Q    : Quota Defined
 RO   : Read Only
 RW   : Read Write
 RD   : Replication Destination
 RLGE : Retention-Lock Governance Enabled
 RLGD : Retention-Lock Governance Disabled
 RLCE : Retention-Lock Compliance Enabled
```

The next step is to mount the /boostfs filesystem using boostfsu mtree and create the sub-directories for OIM backup as outlined before.

```
[oracle@cora1 ~]$ uname -a
Linux cora1 3.10.0-514.el7.x86_64 #1 SMP Tue Nov 22 16:42:41 UTC 2016 x86_64 x86_64 x86_64 GNU/Linux
[oracle@cora1 ~]$ df -k
Filesystem      1K-blocks      Used Available Use% Mounted on
/dev/sda1       99984504  20858640  74023888  22% /
devtmpfs         1918372         0   1918372   0% /dev
tmpfs            1932776    417740   1515036  22% /dev/shm
tmpfs            1932776      9180   1923596   1% /run
tmpfs            1932776         0   1932776   0% /sys/fs/cgroup
tmpfs             386556         0    386556   0% /run/user/50149
tmpfs             386556        16    386540   1% /run/user/42
[oracle@cora1 ~]$ /opt/emc/boostfs/bin/boostfs mount -d ddt.local -s boostfsu -o security=lockbox
/boostfs

mount: Mounting ddt.local:boostfsu on /boostfs
[oracle@cora1 ~]$ df -k
Filesystem      1K-blocks      Used Available Use% Mounted on
/dev/sda1       99984504  20858664  74023864  22% /
devtmpfs         1918372         0   1918372   0% /dev
tmpfs            1932776    417740   1515036  22% /dev/shm
tmpfs            1932776      9184   1923592   1% /run
tmpfs            1932776         0   1932776   0% /sys/fs/cgroup
tmpfs             386556         0    386556   0% /run/user/50149
tmpfs             386556        16    386540   1% /run/user/42
boostfs         74939904    400896  74539008   1% /boostfs
[oracle@cora1 ~]$ mkdir -p /boostfs/cora1/BOOST/FULL
[oracle@cora1 ~]$ mkdir -p /boostfs/cora1/BOOST/ARCH
[oracle@cora1 ~]$ mkdir -p /boostfs/cora1/BOOST/CONTROL
[oracle@cora1 ~]$ mkdir -p /boostfs/cora1/BOOST/SNAPSHOT
[oracle@cora1 ~]$ mkdir -p /boostfs/cora1/BOOST/INCR
[oracle@cora1 ~]$ ls -l /boostfs/cora1/BOOST
total 3
drwxr-xr-x. 2 oracle oinstall 101 Jan 21  2019 ARCH
drwxr-xr-x. 2 oracle oinstall 101 Jan 21  2019 CONTROL
drwxr-xr-x. 2 oracle oinstall 101 Jan 21  2019 FULL
drwxr-xr-x. 2 oracle oinstall 101 Jan 21  2019 INCR
drwxr-xr-x. 2 oracle oinstall 101 Jan 21  2019 SNAPSHOT
```

Step 2. Performing first full (l0) backup

The next step is to run a full backup and associated archive logs and observe the benefits of DD Boost with BoostFS. It is important to ensure that RMAN compression is not used with Data Domain backups as the Boost plug-in will perform the compression without affecting Data Domain de-duplication.

```
[oracle@cora1 ~]$ rman target /

Recovery Manager: Release 12.1.0.2.0 - Production on Sun Jan 20 18:38:59 2019

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connected to target database: BOOST (DBID=175849284)

RMAN> CONFIGURE DEFAULT DEVICE TYPE TO DISK;
using target database control file instead of recovery catalog
old RMAN configuration parameters:
CONFIGURE DEFAULT DEVICE TYPE TO 'SBT_TAPE';
new RMAN configuration parameters:
CONFIGURE DEFAULT DEVICE TYPE TO DISK;
new RMAN configuration parameters are successfully stored

RMAN> CONFIGURE BACKUP OPTIMIZATION ON;
```

```
old RMAN configuration parameters:
CONFIGURE BACKUP OPTIMIZATION ON;
new RMAN configuration parameters:
CONFIGURE BACKUP OPTIMIZATION ON;
new RMAN configuration parameters are successfully stored

RMAN> CONFIGURE CONTROLFILE AUTOBACKUP ON;
old RMAN configuration parameters:
CONFIGURE CONTROLFILE AUTOBACKUP ON;
new RMAN configuration parameters:
CONFIGURE CONTROLFILE AUTOBACKUP ON;
new RMAN configuration parameters are successfully stored

RMAN> CONFIGURE ENCRYPTION FOR DATABASE OFF;
new RMAN configuration parameters:
CONFIGURE ENCRYPTION FOR DATABASE OFF;
new RMAN configuration parameters are successfully stored

RMAN> CONFIGURE COMPRESSION ALGORITHM 'BASIC';
new RMAN configuration parameters:
CONFIGURE COMPRESSION ALGORITHM 'BASIC' AS OF RELEASE 'DEFAULT' OPTIMIZE FOR LOAD TRUE;
new RMAN configuration parameters are successfully stored

RMAN> CONFIGURE DEVICE TYPE DISK BACKUP TYPE TO COPY PARALLELISM 4;
old RMAN configuration parameters:
CONFIGURE DEVICE TYPE DISK BACKUP TYPE TO COPY PARALLELISM 4;
new RMAN configuration parameters:
CONFIGURE DEVICE TYPE DISK BACKUP TYPE TO COPY PARALLELISM 4;
new RMAN configuration parameters are successfully stored

RMAN> CONFIGURE RETENTION POLICY TO RECOVERY WINDOW OF 14 DAYS;
old RMAN configuration parameters:
CONFIGURE RETENTION POLICY TO RECOVERY WINDOW OF 14 DAYS;
new RMAN configuration parameters:
CONFIGURE RETENTION POLICY TO RECOVERY WINDOW OF 14 DAYS;
new RMAN configuration parameters are successfully stored

RMAN> CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO
'/boostfs/cora1/BOOST/CONTROL/%d_%F.ctl';
new RMAN configuration parameters:
CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO
'/boostfs/cora1/BOOST/CONTROL/%d_%F.ctl';
new RMAN configuration parameters are successfully stored

RMAN>
RMAN>
RMAN> run {
2>
3> sql 'ALTER SYSTEM SWITCH LOGFILE';
4>
5> BACKUP AS COPY INCREMENTAL LEVEL 0 TAG "INCR_MERGE" DATABASE format
'/boostfs/cora1/BOOST/FULL/%d_TS_%N_FNO_%f.bkp';
6>
7> sql 'ALTER SYSTEM ARCHIVE LOG CURRENT';
8>
9> backup archivelog all format '/boostfs/cora1/BOOST/ARCH/%d_Archive_%u.arlog' not backed up 1
times;
10>
11> }
sql statement: ALTER SYSTEM SWITCH LOGFILE

Starting backup at 2019-01-20 18:39:08
allocated channel: ORA_DISK_1
```

```
channel ORA_DISK_1: SID=253 device type=DISK
allocated channel: ORA_DISK_2
channel ORA_DISK_2: SID=368 device type=DISK
allocated channel: ORA_DISK_3
channel ORA_DISK_3: SID=15 device type=DISK
allocated channel: ORA_DISK_4
channel ORA_DISK_4: SID=134 device type=DISK
channel ORA_DISK_1: starting datafile copy
input datafile file number=00005 name=/u01/app/oracle/oradata/BOOST/example01.dbf
channel ORA_DISK_2: starting datafile copy
input datafile file number=00001 name=/u01/app/oracle/oradata/BOOST/system01.dbf
channel ORA_DISK_3: starting datafile copy
input datafile file number=00003 name=/u01/app/oracle/oradata/BOOST/sysaux01.dbf
channel ORA_DISK_4: starting datafile copy
input datafile file number=00002 name=/u01/app/oracle/oradata/BOOST/datathon01.dbf
output file name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_2.bkp tag=INCR_MERGE RECID=138
STAMP=998073565
channel ORA_DISK_4: datafile copy complete, elapsed time: 00:00:15
channel ORA_DISK_4: starting datafile copy
input datafile file number=00007 name=/u01/app/oracle/oradata/BOOST/datathon02.dbf
output file name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_7.bkp tag=INCR_MERGE RECID=139
STAMP=998073589
channel ORA_DISK_4: datafile copy complete, elapsed time: 00:00:25
channel ORA_DISK_4: starting datafile copy
input datafile file number=00008 name=/u01/app/oracle/oradata/BOOST/datathon03.dbf
output file name=/boostfs/cora1/BOOST/FULL/BOOST_TS_SYSTEM_FNO_1.bkp tag=INCR_MERGE RECID=140
STAMP=998073591
channel ORA_DISK_2: datafile copy complete, elapsed time: 00:00:41
channel ORA_DISK_2: starting datafile copy
input datafile file number=00009 name=/u01/app/oracle/oradata/BOOST/datathon04.dbf
output file name=/boostfs/cora1/BOOST/FULL/BOOST_TS_EXAMPLE_FNO_5.bkp tag=INCR_MERGE RECID=142
STAMP=998073596
channel ORA_DISK_1: datafile copy complete, elapsed time: 00:00:48
channel ORA_DISK_1: starting datafile copy
input datafile file number=00010 name=/u01/app/oracle/oradata/BOOST/datathon05.dbf
output file name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_9.bkp tag=INCR_MERGE RECID=144
STAMP=998073598
channel ORA_DISK_2: datafile copy complete, elapsed time: 00:00:08
channel ORA_DISK_2: starting datafile copy
input datafile file number=00011 name=/u01/app/oracle/oradata/BOOST/datathon06.dbf
output file name=/boostfs/cora1/BOOST/FULL/BOOST_TS_SYSAUX_FNO_3.bkp tag=INCR_MERGE RECID=141
STAMP=998073596
channel ORA_DISK_3: datafile copy complete, elapsed time: 00:00:49
channel ORA_DISK_3: starting datafile copy
input datafile file number=00012 name=/u01/app/oracle/oradata/BOOST/datathon07.dbf
output file name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_8.bkp tag=INCR_MERGE RECID=143
STAMP=998073598
channel ORA_DISK_4: datafile copy complete, elapsed time: 00:00:09
channel ORA_DISK_4: starting datafile copy
input datafile file number=00013 name=/u01/app/oracle/oradata/BOOST/datathon08.dbf
output file name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_10.bkp tag=INCR_MERGE RECID=145
STAMP=998073604
channel ORA_DISK_1: datafile copy complete, elapsed time: 00:00:07
channel ORA_DISK_1: starting datafile copy
input datafile file number=00014 name=/u01/app/oracle/oradata/BOOST/datathon09.dbf
output file name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_11.bkp tag=INCR_MERGE RECID=147
STAMP=998073607
channel ORA_DISK_2: datafile copy complete, elapsed time: 00:00:08
channel ORA_DISK_2: starting datafile copy
input datafile file number=00015 name=/u01/app/oracle/oradata/BOOST/datathon10.dbf
output file name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_12.bkp tag=INCR_MERGE RECID=146
STAMP=998073607
channel ORA_DISK_3: datafile copy complete, elapsed time: 00:00:08
```

```
channel ORA_DISK_3: starting datafile copy
input datafile file number=00004 name=/u01/app/oracle/oradata/BOOST/undotbs01.dbf
output file name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_13.bkp tag=INCR_MERGE RECID=148
STAMP=998073610
channel ORA_DISK_4: datafile copy complete, elapsed time: 00:00:11
channel ORA_DISK_4: starting datafile copy
input datafile file number=00006 name=/u01/app/oracle/oradata/BOOST/users01.dbf
output file name=/boostfs/cora1/BOOST/FULL/BOOST_TS_UNDOTBS1_FNO_4.bkp tag=INCR_MERGE RECID=149
STAMP=998073613
channel ORA_DISK_3: datafile copy complete, elapsed time: 00:00:06
output file name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_14.bkp tag=INCR_MERGE RECID=150
STAMP=998073613
channel ORA_DISK_1: datafile copy complete, elapsed time: 00:00:11
output file name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_15.bkp tag=INCR_MERGE RECID=152
STAMP=998073613
channel ORA_DISK_2: datafile copy complete, elapsed time: 00:00:10
output file name=/boostfs/cora1/BOOST/FULL/BOOST_TS_USERS_FNO_6.bkp tag=INCR_MERGE RECID=151
STAMP=998073613
channel ORA_DISK_4: datafile copy complete, elapsed time: 00:00:07
Finished backup at 2019-01-20 18:40:17

Starting Control File and SPFILE Autobackup at 2019-01-20 18:40:17
piece handle=/boostfs/cora1/BOOST/CONTROL/BOOST_c-175849284-20190120-00.ctl comment=NONE
Finished Control File and SPFILE Autobackup at 2019-01-20 18:40:20

sql statement: ALTER SYSTEM ARCHIVE LOG CURRENT

Starting backup at 2019-01-20 18:40:21
current log archived
using channel ORA_DISK_1
using channel ORA_DISK_2
using channel ORA_DISK_3
using channel ORA_DISK_4
channel ORA_DISK_1: starting archived log copy
input archived log thread=1 sequence=70 RECID=27 STAMP=998073549
channel ORA_DISK_2: starting archived log copy
input archived log thread=1 sequence=71 RECID=28 STAMP=998073621
channel ORA_DISK_3: starting archived log copy
input archived log thread=1 sequence=72 RECID=29 STAMP=998073621
output file name=/boostfs/cora1/BOOST/ARCH/BOOST_Archive_72tnqp8l.arlog RECID=32 STAMP=998073622
channel ORA_DISK_1: archived log copy complete, elapsed time: 00:00:01
output file name=/boostfs/cora1/BOOST/ARCH/BOOST_Archive_73tnqp8l.arlog RECID=30 STAMP=998073621
channel ORA_DISK_2: archived log copy complete, elapsed time: 00:00:01
output file name=/boostfs/cora1/BOOST/ARCH/BOOST_Archive_74tnqp8l.arlog RECID=31 STAMP=998073622
channel ORA_DISK_3: archived log copy complete, elapsed time: 00:00:01
Finished backup at 2019-01-20 18:40:22

Starting Control File and SPFILE Autobackup at 2019-01-20 18:40:22
piece handle=/boostfs/cora1/BOOST/CONTROL/BOOST_c-175849284-20190120-01.ctl comment=NONE
Finished Control File and SPFILE Autobackup at 2019-01-20 18:40:25
```

Since the Data Domain is empty, there will be no scope for de-duplication of the first full backup. However, data will be compressed and sent to Data Domain, reducing the network traffic (see below):

```
sysadmin@ddt# sysadmin@ddt# ddboost show stat int 1
01/20 08:02:36
  Backup         Post-comp        Network         Restore           Network          Backup    Restore
   KB/s          Written KB/s     In KB/s          KB/s             Out KB/s          Conn      Conn
--------------- --------------- --------------- --------------- --------------- ------- -------
        75,426          22,485          22,494               0               0       4       0
        91,311          25,773          25,784               0               0       4       0
        88,405          22,580          22,591               0               0       4       0
       147,239          17,667          17,684               0               0       4       0
       101,179          17,746          17,759               0               0       4       0
        94,401          17,518          17,528               0               0       3       0
        87,944          20,417          20,428               0               0       3       0
       154,230          29,686          29,704               0               0       4       0
        64,379          15,090          15,098               0               0       4       0
       132,688          30,369          30,385               0               0       4       0
       115,227          22,095          22,108               0               0       4       0
       101,776          19,779          19,792               0               0       4       0
        91,698          20,405          20,416               0               0       4       0
       112,207          25,143          25,156               0               0       4       0
       117,701          15,082          15,097               0               0       4       0
```

Let us now see the efficiency of the first full backup stored within Data Domain.

```
sysadmin@ddt# ddboost storage-unit show compression boostfsu

List of files in boostfsu and their compression info:

cora1:
Total files: 20;  bytes/storage_used: 5.6
        Logical Bytes:       5,688,000,000
       Original Bytes:       5,708,114,477
  Globally Compressed:       5,558,456,330
    Locally Compressed:      1,002,557,797
            Meta-data:          24,028,792
```

The first full 5.6 GB copy backup uses 1GB of physical space, providing 5.6:1 de-duplication and compression.

With BoostFS, we can also list the full backup and any snapshots directly from the host:

```
[oracle@cora1 ~]$ ls -l /boostfs/cora1/BOOST/FULL
total 344888
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_10.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_11.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_12.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_13.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_14.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_15.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_2.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_7.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_8.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_9.bkp
-rw-r-----. 1 oracle oinstall 1304174592 Jan 21  2019 BOOST_TS_EXAMPLE_FNO_5.bkp
-rw-r-----. 1 oracle oinstall  734011392 Jan 21  2019 BOOST_TS_SYSAUX_FNO_3.bkp
-rw-r-----. 1 oracle oinstall  838868992 Jan 21  2019 BOOST_TS_SYSTEM_FNO_1.bkp
-rw-r-----. 1 oracle oinstall  146808832 Jan 21  2019 BOOST_TS_UNDOTBS1_FNO_4.bkp
-rw-r-----. 1 oracle oinstall    5251072 Jan 21  2019 BOOST_TS_USERS_FNO_6.bkp
[oracle@cora1 ~]$ ls -l /boostfs/cora1/BOOST/SNAPSHOT
total 0
```

Step 3. Performing a snapshot copy of the first full (l0) backup

The next step is to preserve a copy of the first full backup that was performed to the /FULL directory for any future restore requirement. The following section creates a snapshot of the /FULL directory as 1_FIRST_FULL in the /SNAPSHOT directory (Note: to set up remote ssh to Data Domain for fastcopy, refer to How to set up remote ssh to perform Data Domain fastcopy in the Reference section)

```
[oracle@cora1 ~]$ ssh fastcopy@ddt.local filesys fastcopy source /data/col1/boostfsu/cora1/BOOST/FULL
destination /data/col1/boostfsu/cora1/BOOST/SNAPSHOT/1_FIRST_FULL
EMC Data Domain Virtual Edition
(00:00) Waiting for fastcopy to complete...
Fastcopy status: fastcopy /data/col1/boostfsu/cora1/BOOST/FULL to
/data/col1/boostfsu/cora1/BOOST/SNAPSHOT/1_FIRST_FULL: copied 15 files, 1 directory in 0.18 seconds
```

Now we have created a snapshot in the /SNAPSHOT directory. These files are visible on the /boostfs filesystem. It is important to note the fastcopy is a pointer-based image with no physical copying of data and therefore is very quick regardless of the size of the database.

```
[oracle@cora1 ~]$ ls -l /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/
total 344888
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_10.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_11.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_12.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_13.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_14.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_15.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_2.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_7.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_8.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_9.bkp
-rw-r-----. 1 oracle oinstall 1304174592 Jan 21  2019 BOOST_TS_EXAMPLE_FNO_5.bkp
-rw-r-----. 1 oracle oinstall  734011392 Jan 21  2019 BOOST_TS_SYSAUX_FNO_3.bkp
-rw-r-----. 1 oracle oinstall  838868992 Jan 21  2019 BOOST_TS_SYSTEM_FNO_1.bkp
-rw-r-----. 1 oracle oinstall  146808832 Jan 21  2019 BOOST_TS_UNDOTBS1_FNO_4.bkp
-rw-r-----. 1 oracle oinstall    5251072 Jan 21  2019 BOOST_TS_USERS_FNO_6.bkp
```

Now that we have created a copy of the full backup, let us check the space consumption within Data Domain.

```
sysadmin@ddt# ddboost storage-unit show compression boostfsu

List of files in boostfsu and their compression info:

cora1:
Total files: 35;  bytes/storage_used: 11.1
        Logical Bytes:      11,338,636,800
       Original Bytes:      11,378,634,507
   Globally Compressed:      5,558,456,330
    Locally Compressed:      1,002,557,797
            Meta-data:         24,031,072
```

We can see that the physical capacity has not increased at all, while the logical size has, providing a 11.1:1 de-duplication and compression benefit. Note: Globally Compressed is the de-duplication impact and Locally Compressed is the compression impact in the values above.

The next step is to catalog this backup within Oracle so that it can be used for any future restore process by Oracle. The Snapshot backup is tagged as "cora1_BOOST_1_FIRST_FULL".

```
[oracle@cora1 ~]$ rman target /

Recovery Manager: Release 12.1.0.2.0 - Production on Sun Jan 20 19:26:23 2019

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connected to target database: BOOST (DBID=175849284)

RMAN> catalog datafilecopy '/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_10.bkp'
TAG='cora1_BOOST_1_FIRST_FULL' ;

catalog datafilecopy '/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_11.bkp'
TAG='cora1_BOOST_1_FIRST_FULL' ;
catalog datafilecopy '/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_12.bkp'
TAG='cora1_BOOST_1_FIRST_FULL' ;
catalog datafilecopy '/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_13.bkp'
TAG='cora1_BOOST_1_FIRST_FULL' ;
catalog datafilecopy '/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_14.bkp'
TAG='cora1_BOOST_1_FIRST_FULL' ;
catalog datafilecopy '/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_15.bkp'
TAG='cora1_BOOST_1_FIRST_FULL' ;
catalog datafilecopy '/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_2.bkp'
TAG='cora1_BOOST_1_FIRST_FULL' ;
catalog datafilecopy '/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_7.bkp'
TAG='cora1_BOOST_1_FIRST_FULL' ;
catalog datafilecopy '/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_8.bkp'
TAG='cora1_BOOST_1_FIRST_FULL' ;
catalog datafilecopy '/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_9.bkp'
TAG='cora1_BOOST_1_FIRST_FULL' ;
catalog datafilecopy '/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_EXAMPLE_FNO_5.bkp'
TAG='cora1_BOOST_1_FIRST_FULL' ;
catalog datafilecopy '/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_SYSAUX_FNO_3.bkp'
TAG='cora1_BOOST_1_FIRST_FULL' ;
catalog datafilecopy '/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_SYSTEM_FNO_1.bkp'
TAG='cora1_BOOST_1_FIRST_FULL' ;
catalog datafilecopy '/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_UNDOTBS1_FNO_4.bkp'
TAG='cora1_BOOST_1_FIRST_FULL' ;
catalog datafilecopy '/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_USERS_FNO_6.bkp'
TAG='cora1_BOOST_1_FIRST_FULL' ;
using target database control file instead of recovery catalog
cataloged datafile copy
datafile copy file name=/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_10.bkp
RECID=153 STAMP=998076390
RMAN>
cataloged datafile copy
datafile copy file name=/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_11.bkp
RECID=154 STAMP=998076394
RMAN>
cataloged datafile copy
datafile copy file name=/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_12.bkp
RECID=155 STAMP=998076397
RMAN>
cataloged datafile copy
datafile copy file name=/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_13.bkp
RECID=156 STAMP=998076400
RMAN>
cataloged datafile copy
datafile copy file name=/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_14.bkp
RECID=157 STAMP=998076402
RMAN>
```

```
cataloged datafile copy
datafile copy file name=/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_15.bkp
RECID=158 STAMP=998076406
RMAN>
cataloged datafile copy
datafile copy file name=/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_2.bkp
RECID=159 STAMP=998076410
RMAN>
cataloged datafile copy
datafile copy file name=/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_7.bkp
RECID=160 STAMP=998076413
RMAN>
cataloged datafile copy
datafile copy file name=/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_8.bkp
RECID=161 STAMP=998076414
RMAN>
cataloged datafile copy
datafile copy file name=/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_9.bkp
RECID=162 STAMP=998076417
RMAN>
cataloged datafile copy
datafile copy file name=/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_EXAMPLE_FNO_5.bkp
RECID=163 STAMP=998076419
RMAN>
cataloged datafile copy
datafile copy file name=/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_SYSAUX_FNO_3.bkp
RECID=164 STAMP=998076420
RMAN>
cataloged datafile copy
datafile copy file name=/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_SYSTEM_FNO_1.bkp
RECID=165 STAMP=998076422
RMAN>
cataloged datafile copy
datafile copy file name=/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_UNDOTBS1_FNO_4.bkp
RECID=166 STAMP=998076426
RMAN>
cataloged datafile copy
datafile copy file name=/boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_USERS_FNO_6.bkp RECID=167
STAMP=998076431
```

RMAN Catalog now has a record of both backup copies for each database file so the original backup with tag "INCR_MERGE" can now be used for Oracle Incremental Merge backup.

```
RMAN> list copy;

specification does not match any control file copy in the repository
List of Datafile Copies
=======================

Key     File S Completion Time     Ckp SCN    Ckp Time
------- ---- - ------------------- ---------- -------------------
165     1    A 2019-01-20 19:27:02 3585596    2019-01-20 18:39:10
        Name: /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_SYSTEM_FNO_1.bkp
        Tag: CORA1_BOOST_1_FIRST_FULL

140     1    A 2019-01-20 18:39:51 3585596    2019-01-20 18:39:10
        Name: /boostfs/cora1/BOOST/FULL/BOOST_TS_SYSTEM_FNO_1.bkp
        Tag: INCR_MERGE

159     2    A 2019-01-20 19:26:50 3585600    2019-01-20 18:39:10
        Name: /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_2.bkp
        Tag: CORA1_BOOST_1_FIRST_FULL
```

```
138     2    A 2019-01-20 18:39:25 3585600    2019-01-20 18:39:10
        Name: /boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_2.bkp
        Tag: INCR_MERGE

164     3    A 2019-01-20 19:27:00 3585597    2019-01-20 18:39:10
        Name: /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_SYSAUX_FNO_3.bkp
        Tag: CORA1_BOOST_1_FIRST_FULL

141     3    A 2019-01-20 18:39:56 3585597    2019-01-20 18:39:10
        Name: /boostfs/cora1/BOOST/FULL/BOOST_TS_SYSAUX_FNO_3.bkp
        Tag: INCR_MERGE

166     4    A 2019-01-20 19:27:06 3585663    2019-01-20 18:40:07
        Name: /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_UNDOTBS1_FNO_4.bkp
        Tag: CORA1_BOOST_1_FIRST_FULL

149     4    A 2019-01-20 18:40:13 3585663    2019-01-20 18:40:07
        Name: /boostfs/cora1/BOOST/FULL/BOOST_TS_UNDOTBS1_FNO_4.bkp
        Tag: INCR_MERGE

163     5    A 2019-01-20 19:26:59 3585593    2019-01-20 18:39:10
        Name: /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_EXAMPLE_FNO_5.bkp
        Tag: CORA1_BOOST_1_FIRST_FULL

142     5    A 2019-01-20 18:39:56 3585593    2019-01-20 18:39:10
        Name: /boostfs/cora1/BOOST/FULL/BOOST_TS_EXAMPLE_FNO_5.bkp
        Tag: INCR_MERGE

167     6    A 2019-01-20 19:27:11 3585667    2019-01-20 18:40:10
        Name: /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_USERS_FNO_6.bkp
        Tag: CORA1_BOOST_1_FIRST_FULL

151     6    A 2019-01-20 18:40:13 3585667    2019-01-20 18:40:10
        Name: /boostfs/cora1/BOOST/FULL/BOOST_TS_USERS_FNO_6.bkp
        Tag: INCR_MERGE

160     7    A 2019-01-20 19:26:53 3585607    2019-01-20 18:39:25
        Name: /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_7.bkp
        Tag: CORA1_BOOST_1_FIRST_FULL

139     7    A 2019-01-20 18:39:49 3585607    2019-01-20 18:39:25
        Name: /boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_7.bkp
        Tag: INCR_MERGE

161     8    A 2019-01-20 19:26:54 3585625    2019-01-20 18:39:50
        Name: /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_8.bkp
        Tag: CORA1_BOOST_1_FIRST_FULL

143     8    A 2019-01-20 18:39:58 3585625    2019-01-20 18:39:50
        Name: /boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_8.bkp
        Tag: INCR_MERGE

162     9    A 2019-01-20 19:26:57 3585628    2019-01-20 18:39:51
        Name: /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_9.bkp
        Tag: CORA1_BOOST_1_FIRST_FULL

144     9    A 2019-01-20 18:39:58 3585628    2019-01-20 18:39:51
        Name: /boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_9.bkp
        Tag: INCR_MERGE

153     10   A 2019-01-20 19:26:30 3585638    2019-01-20 18:39:59
        Name: /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_10.bkp
```

```
         Tag: CORA1_BOOST_1_FIRST_FULL

145      10   A 2019-01-20 18:40:04 3585638    2019-01-20 18:39:59
         Name: /boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_10.bkp
         Tag: INCR_MERGE

154      11   A 2019-01-20 19:26:34 3585641    2019-01-20 18:39:59
         Name: /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_11.bkp
         Tag: CORA1_BOOST_1_FIRST_FULL

147      11   A 2019-01-20 18:40:07 3585641    2019-01-20 18:39:59
         Name: /boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_11.bkp
         Tag: INCR_MERGE

155      12   A 2019-01-20 19:26:37 3585644    2019-01-20 18:39:59
         Name: /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_12.bkp
         Tag: CORA1_BOOST_1_FIRST_FULL

146      12   A 2019-01-20 18:40:07 3585644    2019-01-20 18:39:59
         Name: /boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_12.bkp
         Tag: INCR_MERGE

156      13   A 2019-01-20 19:26:40 3585647    2019-01-20 18:39:59
         Name: /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_13.bkp
         Tag: CORA1_BOOST_1_FIRST_FULL

148      13   A 2019-01-20 18:40:10 3585647    2019-01-20 18:39:59
         Name: /boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_13.bkp
         Tag: INCR_MERGE

157      14   A 2019-01-20 19:26:42 3585657    2019-01-20 18:40:06
         Name: /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_14.bkp
         Tag: CORA1_BOOST_1_FIRST_FULL

150      14   A 2019-01-20 18:40:13 3585657    2019-01-20 18:40:06
         Name: /boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_14.bkp
         Tag: INCR_MERGE

158      15   A 2019-01-20 19:26:46 3585660    2019-01-20 18:40:07
         Name: /boostfs/cora1/BOOST/SNAPSHOT/1_FIRST_FULL/BOOST_TS_DATATHON_FNO_15.bkp
         Tag: CORA1_BOOST_1_FIRST_FULL

152      15   A 2019-01-20 18:40:13 3585660    2019-01-20 18:40:07
         Name: /boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_15.bkp
         Tag: INCR_MERGE
```

Step 4. Performing an incrementally merged backup (L1) using OIM

Before doing an incremental backup, let us generate some changes by creating a new table – test_table – with 100,000 rows.

```
[oracle@cora1 ~]$ sqlplus / as sysdba

SQL*Plus: Release 12.1.0.2.0 Production on Sun Jan 20 19:33:37 2019

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Connected to:
```

```
Oracle Database 12c Enterprise Edition Release 12.1.0.2.0 - 64bit Production
With the Partitioning, OLAP, Advanced Analytics and Real Application Testing options

SQL> create table test_table as select * from datathon.bigtab where rownum < 100001 ;

Table created.

SQL> Select count(*) from test_table;

   COUNT(*)
----------
    100000
```

The next step is to do an incremental backup (to /INCR directory) and merge the incremental changes with the previous full backup with tag name "INCR_MERGE" (present in /FULL directory). For completeness, we also backup Archive logs to the /ARCH directory.

```
RMAN> run {
2>
3> sql 'ALTER SYSTEM SWITCH LOGFILE';
4>
5> BACKUP INCREMENTAL LEVEL 1 FOR RECOVER OF COPY WITH TAG "INCR_MERGE" DATABASE format
'/boostfs/cora1/BOOST/INCR/%d_INCR_%U.bkp';
6>
7> RECOVER COPY OF DATABASE WITH TAG "INCR_MERGE";
8>
9> sql 'ALTER SYSTEM ARCHIVE LOG CURRENT';
10>
11> backup archivelog all format '/boostfs/cora1/BOOST/ARCH/%d_Archive_%u.arlog' not backed up 1
times;
12>
13> }
using target database control file instead of recovery catalog
sql statement: ALTER SYSTEM SWITCH LOGFILE

Starting backup at 2019-01-20 19:36:14
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=355 device type=DISK
allocated channel: ORA_DISK_2
channel ORA_DISK_2: SID=368 device type=DISK
allocated channel: ORA_DISK_3
channel ORA_DISK_3: SID=15 device type=DISK
allocated channel: ORA_DISK_4
channel ORA_DISK_4: SID=130 device type=DISK
channel ORA_DISK_1: starting incremental level 1 datafile backup set
channel ORA_DISK_1: specifying datafile(s) in backup set
input datafile file number=00001 name=/u01/app/oracle/oradata/BOOST/system01.dbf
input datafile file number=00011 name=/u01/app/oracle/oradata/BOOST/datathon06.dbf
input datafile file number=00013 name=/u01/app/oracle/oradata/BOOST/datathon08.dbf
input datafile file number=00015 name=/u01/app/oracle/oradata/BOOST/datathon10.dbf
channel ORA_DISK_1: starting piece 1 at 2019-01-20 19:36:15
channel ORA_DISK_2: starting incremental level 1 datafile backup set
channel ORA_DISK_2: specifying datafile(s) in backup set
input datafile file number=00005 name=/u01/app/oracle/oradata/BOOST/example01.dbf
input datafile file number=00006 name=/u01/app/oracle/oradata/BOOST/users01.dbf
input datafile file number=00014 name=/u01/app/oracle/oradata/BOOST/datathon09.dbf
channel ORA_DISK_2: starting piece 1 at 2019-01-20 19:36:15
channel ORA_DISK_3: starting incremental level 1 datafile backup set
channel ORA_DISK_3: specifying datafile(s) in backup set
input datafile file number=00003 name=/u01/app/oracle/oradata/BOOST/sysaux01.dbf
input datafile file number=00009 name=/u01/app/oracle/oradata/BOOST/datathon04.dbf
input datafile file number=00012 name=/u01/app/oracle/oradata/BOOST/datathon07.dbf
input datafile file number=00004 name=/u01/app/oracle/oradata/BOOST/undotbs01.dbf
```

```
channel ORA_DISK_3: starting piece 1 at 2019-01-20 19:36:15
channel ORA_DISK_4: starting incremental level 1 datafile backup set
channel ORA_DISK_4: specifying datafile(s) in backup set
input datafile file number=00002 name=/u01/app/oracle/oradata/BOOST/datathon01.dbf
input datafile file number=00007 name=/u01/app/oracle/oradata/BOOST/datathon02.dbf
input datafile file number=00008 name=/u01/app/oracle/oradata/BOOST/datathon03.dbf
input datafile file number=00010 name=/u01/app/oracle/oradata/BOOST/datathon05.dbf
channel ORA_DISK_4: starting piece 1 at 2019-01-20 19:36:15
channel ORA_DISK_3: finished piece 1 at 2019-01-20 19:36:18
piece handle=/boostfs/cora1/BOOST/INCR/BOOST_INCR_78tnqshf_1_1.bkp tag=INCR_MERGE comment=NONE
channel ORA_DISK_3: backup set complete, elapsed time: 00:00:03
channel ORA_DISK_4: finished piece 1 at 2019-01-20 19:36:18
piece handle=/boostfs/cora1/BOOST/INCR/BOOST_INCR_79tnqshf_1_1.bkp tag=INCR_MERGE comment=NONE
channel ORA_DISK_4: backup set complete, elapsed time: 00:00:03
channel ORA_DISK_1: finished piece 1 at 2019-01-20 19:36:22
piece handle=/boostfs/cora1/BOOST/INCR/BOOST_INCR_76tnqshf_1_1.bkp tag=INCR_MERGE comment=NONE
channel ORA_DISK_1: backup set complete, elapsed time: 00:00:07
channel ORA_DISK_2: finished piece 1 at 2019-01-20 19:36:22
piece handle=/boostfs/cora1/BOOST/INCR/BOOST_INCR_77tnqshf_1_1.bkp tag=INCR_MERGE comment=NONE
channel ORA_DISK_2: backup set complete, elapsed time: 00:00:07
Finished backup at 2019-01-20 19:36:22

Starting recover at 2019-01-20 19:36:23
using channel ORA_DISK_1
using channel ORA_DISK_2
using channel ORA_DISK_3
using channel ORA_DISK_4
channel ORA_DISK_1: starting incremental datafile backup set restore
channel ORA_DISK_1: specifying datafile copies to recover
recovering datafile copy file number=00002 name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_2.bkp
recovering datafile copy file number=00007 name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_7.bkp
recovering datafile copy file number=00008 name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_8.bkp
recovering datafile copy file number=00010
name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_10.bkp
channel ORA_DISK_1: reading from backup piece /boostfs/cora1/BOOST/INCR/BOOST_INCR_79tnqshf_1_1.bkp
channel ORA_DISK_2: starting incremental datafile backup set restore
channel ORA_DISK_2: specifying datafile copies to recover
recovering datafile copy file number=00003 name=/boostfs/cora1/BOOST/FULL/BOOST_TS_SYSAUX_FNO_3.bkp
recovering datafile copy file number=00004 name=/boostfs/cora1/BOOST/FULL/BOOST_TS_UNDOTBS1_FNO_4.bkp
recovering datafile copy file number=00009 name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_9.bkp
recovering datafile copy file number=00012
name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_12.bkp
channel ORA_DISK_2: reading from backup piece /boostfs/cora1/BOOST/INCR/BOOST_INCR_78tnqshf_1_1.bkp
channel ORA_DISK_3: starting incremental datafile backup set restore
channel ORA_DISK_3: specifying datafile copies to recover
recovering datafile copy file number=00001 name=/boostfs/cora1/BOOST/FULL/BOOST_TS_SYSTEM_FNO_1.bkp
recovering datafile copy file number=00011
name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_11.bkp
recovering datafile copy file number=00013
name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_13.bkp
recovering datafile copy file number=00015
name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_15.bkp
channel ORA_DISK_3: reading from backup piece /boostfs/cora1/BOOST/INCR/BOOST_INCR_76tnqshf_1_1.bkp
channel ORA_DISK_4: starting incremental datafile backup set restore
channel ORA_DISK_4: specifying datafile copies to recover
recovering datafile copy file number=00005 name=/boostfs/cora1/BOOST/FULL/BOOST_TS_EXAMPLE_FNO_5.bkp
recovering datafile copy file number=00006 name=/boostfs/cora1/BOOST/FULL/BOOST_TS_USERS_FNO_6.bkp
recovering datafile copy file number=00014
name=/boostfs/cora1/BOOST/FULL/BOOST_TS_DATATHON_FNO_14.bkp
channel ORA_DISK_4: reading from backup piece /boostfs/cora1/BOOST/INCR/BOOST_INCR_77tnqshf_1_1.bkp
channel ORA_DISK_1: piece handle=/boostfs/cora1/BOOST/INCR/BOOST_INCR_79tnqshf_1_1.bkp tag=INCR_MERGE
channel ORA_DISK_1: restored backup piece 1
channel ORA_DISK_1: restore complete, elapsed time: 00:00:02
```

```
channel ORA_DISK_2: piece handle=/boostfs/cora1/BOOST/INCR/BOOST_INCR_78tnqshf_1_1.bkp tag=INCR_MERGE
channel ORA_DISK_2: restored backup piece 1
channel ORA_DISK_2: restore complete, elapsed time: 00:00:04
channel ORA_DISK_4: piece handle=/boostfs/cora1/BOOST/INCR/BOOST_INCR_77tnqshf_1_1.bkp tag=INCR_MERGE
channel ORA_DISK_4: restored backup piece 1
channel ORA_DISK_4: restore complete, elapsed time: 00:00:03
channel ORA_DISK_3: piece handle=/boostfs/cora1/BOOST/INCR/BOOST_INCR_76tnqshf_1_1.bkp tag=INCR_MERGE
channel ORA_DISK_3: restored backup piece 1
channel ORA_DISK_3: restore complete, elapsed time: 00:00:08
Finished recover at 2019-01-20 19:36:31

Starting Control File and SPFILE Autobackup at 2019-01-20 19:36:31
piece handle=/boostfs/cora1/BOOST/CONTROL/BOOST_c-175849284-20190120-02.ctl comment=NONE
Finished Control File and SPFILE Autobackup at 2019-01-20 19:36:32

sql statement: ALTER SYSTEM ARCHIVE LOG CURRENT

Starting backup at 2019-01-20 19:36:32
current log archived
using channel ORA_DISK_1
using channel ORA_DISK_2
using channel ORA_DISK_3
using channel ORA_DISK_4
channel ORA_DISK_1: starting archived log copy
input archived log thread=1 sequence=73 RECID=33 STAMP=998076974
channel ORA_DISK_2: starting archived log copy
input archived log thread=1 sequence=70 RECID=27 STAMP=998073549
channel ORA_DISK_3: starting archived log copy
input archived log thread=1 sequence=71 RECID=28 STAMP=998073621
channel ORA_DISK_4: starting archived log copy
input archived log thread=1 sequence=74 RECID=34 STAMP=998076992
output file name=/boostfs/cora1/BOOST/ARCH/BOOST_Archive_7btnqsi2.arlog RECID=36 STAMP=998076994
channel ORA_DISK_1: archived log copy complete, elapsed time: 00:00:01
channel ORA_DISK_1: starting archived log copy
input archived log thread=1 sequence=72 RECID=29 STAMP=998073621
output file name=/boostfs/cora1/BOOST/ARCH/BOOST_Archive_7etnqsi3.arlog RECID=37 STAMP=998076996
channel ORA_DISK_4: archived log copy complete, elapsed time: 00:00:01
channel ORA_DISK_4: starting archived log copy
input archived log thread=1 sequence=75 RECID=35 STAMP=998076992
output file name=/boostfs/cora1/BOOST/ARCH/BOOST_Archive_7ctnqsi2.arlog RECID=39 STAMP=998076996
channel ORA_DISK_2: archived log copy complete, elapsed time: 00:00:02
output file name=/boostfs/cora1/BOOST/ARCH/BOOST_Archive_7dtnqsi2.arlog RECID=38 STAMP=998076996
channel ORA_DISK_3: archived log copy complete, elapsed time: 00:00:02
output file name=/boostfs/cora1/BOOST/ARCH/BOOST_Archive_7ftnqsi3.arlog RECID=40 STAMP=998076997
channel ORA_DISK_1: archived log copy complete, elapsed time: 00:00:01
output file name=/boostfs/cora1/BOOST/ARCH/BOOST_Archive_7gtnqsi4.arlog RECID=41 STAMP=998076997
channel ORA_DISK_4: archived log copy complete, elapsed time: 00:00:03
Finished backup at 2019-01-20 19:36:39

Starting Control File and SPFILE Autobackup at 2019-01-20 19:36:39
piece handle=/boostfs/cora1/BOOST/CONTROL/BOOST_c-175849284-20190120-03.ctl comment=NONE
Finished Control File and SPFILE Autobackup at 2019-01-20 19:36:40
```

Let us see how much physical storage capacity we added to the Data Domain after the incremental merge backup.

```
sysadmin@ddt# ddboost storage-unit show compression boostfsu

List of files in boostfsu and their compression info:

cora1:
Total files: 47;  bytes/storage_used: 11.0
         Logical Bytes:      11,424,694,272
        Original Bytes:      11,490,222,792
   Globally Compressed:       5,634,205,336
    Locally Compressed:       1,020,796,320
             Meta-data:          24,358,408
sysadmin@ddt#
```

About 18MB of additional physical capacity was generated out of the 100,000 rows new table that we created.

Step 5. Perform a snapshot copy of the Incrementally (L1) merged full backup

The next step is to preserve a copy of the OIM backup that was performed to the /INCR directory updated to the previous full backup in the /FULL directory. The following step creates a snapshot of the /FULL directory as 2_SECOND_FULL in the /SNAPSHOT directory.

```
[oracle@cora1 ~]$ ssh fastcopy@ddt.local filesys fastcopy source /data/col1/boostfsu/cora1/BOOST/FULL
destination /data/col1/boostfsu/cora1/BOOST/SNAPSHOT/2_SECOND_FULL
EMC Data Domain Virtual Edition
(00:00) Waiting for fastcopy to complete...
Fastcopy status: fastcopy /data/col1/boostfsu/cora1/BOOST/FULL to
/data/col1/boostfsu/cora1/BOOST/SNAPSHOT/2_SECOND_FULL: copied 15 files, 1 directory in 0.16 seconds
```

A snapshot copy of the incrementally merged second full backup is available in the snapshot directory. This backup now has a copy of the table (TEST_TABLE) that was previously created.

```
[oracle@cora1 ~]$ ls -l /boostfs/cora1/BOOST/SNAPSHOT
total 1
drwxr-xr-x. 2 oracle oinstall 1239 Jan 21  2019 1_FIRST_FULL
drwxr-xr-x. 2 oracle oinstall 1239 Jan 21  2019 2_SECOND_FULL
[oracle@cora1 ~]$ ls -l /boostfs/cora1/BOOST/SNAPSHOT/2_SECOND_FULL/
total 345528
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_10.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_11.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_12.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_13.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_14.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_15.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_2.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_7.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_8.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_9.bkp
-rw-r-----. 1 oracle oinstall 1304174592 Jan 21  2019 BOOST_TS_EXAMPLE_FNO_5.bkp
-rw-r-----. 1 oracle oinstall  734011392 Jan 21  2019 BOOST_TS_SYSAUX_FNO_3.bkp
-rw-r-----. 1 oracle oinstall  849354752 Jan 21  2019 BOOST_TS_SYSTEM_FNO_1.bkp
-rw-r-----. 1 oracle oinstall  146808832 Jan 21  2019 BOOST_TS_UNDOTBS1_FNO_4.bkp
-rw-r-----. 1 oracle oinstall    5251072 Jan 21  2019 BOOST_TS_USERS_FNO_6.bkp
[oracle@cora1 ~]$
```

Now that we have created a second copy of the full backup, let us check the space consumption within Data Domain.

```
sysadmin@ddt# ddboost storage-unit show compression boostfsu

List of files in boostfsu and their compression info:

cora1:
Total files: 62;  bytes/storage_used: 16.5
        Logical Bytes:        17,085,816,832
       Original Bytes:        17,195,866,590
  Globally Compressed:         5,634,205,336
   Locally Compressed:         1,020,796,320
            Meta-data:            24,360,688
```

The physical capacity consumption remains the same and the efficiency has increased to 16.5:1 (16.5GB of backup uses approximately 1GB of physical capacity, demonstrating the power of de-duplication).

The next step is to catalog this backup within Oracle so that it can be used for any future restore process by Oracle. The Snapshot backup is tagged as "cora1_BOOST_2_SECOND_FULL". (NOTE: output not shown as it is similar to previous catalog operation)

Oracle Incremental Backup Restore Scenarios

The following section demonstrates restore scenarios using the previously performed FULL and OIM FULL backups.

Restoring a loss of database data file

For this restore test, File #6 (users01.dbf) file will be deleted and recovered using RMAN restore and recover commands.

```
[oracle@cora1 ~]$ rm -i /u01/app/oracle/oradata/BOOST/users01.dbf
rm: remove regular file '/u01/app/oracle/oradata/BOOST/users01.dbf'? y
[oracle@cora1 ~]$
[oracle@cora1 ~]$ rman target /

Recovery Manager: Release 12.1.0.2.0 - Production on Sun Jan 20 20:00:50 2019

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connected to target database: BOOST (DBID=175849284)

RMAN> @r.sql

RMAN>
RMAN> CONFIGURE DEVICE TYPE SBT_TAPE CLEAR;
using target database control file instead of recovery catalog
old RMAN configuration parameters:
CONFIGURE DEVICE TYPE 'SBT_TAPE' BACKUP TYPE TO BACKUPSET PARALLELISM 4;
RMAN configuration parameters are successfully reset to default value

RMAN> CONFIGURE DEFAULT DEVICE TYPE TO DISK;
old RMAN configuration parameters:
CONFIGURE DEFAULT DEVICE TYPE TO DISK;
new RMAN configuration parameters:
CONFIGURE DEFAULT DEVICE TYPE TO DISK;
new RMAN configuration parameters are successfully stored

RMAN> CONFIGURE DEVICE TYPE DISK BACKUP TYPE TO COPY PARALLELISM 1;
```

```
old RMAN configuration parameters:
CONFIGURE DEVICE TYPE DISK BACKUP TYPE TO COPY PARALLELISM 4;
new RMAN configuration parameters:
CONFIGURE DEVICE TYPE DISK BACKUP TYPE TO COPY PARALLELISM 1;
new RMAN configuration parameters are successfully stored

RMAN>
RMAN> run {
2>
3> shutdown abort;
4>
5> startup mount;
6>
7> restore datafile 6;
8>
9> recover datafile 6;
10>
11> alter database open;
12>
13> }
Oracle instance shut down

connected to target database (not started)
Oracle instance started
database mounted

Total System Global Area     536870912 bytes

Fixed Size                     2926472 bytes
Variable Size                411043960 bytes
Database Buffers             117440512 bytes
Redo Buffers                   5459968 bytes

Starting restore at 2019-01-20 20:01:39
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=243 device type=DISK

channel ORA_DISK_1: restoring datafile 00006
input datafile copy RECID=196 STAMP=998077923 file
name=/boostfs/cora1/BOOST/SNAPSHOT/2_SECOND_FULL/BOOST_TS_USERS_FNO_6.bkp
destination for restore of datafile 00006: /u01/app/oracle/oradata/BOOST/users01.dbf
channel ORA_DISK_1: copied datafile copy of datafile 00006
output file name=/u01/app/oracle/oradata/BOOST/users01.dbf RECID=0 STAMP=0
Finished restore at 2019-01-20 20:01:44

Starting recover at 2019-01-20 20:01:44
using channel ORA_DISK_1

starting media recovery
media recovery complete, elapsed time: 00:00:00

Finished recover at 2019-01-20 20:01:44

Statement processed

RMAN>
```

Since every Full and OIM backups were snapshotted and cataloged within Oracle, RMAN was able to restore the deleted file directly from the latest backup snapshot (2_SECOND_FULL) to recover the deleted datafile.

Restoring a loss of database object (table) using "Live Mount" of database backup on BoostFS

To demonstrate this capability, the previously created table (TEST_TABLE) will be <u>dropped</u> from the "BOOST" database and a snapshot of 2_SECOND_FULL snapshot will be created as "TEST" in the /SNAPSHOT directory. The TEST snapshot will then be used to start a database named "TEST" simultaneously and TEST_TABLE exported from "TEST" database and imported back to "BOOST" database. At the end, "TEST" database will be shut down and its snapshot directory/files removed.

Figure 4 depicts the flow of activities:
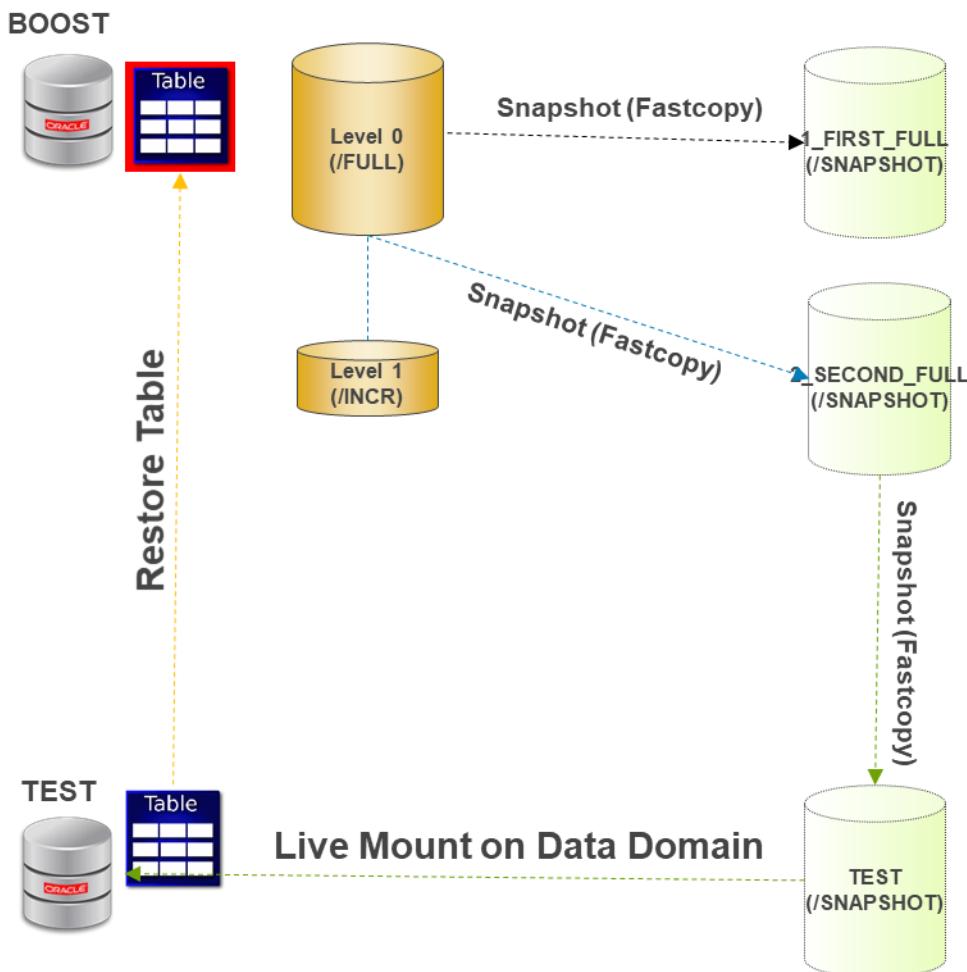
Figure 4 Database Live Mount with Table restore

Step 1. Drop table TEST_TABLE from BOOST database

```
[oracle@cora1 ~]$ ps -ef | grep pmon
oracle    67660      1  0 20:01 ?        00:00:00 ora_pmon_BOOST
oracle    75961  11674  0 20:17 pts/0    00:00:00 grep --color=auto pmon
[oracle@cora1 ~]$ ORACLE_SID=BOOST sqlplus / as sysdba

SQL*Plus: Release 12.1.0.2.0 Production on Sun Jan 20 20:17:30 2019

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Connected to:
```

```
Oracle Database 12c Enterprise Edition Release 12.1.0.2.0 - 64bit Production
With the Partitioning, OLAP, Advanced Analytics and Real Application Testing options

SQL> drop table test_table;

Table dropped.

SQL> exit
Disconnected from Oracle Database 12c Enterprise Edition Release 12.1.0.2.0 - 64bit Production
With the Partitioning, OLAP, Advanced Analytics and Real Application Testing options
```

Step 2. Create a snapshot of 2_SECOND_FULL as TEST for Live Mount

```
[oracle@cora1 ~]$ ls -l /boostfs/cora1/BOOST/SNAPSHOT
total 1
drwxr-xr-x. 2 oracle oinstall 1239 Jan 21  2019 1_FIRST_FULL
drwxr-xr-x. 2 oracle oinstall 1239 Jan 21  2019 2_SECOND_FULL
[oracle@cora1 ~]$ ssh fastcopy@ddt.local filesys fastcopy source
/data/col1/boostfsu/cora1/BOOST/SNAPSHOT/2_SECOND_FULL destination
/data/col1/boostfsu/cora1/BOOST/SNAPSHOT/TEST
EMC Data Domain Virtual Edition
(00:00) Waiting for fastcopy to complete...
Fastcopy status: fastcopy /data/col1/boostfsu/cora1/BOOST/SNAPSHOT/2_SECOND_FULL to
/data/col1/boostfsu/cora1/BOOST/SNAPSHOT/TEST: copied 15 files, 1 directory in 0.03 seconds
[oracle@cora1 ~]$ ls -l /boostfs/cora1/BOOST/SNAPSHOT
total 2
drwxr-xr-x. 2 oracle oinstall 1239 Jan 21  2019 1_FIRST_FULL
drwxr-xr-x. 2 oracle oinstall 1239 Jan 21  2019 2_SECOND_FULL
drwxr-xr-x. 2 oracle oinstall 1239 Jan 21  2019 TEST
[oracle@cora1 ~]$ ls -l /boostfs/cora1/BOOST/SNAPSHOT/TEST
total 345528
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_10.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_11.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_12.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_13.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_14.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_15.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_2.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_7.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_8.bkp
-rw-r-----. 1 oracle oinstall  262152192 Jan 21  2019 BOOST_TS_DATATHON_FNO_9.bkp
-rw-r-----. 1 oracle oinstall 1304174592 Jan 21  2019 BOOST_TS_EXAMPLE_FNO_5.bkp
-rw-r-----. 1 oracle oinstall  734011392 Jan 21  2019 BOOST_TS_SYSAUX_FNO_3.bkp
-rw-r-----. 1 oracle oinstall  849354752 Jan 21  2019 BOOST_TS_SYSTEM_FNO_1.bkp
-rw-r-----. 1 oracle oinstall  146808832 Jan 21  2019 BOOST_TS_UNDOTBS1_FNO_4.bkp
-rw-r-----. 1 oracle oinstall    5251072 Jan 21  2019 BOOST_TS_USERS_FNO_6.bkp
```

Step 3. Check the capacity impact of creating "TEST" snapshot on Data Domain

```
sysadmin@ddt# ddboost storage-unit show compression boostfsu

List of files in boostfsu and their compression info:

cora1:
Total files: 77;  bytes/storage_used: 21.9
        Logical Bytes:       22,746,939,392
       Original Bytes:       22,902,288,070
   Globally Compressed:       5,634,594,177
     Locally Compressed:      1,021,067,474
            Meta-data:          24,365,128
sysadmin@ddt#
```

There is negligible increase in capacity as snapshots do not consume storage capacity on Data Domain. The slight increase (0.5MB) noticed is mainly from the previous recovery exercise of dropping and restoring users table.

Step 4. Start a new "TEST" database using the /TEST snapshot that was created previously

A small init.ora file will be used to start the "TEST" oracle instance,

Contents of the InitTEST.ora:

```
 [oracle@cora1 ~]$ cat /tmp/TEST/initTEST.ora
#
# Init.ora file with min parameters to startup TEST
#
*.db_block_size=8192
*.db_domain=''
*.db_name='TEST'
*.control_files='/tmp/TEST/TEST_control01.ctl'
*.audit_file_dest='/tmp/TEST/'
*.audit_trail='db'
*.db_create_file_dest='/tmp/TEST/'
*.db_recovery_file_dest='/tmp/TEST/'
*.diagnostic_dest='/tmp/TEST/'
*.db_recovery_file_dest_size=8589934592
*._allow_resetlogs_corruption=TRUE
*._allow_error_simulation=TRUE
*.remote_login_passwordfile='EXCLUSIVE'
*.compatible='12.1.0.2.0'
```

Start up TEST Oracle database using the /tmp/TEST/initTEST.ora and create a new controlfile using the database files in /TEST snapshot directory on the /boostfs filesystem and open the database (Live Mount).

```
[oracle@cora1 ~]$ ORACLE_SID=TEST sqlplus / as sysdba
SQL*Plus: Release 12.1.0.2.0 Production on Sun Jan 20 20:34:53 2019

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Connected to an idle instance.

SQL> startup nomount pfile=/tmp/TEST/initTEST.ora
ORACLE instance started.

Total System Global Area  272629760 bytes
Fixed Size                  2923336 bytes
Variable Size             213910712 bytes
Database Buffers           50331648 bytes
Redo Buffers                5464064 bytes
SQL>
SQL> CREATE CONTROLFILE REUSE SET DATABASE "TEST" RESETLOGS NOARCHIVELOG
MAXLOGFILES 16
MAXLOGMEMBERS 3
MAXDATAFILES 512
MAXINSTANCES 8
MAXLOGHISTORY 292
LOGFILE
  GROUP 1 '/tmp/TEST/TEST_redo01.log'  SIZE 5M BLOCKSIZE 512 reuse,
  GROUP 2 '/tmp/TEST/TEST_redo02.log'  SIZE 5M BLOCKSIZE 512 reuse,
  GROUP 3 '/tmp/TEST/TEST_redo03.log'  SIZE 5M BLOCKSIZE 512 reuse
 DATAFILE
```

```
  '/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_10.bkp',
  '/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_11.bkp',
  '/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_12.bkp',
  '/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_13.bkp',
  '/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_14.bkp',
  '/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_15.bkp',
  '/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_2.bkp',
  '/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_7.bkp',
  '/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_8.bkp',
  '/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_9.bkp',
  '/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_EXAMPLE_FNO_5.bkp',
  '/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_SYSAUX_FNO_3.bkp',
  '/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_SYSTEM_FNO_1.bkp',
  '/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_UNDOTBS1_FNO_4.bkp',
  '/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_USERS_FNO_6.bkp';

Control file created.

SQL> ALTER DATABASE OPEN RESETLOGS;

Database altered.

SQL> select file_name from dba_data_files;

FILE_NAME
--------------------------------------------------------------------------------
/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_SYSTEM_FNO_1.bkp
/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_SYSAUX_FNO_3.bkp
/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_UNDOTBS1_FNO_4.bkp
/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_USERS_FNO_6.bkp
/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_EXAMPLE_FNO_5.bkp
/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_15.bkp
/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_14.bkp
/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_13.bkp
/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_12.bkp
/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_11.bkp
/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_10.bkp
/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_9.bkp
/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_8.bkp
/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_7.bkp
/boostfs/cora1/BOOST/SNAPSHOT/TEST/BOOST_TS_DATATHON_FNO_2.bkp

15 rows selected.

SQL> Select count(*) from test_table;

  COUNT(*)
----------
    100000
SQL> exit
Disconnected from Oracle Database 12c Enterprise Edition Release 12.1.0.2.0 - 64bit Production
With the Partitioning, OLAP, Advanced Analytics and Real Application Testing options
[oracle@cora1 ~]$ ps -ef | grep pmon
oracle    67660     1  0 20:01 ?        00:00:00 ora_pmon_BOOST
oracle    85212     1  0 20:35 ?        00:00:00 ora_pmon_TEST
oracle    90045 11674  0 20:41 pts/0    00:00:00 grep --color=auto pmon
[oracle@cora1 ~]$
```

There are now two databases running with "TEST" instance Live Mounted on /boostfs (Data Domain). The copy of the database is at the second backup and the "TEST_TABLE" is intact and therefore can be exported and imported back to the "BOOST" databases.

On completion, TEST oracle instance is shut down and the snapshot is removed.

Step 5. Export TEST_TABLE from "TEST" database to "BOOST" database and cleanup.

```
[oracle@cora1 ~]$ ORACLE_SID=TEST exp file=test.dmp tables= test_table rows=y

Export: Release 12.1.0.2.0 - Production on Sun Jan 20 20:45:09 2019

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Username: / as sysdba

Connected to: Oracle Database 12c Enterprise Edition Release 12.1.0.2.0 - 64bit Production
With the Partitioning, OLAP, Advanced Analytics and Real Application Testing options
Export done in US7ASCII character set and AL16UTF16 NCHAR character set
server uses WE8MSWIN1252 character set (possible charset conversion)

About to export specified tables via Conventional Path ...
. . exporting table                      TEST_TABLE     100000 rows exported
Export terminated successfully without warnings.
[oracle@cora1 ~]$ ORACLE_SID=BOOST imp file=test.dmp full=y

Import: Release 12.1.0.2.0 - Production on Sun Jan 20 20:45:40 2019

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Username: / as sysdba

Connected to: Oracle Database 12c Enterprise Edition Release 12.1.0.2.0 - 64bit Production
With the Partitioning, OLAP, Advanced Analytics and Real Application Testing options

Export file created by EXPORT:V12.01.00 via conventional path
import done in US7ASCII character set and AL16UTF16 NCHAR character set
import server uses WE8MSWIN1252 character set (possible charset conversion)
. importing SYS's objects into SYS
. importing SYS's objects into SYS
. . importing table                    "TEST_TABLE"     100000 rows imported
Import terminated successfully without warnings.
[oracle@cora1 ~]$ ORACLE_SID=BOOST sqlplus / as sysdba
SQL*Plus: Release 12.1.0.2.0 Production on Sun Jan 20 20:45:56 2019

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Connected to:
Oracle Database 12c Enterprise Edition Release 12.1.0.2.0 - 64bit Production
With the Partitioning, OLAP, Advanced Analytics and Real Application Testing options

SQL> select count(*) from test_table;

  COUNT(*)
----------
    100000

SQL> exit
Disconnected from Oracle Database 12c Enterprise Edition Release 12.1.0.2.0 - 64bit Production
With the Partitioning, OLAP, Advanced Analytics and Real Application Testing options
[oracle@cora1 ~]$ ORACLE_SID=TEST sqlplus / as sysdba

SQL*Plus: Release 12.1.0.2.0 Production on Sun Jan 20 20:47:09 2019

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```

```
Connected to:
Oracle Database 12c Enterprise Edition Release 12.1.0.2.0 - 64bit Production
With the Partitioning, OLAP, Advanced Analytics and Real Application Testing options

SQL> shutdown abort;
ORACLE instance shut down.
SQL> exit
Disconnected from Oracle Database 12c Enterprise Edition Release 12.1.0.2.0 - 64bit Production
With the Partitioning, OLAP, Advanced Analytics and Real Application Testing options
[oracle@cora1 ~]$ rm -rf /boostfs/cora1/BOOST/SNAPSHOT/TEST
[oracle@cora1 ~]$
```

Summary

Data Domain Boost provides simple, fast and efficient backups with source de-duplication and compression and is now available using a simple file system mount. Oracle Incremental Merge backups provide a forever incremental approach to creating full restore points using incremental backups. The BoostFS-based Oracle Incremental Merge backups discussed in this article provide a simple, fast and efficient backup for any large Oracle database. The solution can be deployed in private or public cloud using either physical or virtual Data Domain.

While this article provides an example of how BoostFS and OIM can be used with any large Oracle database, the use cases for BoostFS extend well beyond Oracle. BoostFS is capable of supporting simple, fast and efficient backup of any traditional or modern databases of the future, incorporating Data Domain Invulnerability Architecture and the many benefits of Data Domain.

References

Sample OIM scripts with BoostFS

A set of universal scripts to perform Oracle Incremental Merge has been made available in Github at the following location. The scrips are parameter driven (parameter file is 00_set_environment.inc) and can be used to back up and live mount Oracle databases.

https://github.com/ozprem/BoostFS_OIM

How to set up remote ssh to perform Data Domain fastcopy

<u>Set up Data Domain remote login for fastcopy via ssh</u>

```
Step 1: Open ssh to Data Domain and create a new data domain user (eg: fastcopy) with admin level
access

user add fastcopy password P@ssword123! role limited-admin force-password-change no
user password aging set fastcopy max-days-between-change 99999

Step 2: Login as oracle user on linux to enable remote access to Fastcopy user created above:

ssh-keygen -t ecdsa

NOTE: a new file gets created in /home/oracle/.ssh/id_ecdsa.pub

ssh fastcopy@ddt.local adminaccess add ssh-keys < /home/oracle/.ssh/id_ecdsa.pub
```