Oracle RMAN in Oracle Database 12c: New Features & Best Practices

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Agenda

- RMAN Through The Years
- What’s New in RMAN?
  - Fine-Grained Recovery: Table Recovery from Backup
  - Simplify Platform Migration: Cross-Platform Backup & Restore
  - Improved Performance: Faster Clone and Standby Database Creation
  - Multitenant Database: Pluggable Database Backup & Recovery
- State Street Case Study
- Summary / Q&A
RMAN..Through The Years
15+ Years of Innovation

- Parallel Backups
- DUPLICATE
- Block Media Recovery
- Automatic Control File & SPFILE Backup
- CONFIGURE Persistent Settings
- BACKUP BACKUPSET

- Fast Recovery Area
- Fast Incremental Backups
- Incrementally Updated Backups
- SWITCH TO COPY
- Offload Backups to Standby Database

- Table Recovery
- Cross-Platform Backup & Restore
- Fast Active DUPLICATE
- Fast Standby Database Synchronization
- Multitenant Database Backup & Recovery

Oracle8, Oracle8i, Oracle9i
Circa 1997-2002

Oracle 10g, Oracle 11g
Circa 2003-2012

Oracle Database 12c
June 2013
Table Recovery From Backup

Fine-Grained Recovery

- Simple `RECOVER TABLE` command to recover one or more tables/partitions (most recent or older version) from an RMAN backup
- Eliminates time and complexity associated with manual restore, recover & export
  - Enables fine-grained point-in-time recovery of individual tables/partitions instead of the contents of the entire tablespace
- Useful when there is insufficient `UNDO` to perform Flashback Table
Table Recovery: Under the Hood

- RMAN backups taken as normal using **DISK** and/or **SBT** channels.
- Upon **RECOVER TABLE**, an auxiliary instance is started using the primary control file, **SYSTEM, SYSAUX, UNDO**, and user tablespaces containing the table(s).
- Auxiliary instance is recovered to the desired time/SCN.
- Tables are imported by primary instance via SQL*Net.
Table Recovery Tips

- Database must be in ARCHIVELOG mode
- Determine if there are dependent tables that need to be included in the recovery, based on foreign key constraints.
- Ensure sufficient disk space on database server for auxiliary instance:
  - SUM [SYSTEM, SYSAUX, UNDO, SYSEXT (if present), User Tablespace(s) that contain table(s)]
- Ensure that at least one full backup has been taken of the above tablespaces, along with backup of all archived logs since that time.
Table Recovery Tips

- For recovering tables within a PDB, connect to CDB as ROOT user.
- If source table does not exist anymore (e.g. dropped), then table and all associated indexes, constraints, triggers will also be recovered.
- If source table exists, then table must be recovered with a new name (`REMAP TABLE`) or to a new tablespace (`REMAP TABLESPACE`).
  - Indexes, constraints, triggers will NOT be recovered in this case.
- To manage table import yourself, use:
  - `RECOVER TABLE .. NOTABLEIMPORT`  
    `DATAPUMP DESTINATION <dir> DATAPUMP FILE <filename>`
DEMO: Table Recovery from Backups
Cross-Platform Backup & Restore

Simplified Platform Migration

- Simplifies procedure for platform migration
- Minimize read-only impact using incremental-based approach
Cross-Platform Backup & Restore Example

AIX to Linux

- On destination Linux host:
  - Create ‘shell’ database (SYSTEM, SYSAUX, UNDO)

- On source AIX database:
  - ALTER TABLESPACE PROJECTS, TASKS READ ONLY;
  - SQL> EXECUTE DBMS_TTS.TRANSPORT_SET_CHECK(PROJECTS, TASKS, TRUE)
  - SQL> SELECT * FROM TRANSPORT_SET_VIOLATIONS;
    - Check that user tablespaces are self-contained
  - BACKUP FOR TRANSPORT
    FORMAT '/tmp/xplat_backups/trans_ts.bck'
    DATAPUMP FORMAT '/tmp/xplat_backups/trans_ts_dmp.bck'
    TABLESPACE PROJECTS, TASKS;
  - Copy all backups to destination server
Cross-Platform Backup & Restore Example

AIX to Linux (cont.)

- On destination Linux database:
  - Create tablespace users as they exist on source database
  - RESTORE FROM PLATFORM ‘AIX-Based Systems (64-bit)’ FOREIGN TABLESPACE PROJECTS, TASKS TO NEW FROM BACKUPSET '/tmp/xplat_restores/trans_ts.bck' DUMP FILE FROM BACKUPSET '/tmp/xplat_restores/trans_ts_dmp.bck';
  - Data file blocks automatically endian-converted during restore
  - Data Pump metadata dump file automatically imported to plug in user tablespaces
  - SQL> ALTER TABLESPACE PROJECTS, TASKS READ WRITE;
Minimize Read-Only Downtime on Source DB

How It Works

- Successive incrementals are converted & applied to restored data files, while tablespaces are in read-write.
- Final incremental is taken while tablespaces are in read-only, including backup of Data Pump metadata export.
- After final incremental is converted and applied to restored data files, then user tablespaces are plugged in.

Reduce downtime by **8X** versus traditional migration approaches

Oracle Database 10.2 and 11g Backups Can Be Restored & Recovered Cross-Platform to Oracle Database 12c
Minimize Read-Only Downtime Example
AIX to Linux using Incremental Backups

- On destination Linux host:
  - Create ‘shell’ database (SYSTEM, SYSAUX, UNDO)

- On source AIX database (while tablespaces are read-write):
  - Check that tablespaces are self-contained using DBMS_TTS.TRANSPORT_SET_CHECK
  - Day 1: BACKUP FOR TRANSPORT ALLOW INCONSISTENT
            INCREMENTAL LEVEL 0
            TABLESPACE PROJECTS, TASKS
            FORMAT '/tmp/xplat_backups/my_tbs_incon.bck';
  - Day 2..N: BACKUP FOR TRANSPORT ALLOW INCONSISTENT
               INCREMENTAL LEVEL 1
               TABLESPACE PROJECTS, TASKS
               FORMAT '/tmp/xplat_backups/my_tbs_incon1.bck';
  - Copy backups to destination server
  - Repeat INCREMENTAL LEVEL 1 backup + copy to destination server, as desired
Minimize Read-Only Downtime Example
AIX to Linux using Incremental Backups (cont.)

- On destination Linux database (in parallel with incremenitals taken on source):
  - `RESTORE FROM PLATFORM 'AIX-Based Systems (64-bit)'`  
    `FOREIGN DATAFILE`
    `6 FORMAT '/tmp/aux/projects_tbs_6.df'`,
    `10 FORMAT '/tmp/aux/tasks_tbs_10.df'`
    `FROM BACKUPSET '/tmp/xplat_restores/my_tbs_incon.bck'`;  
  - `DATAFILE <#>` is the `<#>` used in source AIX database  
  - `RECOVER FROM PLATFORM 'AIX-Based Systems (64-bit)'`  
    `FOREIGN DATAFILECOPY`
    `' /tmp/aux/projects_tbs_6.df',`
    `' /tmp/aux/tasks_tbs_10.df'`
    `FROM BACKUPSET '/tmp/xplat_restores/my_tbs_incon1.bck'`;  
  - Restores and converts incremental blocks, then applies blocks to the restored data files  
  - Run `RECOVER` command for each new incremental taken on source
Backup & Restore: Minimize Read-Only Impact

Example: AIX to Linux using Incremental Backups (cont.)

- On source AIX database:
  - Place user tablespaces in read-only mode, prior to final incremental and Data Pump dump file backups
  - `BACKUP FOR TRANSPORT INCREMENTAL LEVEL 1 TABLESPACE PROJECTS, TASKS FORMAT '/tmp/xplat_backups/my_tbs_ro_incr.bck'
    DATAPUMP FORMAT '/tmp/xplat_backups/my_tbs_dp.bck';`
  - Copy incremental and Data Pump metadata dump file backups to destination Linux host

- On destination Linux database:
  - `RECOVER FROM PLATFORM 'AIX-Based Systems (64-bit)'
    FOREIGN DATAFILECOPY
    '/tmp/aux/projects_tbs_6.df',
    '/tmp/aux/tasks_tbs_10.df'
    FROM BACKUPSET '/tmp/xplat_restores/my_tbs_ro_incr.bck';`
  - `RESTORE FROM PLATFORM 'AIX-Based Systems (64-bit)'
    DUMP FILE 'my_tbs_dp.dmp'
    DATAPUMP DESTINATION '/tmp/dump'
    FROM BACKUPSET '/tmp/xplat_restores/my_tbs_dp.bck';`
Backup & Restore: Minimize Read-Only Impact

Example: AIX to Linux using Incremental Backups (cont.)

- On destination Linux database:
  - Create tablespace users as they exist on source database
  - Run `CREATE DIRECTORY` to create `DP_DIR` directory object, mapped to dump file directory
    - `IMPDP DIRECTORY=DP_DIR`
      - `DUMPFILE=my_tbs_dp.dmp`
      - `TRANSPORT_DATAFILES='/tmp/aux/projects_tbs_6.df', '/tmp/aux/tasks_tbs_10.df'`
      - `NOLOGFILE=Y`
  - Import Data Pump metadata dump file to ‘plug in’ new user tablespaces
  - `SQL> ALTER TABLESPACE PROJECTS, TASKS READ WRITE;`
Active DUPLICATE

One-Command Database Cloning

- Active DUPLICATE debuted in Oracle Database 11g
  - Create clone or standby database as of the current time
  - Utilizes source (TARGET) database channels to copy data files and archived logs to clone (AUXILIARY) database server – eliminates backup staging area
  - Performance typically gated by network bandwidth
Oracle Database 12c Active DUPLICATE
Improved Performance via Reduced Network Consumption

- New Active DUPLICATE
  - Utilizes clone database channels to pull (i.e. restore) data files and archived logs from source database
  - Configure or allocate AUXILIARY channels >= TARGET channels
  - Data files are packaged as backup sets – much smaller than copies
    - RMAN compression and multi-section settings can also be specified

![Diagram showing the process of restoring a clone database from a source database](image-url)
Fast Standby Database Synchronization

Simplified Standby Sync-Up with Primary Database

- **RECOVER DATABASE FROM SERVICE <PRIMARY DB SID>**
  - Run command connected to standby database as TARGET and primary as AUXILIARY
  - Generates incremental backup on primary as of the current SCN on standby database
  - Incremental backup pulled from primary & applied on standby data files to sync up changes
  - Refer to documentation for full procedure details:
    - [http://docs.oracle.com/cd/E16655_01/backup.121/e17630/rcmadvre.htm#sthref1772](http://docs.oracle.com/cd/E16655_01/backup.121/e17630/rcmadvre.htm#sthref1772)
Multitenant Database Backup & Restore

• New **PLUGGABLE DATABASE** and **ROOT** keywords

• Connect in RMAN as:
  • ROOT common user: Backup, Restore, Recover CDB or selected PDBs
  • PDB local user: Backup & Restore PDB (excludes archived logs)

• Backup commands as ROOT user:

  RMAN> BACKUP DATABASE; -- Backup CDB, including all PDBs
  RMAN> BACKUP (PLUGGABLE DATABASE <PDB1>, <PDB2>);
  RMAN> BACKUP TABLESPACE <PDB1>:<TBS1>, <PDB2>:<TBS1>;

• Restore commands as ROOT user:

  RMAN> RESTORE DATABASE; -- Restore CDB, including all PDBs
  RMAN> RESTORE DATABASE ROOT; -- Restore ROOT data files
  RMAN> RESTORE PLUGGABLE DATABASE <PDB1>;
  RMAN> restore TABLESPACE <PDB2>:<TBS1>;
Multitenant Database Recovery (ROOT user)

- CDB Complete Recovery (Root + All PDBs)
  ```sql
  RMAN> RECOVER DATABASE;
  ```

- CDB Point-in-Time Recovery (Root + All PDBs)
  ```sql
  RMAN> RUN {
      SET UNTIL <TIME/SCN> <xxx>;
      RESTORE DATABASE;
      RECOVER DATABASE;
      ALTER DATABASE OPEN RESETLOGS;
  }
  ```

- PDB Complete and Point-in-Time Recovery
  ```sql
  RMAN> RUN {
      SET UNTIL <TIME/SCN> <yyy>;
      RESTORE PLUGGABLE DATABASE <PDB>;
      RECOVER PLUGGABLE DATABASE <PDB>;
      ALTER PLUGGABLE DATABASE <PDB> OPEN RESETLOGS;
  }
  ```
DEMO:
Pluggable Database
Point-in-Time Recovery
Additional New Features

- **Expanded Multisection Backup Support**
  - Multisection (`BACKUP .. SECTION SIZE`) debuted for full backups in Oracle Database 11g
  - Divides large data files into smaller sections that are backed up in parallel
  - Now supported for incremental backups and image copies
  - Incremental backup for each data file is divided into sections & backed up in parallel
  - For image copies, sections are backed up in parallel & recomposed at the end

- **Enhanced Separation of Duty**
  - New `SYSBACKUP` privilege only authorizes RMAN operations
    - `RMAN TARGET '<USER>/<PWD>' @<SID> AS SYSBACKUP`
The Oracle Database Backup Logging
Recovery Appliance

- Leverages your existing RMAN skill set for centralized, consolidated data protection of your entire Oracle database enterprise. More info at:
  - [www.oracle.com/databasebackupappliance](http://www.oracle.com/databasebackupappliance)
State Street Case Study
Oracle OpenWorld 2013

September 23, 2013
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Agenda

- State Street Company Overview
- Exadata Environment
- RMAN 11g Features Used
- ZFS with Direct NFS
- RMAN 12c Excitement
Our History

Culture of Innovation – Proven Track Record

Businesses

1970s
- State Street Global Advisors
- Formed Transfer Agency JV (BFDS)
- Global Link
- Multicurrency Horizon Platform
- Acquisition: Princeton Financial Systems

1980s
- Fund Administration Business
- SPDR ETF
- FX Connect first trade
- Advanced Research Center
- State Street Global Alliance
- State Street China Technology
- Acquisition: IFS

1990s
- IM Operations Outsourcing
- Global Trustee Business
- State Street Associates
- State Street Global Alliance Center
- Acquisition: Deutsche Bank’s GSS Business
- First International Real Estate ETF
- First China ETF
- My.statestreet.com
- First Gold ETF
- Investor Confidence Index

2000s
- Alpha Strategies
- LDI Strategies
- First International Real Estate ETF
- Real Estate ETF
- Alpha Strategies
- Asset Managers
- First Gold ETF
- My.statestreet.com
- Springboard Mobile App
- Collateral Tracking Service
- Strategic Alliance: InfraHedge
- Servicing
- SSIA Dashboard
- Acquisition: Investors Financial Services Corp
- Acquisition: Currenex
- Acquisition: Palmeri
- Acquisition: IFS
- Acquisition: Deutsche Bank’s GSS Business

2010s
- Acquisition: Intesa Sanpaolo securities services business
- Acquisition: Bank of Ireland Asset Management
- Acquisition: Goldman Sachs Administration Services
- Acquisition: Complementa and Pulse Trading
- Strategic Alliance: InfraHedge
- Servicing
- SSIA Dashboard
- SwapEx
- TotalETF
- Springboard Mobile App
- UCITS IV KIIID Servicing
- Collateral Tracking Service
- Derivatives Clearing Solution
- Acquisition: Bank of Ireland Asset Management
- Acquisition: Goldman Sachs Administration Services
- Acquisition: Complementa and Pulse Trading
- Strategic Alliance: InfraHedge
- Servicing
- SSIA Dashboard
- SwapEx
- TotalETF
- Springboard Mobile App
- UCITS IV KIIID Servicing
- Collateral Tracking Service
- Derivatives Clearing Solution

Products / Services

State Street Corporation
Our Company Today
Strong Global Enterprise

**STATE STREET.**
**STATE STREET GLOBAL ADVISORS.**
Developing investment strategies that make the best use of client capital
- Assets under management of $2.1 trillion*
- One of the world’s largest managers of institutional assets
- Provider of a comprehensive range of investment strategies that span the risk/return spectrum
- With approximately $340 billion* in ETF assets under management, we have one of the broadest ranges of ETFs in the industry

**STATE STREET GLOBAL MARKETS.**
Research and trading solutions that improve the efficient use of client capital
- Global leader in investment research, trading and securities lending
- Total of approximately $2.5 trillion in average lendable assets for Q4 2012
- $16.8 trillion in foreign exchange and interbank volume traded in 2012
- Source of investor behavior and other research, advanced portfolio strategies, trade process optimization and global connectivity across multiple asset classes and markets

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- Assets under custody and administration of $24.4 trillion*
- One of the world’s leading investment service providers
- Provides fund accounting, fund administration, custody, investment operations outsourcing, recordkeeping, performance and analytics, and transfer agency services

* As of December 31, 2012

*State Street Corporation*
Our Company Today

29,660 employees worldwide

AUSTRALIA
Sydney
AUSTRIA
Vienna
BELGIUM
Brussels
La Hulpe
BRUNEI DARUSSALAM
Jerudong
CANADA
Montreal
Toronto
Vancouver
CHANNEL ISLANDS
Guernsey
Jersey
FRANCE
Paris
GERMANY
Cologne
Frankfurt
Munich
Bangalore
Mumbai
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IRELAND
Drogheda
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Naas
Milan
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JAPAN
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LIECHTENSTEIN
Vaduz
LUXEMBOURG
Luxembourg
MALAYSIA
Kuala Lumpur
MAURITIUS
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NETHERLANDS
Amsterdam
PEOPLE’S REPUBLIC OF CHINA
Beijing
Hangzhou
Hong Kong
Shanghai
Krakow
QATAR
Doha
SINGAPORE
Singapore
SOUTH AFRICA
Cape Town
SOUTH KOREA
Seoul
SWITZERLAND
Altishofen
St. Gallen
Zurich
TAIWAN
Taipei City
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ARAB EMIRATES
Dubai
UNITED KINGDOM
Edinburgh
London
Windsor
UNITED STATES
California
Connecticut
Florida
Georgia
Massachusetts
Missouri
New Hampshire
New Jersey
New York
Oregon
Pennsylvania
Texas

* As of December 31, 2012
Exadata Environment Components

• Exadata X2-2/X3-2 also utilizing multi-racking
  – 12 full rack and 1 half rack used with multi-racking
  – Largest database 28TB, with most in 4-10TB range and some in 500GB to 2TB range
  – All running Oracle Database 11.2.0.3

• ZFS 7420 (2 write heads) for RMAN backups
  – 2 Exadatas share a ZFS
  – Golden Gate trail files also stored on ZFS
  – TSM RMAN Proxy Copy used to copy ZFS backups to tape for long term retention needs

• ASR (Hardware failures via Automatic Service Request creation)
• Golden Gate for data replication
• Oracle Enterprise Manager 12c
  – SNMP traps to Netcool -> Remedy
  – ZFS Plugin for OEM12c
Exadata

Oracle Net services client access

Node 1

Instance 1
App Schema1
App Schema2

ASM
OEL

Node 2

Instance 2
App Schema1

ASM
OEL

Node n

Instance n
App Schema3

ASM
OEL

Oracle Net services client access

Query Offloading capability to Cell Server

InfiniBand Switch / Network

Exadata Storage

Oracle Database

Cell Server

Smart Scan capability

Flash Cache

IORM (IO Resource Manager)

Automatic Storage Management

Oracle Enterprise Linux

Flash Cache

IORM (IO Resource Manager)

Exadata Storage

Smart Scan capability
RMAN 11g Features Used at State Street

• **Compression using ZLIB**
  – `RMAN> CONFIGURE COMPRESSION ALGORITHM 'ZLIB';`
  – Typical compression ratios of at least 25%
  – Requires Advanced Compression Option

• **Parallel backup of the same data file**
  – In Oracle Database 11g RMAN, channels can break data files into chunks known as ‘sections’.
    • `BACKUP INCREMENTAL LEVEL 0 DATABASE .. SECTION SIZE <x>`
  – Our setup is on Exadata using ASM.
  – On traditional systems, if the data file resides on a single disk, there is no advantage to using parallel backups within the data file.

• **DUPLICATE database from backup**
  – Used for creating standby and non-production testing environments
  – RMAN enhances DUPLICATE so that a connection to the source database is no longer required
    • Eliminates RMAN session dependency on WAN network connection back to source when creating new standby databases.
  – In an event of a failure during DUPLICATE, RMAN identifies the failure point and resumes from that point the next time DUPLICATE is run.

• **Backup Strategy**
  – Weekly Full and Daily Incremental Backups
RMAN 11g Features Used at State Street

• “Oops”..dropped a tablespace
  – With RMAN 11g, recovery of a tablespace has been further simplified
  – Once completed, tablespace will be offline so only thing left to do is:
    - SQL> ALTER TABLESPACE TS_NAME ONLINE;

• Archived Log Deletion Policy Enhancements
  – Used to ensure log shipment for the Active Data Guard environment is completed prior to deletion of archived logs via RMAN on primary database.
  – `CONFIGURE ARCHIVELOG DELETION POLICY
    {CLEAR |
    TO {APPLIED ON [ALL] STANDBY |
    BACKED UP integer TIMES TO DEVICE TYPE deviceSpecifier |
    NONE |
    SHIPPED TO [ALL] STANDBY}`
RMAN Backups Utilizing ZFS and Direct NFS

• **RMAN / ZFS / DNFS**
  - Performance boost for backups using out of the box ZFS setup
  - CPU reduction on compute nodes using out of the box ZFS setup
    - Direct NFS Client is capable of performing concurrent direct I/O, which bypasses any operating system level caches and eliminates any operating system write-ordering locks.
    - Direct NFS Client performs asynchronous I/O, which allows processing to continue while the I/O request is submitted and processed.
  - **DNFS Setup**
    - To enable Direct NFS Client, you must replace the standard Oracle Disk Manager (ODM) library with one that supports Direct NFS Client while the DB is down.
      - **Exadata_Host**
        - `cd $ORACLE_HOME/lib`
        - `cp libodm11.so libodm11.so_stub`
        - `ln -s libnfsodm11.so libodm11.so`
    - Validation/Management via views
      - (v$dnfs_servers, v$dnfs_stats, v$dnfs_channels)
Future Promising Technologies

• RMAN 12c Excitement
  – Taking Exports on large databases is time consuming - there have been certain situations in the past where an export would make sense, but was not desirable.
  – Of the several great 12c features presented, the one we’re most excited about is table recovery.
    • On our Exadata platforms, we do not perform exports - only RMAN backups - and these can now be used to perform any type of recovery per our requirements.
Thank You !!

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Summary / Q&A

Oracle Database 12c RMAN Continues the Innovation..

- Fine-Grained Recovery: Table Recovery from Backup
- Simplify Platform Migration: Cross-Platform Backup and Restore
- Improved Performance:
  - Fast Clone and Standby Database Creation
  - Fast Synchronization of Standby Database
- Multitenant Database: Pluggable Database Backup and Recovery
- More Efficient Backups: Multisection Incrementals and Image Copies
- Enhanced Separation of Duty: SYSBACKUP Privilege
Resources

- **OTN HA Portal:**
  http://www.oracle.com/goto/availability

- **Maximum Availability Architecture (MAA):**
  http://www.oracle.com/goto/maa

- **MAA Blogs:**
  http://blogs.oracle.com/maa

- **Exadata on OTN:**

- **Oracle HA Customer Success Stories on OTN:**
Hardware and Software
Engineered to Work Together