# 1 RMAN概述

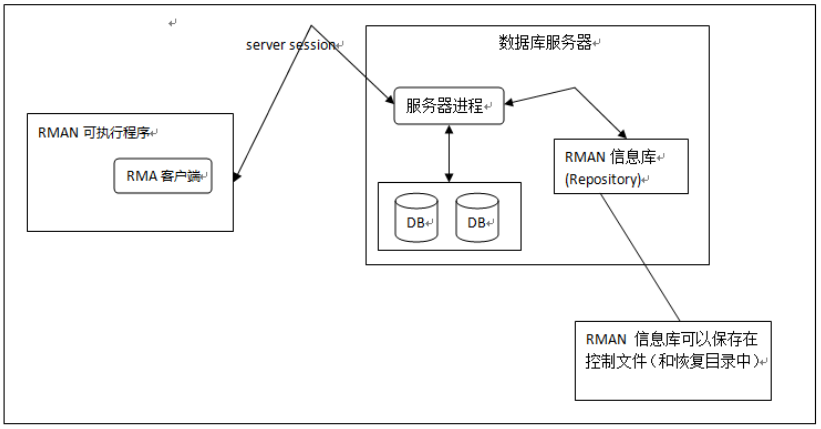
RMAN是指Oracle提供的Recovery Manager，即恢复管理器，是一个更加智能和自动化的备份和恢复管理器。RAMN在数据库服务器的帮助下实现 数据库文件、控制文件、数据库文件和控制文件的映像副本，以及归档日志文件，数据库服务器参数文件的备份。RMAN也允许使用脚本文件实现数据的备份和恢复，而且这些脚本保存在数据库中。

## 1.1 系统架构详解

Oracle的RMAN工具使用会话建立客户端到数据库服务器的连接，用户首先需要启动RMAN可执行程序，然后建立客户端与服务器端的会话连接，用户通过RMAN的客户端进行RMAN操作，执行备份和恢复指令，这些指令在服务器端的服务器进程中执行，而服务器完成实际的磁盘读写操作。

RMAN的系统组成：

- RMAN可执行程序：是一个客户端工具，用来启动与数据库服务器的连接，从而实现备份与恢复的各种操作；
- RMAN客户端：一旦建立了与数据库服务器的会话连接，RMAN可执行程序就创建了一个客户端，通过客户端完成与数据库服务器之间的通信，完成各种备份与恢复操作的指令。RMAN客户端可以连接通过ORACLE NET连接到可访问的任何主机上。
- 服务器进程：在RMAN建立了与数据库服务器的会话连接后，在数据库服务器端启动一个后台进程，它执行RMAN客户端发出的各种数据恢复与备份指令，并完成实际的磁盘或磁带设备的读写任务。
- RMAN信息库：RMAN信息库记录了RMAN的一些信息，如备份的数据文件及副本的目录，归档的重做日志备份文件和副本，表空间和数据文件以及备份或恢复的脚本和RMAN的配置信息。默认使用数据库服务器的控制文件记录这些信息，可以通过转储的控制文件发现这些信息，如使用ALTER DATABASE BACKUP CONTROLFILE TO TRACE。
- 恢复目录：记录RMAN信息库的信息。恢复目录需要提前配置，信息库既可以存储在数据库的控制文件中，也可以存储在恢复目录中。在Oracle中默认先将RMAN信息库写入控制文件，如果存在恢复目录，则需要继续写到恢复目录。使用控制文件的不足时控制文件中记录RMAN信息库的空间有限，当空间不足时可能被覆盖，所以Oracle建议创建单独的恢复目录，这也可以更好的发挥RMAN提供的新特性。




RMAN的系统结构构成

> 上图给出了RMAN的系统结构图，其实也可以理解为一个备份或恢复过程的信息流示意图。RMAN可执行程序启动并建立与数据库服务器的会话连接，客户端发出备份指令，而数据库服务器端的服务器后台进程执行指令完成磁盘读写操作，并将备份信息记录在RMAN信息库中，RMAN信息库可以保持在数据库服务器端的控制文件中，如果使用恢复目录，RMAN信息库同样会自动保存在恢复目录中，实际上发送到RMAN恢复目录的元数据是从控制文件同步来的。

## 1.2 快速恢复区

### 1.2.1 快速恢复区介绍

快速恢复区是存储与备份和恢复数据文件以及相关信息的存储区。快速恢复区保存了每个数据文件的备份、增量备份、控制文件备份以及归档重做日志备份，Oracle也允许在快速恢复区中保存联机重做日志的冗余副本以及当前控制文件的冗余副本，还有，Oracle中闪回特性中的闪回日志也保存在快速恢复区中。

在使用RMAN实现数据库的备份与恢复时，配置的快速恢复区就是RMAN存储所有与备份相关的文件存储区，而此时的文件名不需要用户干预，Oracle使用OMF创建备份文件的文件名，文件名格式可以指定。

使用快速恢复区的优点是，实现了备份文件的自动管理，使得备份与恢复数据库更简单，并且几种管理磁盘空间。要求恢复区的空间足够大，以容纳备份的数据。

#### 1.2.2 快速恢复区设置

设置的参数分别为：db_recovery_file_dest和db_recovery_file_dest_size：

```
SQL> show parameter db_recover

NAME                                 TYPE        VALUE
------------------------------------ ----------- ------------------------------
db_recovery_file_dest                string      /u01/app/oracle/fast_recovery_
                                                 area/orcl
db_recovery_file_dest_size           big integer 8016M
SQL> select * FROM v$recovery_file_dest;

NAME                                 SPACE_LIMIT SPACE_USED SPACE_RECLAIMABLE NUMBER_OF_FILES     CON_ID
------------------------------------ ----------- ---------- ----------------- --------------- ----------
/u01/app/oracle/fast_recovery_area/orcl   8405385216          0             0               0          0
```

#### 1.2.3 解决快速恢复区空间不足

查看快闪恢复区的使用情况，使用：

```
SQL> select * FROM v$recovery_area_usage;

FILE_TYPE               PERCENT_SPACE_USED PERCENT_SPACE_RECLAIMABLE NUMBER_OF_FILES       CON_ID
----------------------- ------------------ ------------------------- --------------- ----------
CONTROL FILE                            0                         0               0          0
REDO LOG                                0                         0               0          0
ARCHIVED LOG                            0                         0               0          0
BACKUP PIECE                            0                         0               0          0
IMAGE COPY                              0                         0               0          0
FLASHBACK LOG                           0                         0               0          0
FOREIGN ARCHIVED LOG                    0                         0               0          0
AUXILIARY DATAFILE COPY                 0                         0               0          0

8 rows selected.
```

解决快速恢复区空间不足有三种方法，分别为：

- 增加磁盘空间；
- 使用crosscheck和delete obsolete指令删除不需要的文件，或者使用delete expire删除不需要的备份文件；
- 删除当前快闪恢复区，重新设置；

### 1.3 建立RMAN和数据库的连接

#### 1.3.1 使用数据库用户名和密码连接RMAN

```
[oracle@strong ~]$ rman target sys/system@orcl
```

Recovery Manager: Release 12.2.0.1.0 - Production on Wed Aug 1 14:07:46 2018

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connected to target database: ORCL (DBID=1510722265)

RMAN>

#### 1.3.2 使用操作系统认证连接RMAN

[oracle@strong ~]$ rman target /

Recovery Manager: Release 12.2.0.1.0 - Production on Wed Aug 1 14:08:37 2018

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connected to target database: ORCL (DBID=1510722265)

RMAN>

## 1.4 RMAN参数配置

#### 1.4.1 默认参数

RMAN> show all;

using target database control file instead of recovery catalog
RMAN configuration parameters for database with db_unique_name ORCL are:
#指定是否启用备份冗余策略
CONFIGURE RETENTION POLICY TO REDUNDANCY 1; # default
#指定是否启用备份优化策略
CONFIGURE BACKUP OPTIMIZATION OFF; # default
#指定默认备份到磁盘或磁带
CONFIGURE DEFAULT DEVICE TYPE TO DISK; # default
#是否在每次备份后自动备份控制文件，自动备份控制文件的同时也会备份参数文件
CONFIGURE CONTROLFILE AUTOBACKUP ON; # default
#指定控制文件备份的路径和格式，默认路径为$ORACLE_HOME/dbs
CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO '%F'; # default
#指定磁盘备份类型对应的并行度
CONFIGURE DEVICE TYPE DISK PARALLELISM 1 BACKUP TYPE TO BACKUPSET; # default
#指定数据文件备份拷贝到磁盘的个数
CONFIGURE DATAFILE BACKUP COPIES FOR DEVICE TYPE DISK TO 1; # default
#指定归档备份拷贝到磁盘的个数
CONFIGURE ARCHIVELOG BACKUP COPIES FOR DEVICE TYPE DISK TO 1; # default
#指定最大备份集大小
CONFIGURE MAXSETSIZE TO UNLIMITED; # default
#数据库加密开关
CONFIGURE ENCRYPTION FOR DATABASE OFF; # default
#数据库加密算法
CONFIGURE ENCRYPTION ALGORITHM 'AES128'; # default
#压缩算法
CONFIGURE COMPRESSION ALGORITHM 'BASIC' AS OF RELEASE 'DEFAULT' OPTIMIZE FOR LOAD TRUE ; # default

CONFIGURE RMAN OUTPUT TO KEEP FOR 7 DAYS; # default
#配置归档日志删除策略
CONFIGURE ARCHIVELOG DELETION POLICY TO NONE; # default
#配置控制文件快照
CONFIGURE SNAPSHOT CONTROLFILE NAME TO '/u01/app/oracle/product/12.2.0/dbhome_1/dbs/snapcf_orcl.f'; # default

#### 1.4.2 参数修改

- CONFIGURE RETENTION POLICY TO REDUNDANCY 1

该参数说明保留备份的副本数量，如果每天都备份一个数据文件，上述参数说明只保留一个该数据文件的副本，并且保留最新的备份副本；
configure retention policy to recovery window of 7 days;

- CONFIGURE DEFAULT DEVICE TYPE TO DISK;

该配置参数说明备份的数据文件默认备份到数据库服务器的磁盘上，该参数可以更改为备份到磁带上，如：
RMAN> configure default device type to sbt;

new RMAN configuration parameters:
CONFIGURE DEFAULT DEVICE TYPE TO 'SBT_TAPE';
new RMAN configuration parameters are successfully stored

RMAN> configure default device type clear;

old RMAN configuration parameters:
CONFIGURE DEFAULT DEVICE TYPE TO 'SBT_TAPE';
RMAN configuration parameters are successfully reset to default value

- CONFIGURE BACKUP OPTIMIZATION OFF;

配置备份优化，默认不使用备份优化，使用备份优化的作用是如果已经备份了某个文件的相同版本，则不会再备份该文件，即只保留一份备份文件；

- CONFIGURE CONTROLFILE AUTOBACKUP ON;

配置默认启动控制文件的自动备份；如果数据库结构发生变化或者是在备份数据库过程中，控制文件会自动备份到指定的目录下；

- CONFIGURE DEVICE TYPE DISK PARALLELISM 1 BACKUP TYPE TO BACKUPSET;

该参数说明RMAN在备份和恢复中的并行度，在执行备份或恢复时，通道数量越多，则任务执行时间越短，备份文件类型为备份集，当然备份文件类型也可以是映像副本（COPY），修改并行数以及备份文件类型的指令如下：
RMAN> CONFIGURE DEVICE TYPE DISK PARALLELISM 3 BACKUP TYPE TO BACKUPSET;

# 2 RMAN备份控制文件

RMAN可单独备份控制文件，如果没有启用快闪恢复区则使用Format参数指定控制文件的备份目录，如果启用了快闪恢复区，RMAN会自动将控制文件复制到快闪恢复区的备份集中。

## 2.1 没有启用快闪恢复区时备份控制文件

RMAN> backup current controlfile format '/home/oracle/rman/ctl_%u.dbf';

Starting backup at 01-AUG-18
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=63 device type=DISK
channel ORA_DISK_1: starting full datafile backup set
channel ORA_DISK_1: specifying datafile(s) in backup set
including current control file in backup set
channel ORA_DISK_1: starting piece 1 at 01-AUG-18

```
channel ORA_DISK_1: finished piece 1 at 01-AUG-18
piece handle=/home/oracle/rman/ctl_01t9fgrp.dbf tag=TAG20180801T142145 comment=NONE
channel ORA_DISK_1: backup set complete, elapsed time: 00:00:03
Finished backup at 01-AUG-18

Starting Control File and SPFILE Autobackup at 01-AUG-18
piece handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/autobackup/2018_08_01/o1_mf_s_983024513_fp2nd26k_.bkp
comment=NONE
Finished Control File and SPFILE Autobackup at 01-AUG-18
```

## 2.2 启用快闪恢复区时备份控制文件

```
RMAN> backup current controlfile;

Starting backup at 01-AUG-18
using channel ORA_DISK_1
channel ORA_DISK_1: starting full datafile backup set
channel ORA_DISK_1: specifying datafile(s) in backup set
including current control file in backup set
channel ORA_DISK_1: starting piece 1 at 01-AUG-18
channel ORA_DISK_1: finished piece 1 at 01-AUG-18
piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_ncnnf_TAG20180801T142315_fp2ngnk3_.
 tag=TAG20180801T142315 comment=NONE
channel ORA_DISK_1: backup set complete, elapsed time: 00:00:03
Finished backup at 01-AUG-18

Starting Control File and SPFILE Autobackup at 01-AUG-18
piece handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/autobackup/2018_08_01/o1_mf_s_983024600_fp2ngroh_.bkp
comment=NONE
Finished Control File and SPFILE Autobackup at 01-AUG-18
```

使用快闪恢复区的好处就是Oracle自动管理文件的备份目录，文件命名使用OMF，DBA也不需要记住这个目录，在恢复时同样不需要记住该目录，RMAN将使用RMAN信息库记录的信息找到备份的文件集。

## 2.3 设置控制文件自动备份

控制文件记录了数据库的物理文件组成等重要信息，一旦数据库结构发生变化（如创建新表空间），控制文件就会更新，此时最好备份该数据文件。Oracle的RMAN支持控制文件的自动备份，使得在数据库结构发生变化或控制文件更新时自动备份控制文件，在执行BACKUP备份数据库时也会在备份的最后阶段备份控制文件。

### 2.3.1 设置自动备份

```
RMAN> CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO '/u01/backup/%F';

new RMAN configuration parameters:
CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO '/u01/backup/%F';
new RMAN configuration parameters are successfully stored
```

### 2.3.2 测试自动备份

```
SQL> create tablespace ts_ctl datafile '/u01/app/oracle/oradata/orcl/tsctl_01.dbf' size 50M;
```

Tablespace created.

SQL> host ls -lh /u01/backup/

# 3 RMAN脱机备份

要实现脱机备份首先需要使用RMAN登录到数据库服务器，关闭数据库然后启动数据库到Mount状态，再执行BACKUP DATABASE命令备份整个数据库。

## 3.1 备份整个数据库

[oracle@strong ~]$ rman target /

Recovery Manager: Release 12.2.0.1.0 - Production on Wed Aug 1 14:33:03 2018



connected to target database: ORCL (DBID=1510722265)

RMAN> shutdown immediate

using target database control file instead of recovery catalog
database closed
database dismounted
Oracle instance shut down

RMAN> startup mount

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

Total System Global Area     788529152 bytes

Fixed Size                  8625656 bytes
Variable Size             566231560 bytes
Database Buffers          209715200 bytes
Redo Buffers                3956736 bytes

RMAN> backup database;

Starting backup at 2018-08-01 14:34:19
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=36 device type=DISK
channel ORA_DISK_1: starting full datafile backup set
channel ORA_DISK_1: specifying datafile(s) in backup set
input datafile file number=00001 name=/u01/app/oracle/oradata/orcl/system01.dbf
input datafile file number=00003 name=/u01/app/oracle/oradata/orcl/sysaux01.dbf
input datafile file number=00004 name=/u01/app/oracle/oradata/orcl/undotbs01.dbf
input datafile file number=00005 name=/u01/app/oracle/oradata/orcl/tsctl_01.dbf

input datafile file number=00007 name=/u01/app/oracle/oradata/orcl/users01.dbf
channel ORA_DISK_1: starting piece 1 at 2018-08-01 14:34:20
channel ORA_DISK_1: finished piece 1 at 2018-08-01 14:38:04
piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T143420_fp2o3f7f_b
tag=TAG20180801T143420 comment=NONE
channel ORA_DISK_1: backup set complete, elapsed time: 00:03:45
Finished backup at 2018-08-01 14:38:05

Starting Control File and SPFILE Autobackup at 2018-08-01 14:38:05
piece handle=/u01/backup/c-1510722265-20180801-02 comment=NONE
Finished Control File and SPFILE Autobackup at 2018-08-01 14:38:09

### 3.2 打开数据库

RMAN> alter database open;

Statement processed

# 4 RMAN联机备份

### 4.1 联机备份准备

在进行联机备份前都要求将数据库置于归档模式，因为处于联机备份的数据库中要备份的所有数据文件头中的SCN被锁定，但是此时在数据库中的数据文件的表依然可以被访问，并执行DML操作，但是这些修改的数据不能写入数据文件，重做日志进程将这些变化的数据全部写到重做日志文件，如果备份时间很长，而且在这期间产生了大量的变化数据，重做日志会切换从而将这些变化的数据写到归档日志中。

查看数据库运行模式：

SQL> archive log list
Database log mode Archive Mode
Automatic archival Enabled
Archive destination USE_DB_RECOVERY_FILE_DEST
Oldest online log sequence 2
Next log sequence to archive 4
Current log sequence 4

### 4.2 联机备份整库

[oracle@strong ~]$ rman target /

Recovery Manager: Release 12.2.0.1.0 - Production on Wed Aug 1 14:45:54 2018



connected to target database: ORCL (DBID=1510722265)

RMAN> backup database plus archivelog delete all input;

Starting backup at 2018-08-01 14:46:12

current log archived
using target database control file instead of recovery catalog
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=58 device type=DISK
channel ORA_DISK_1: starting archived log backup set
channel ORA_DISK_1: specifying archived log(s) in backup set
input archived log thread=1 sequence=4 RECID=1 STAMP=983025999
channel ORA_DISK_1: starting piece 1 at 2018-08-01 14:46:47
channel ORA_DISK_1: finished piece 1 at 2018-08-01 14:47:16
piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_annnn_TAG20180801T144646_fp2otql1_.l
tag=TAG20180801T144646 comment=NONE
channel ORA_DISK_1: backup set complete, elapsed time: 00:00:30
channel ORA_DISK_1: deleting archived log(s)
archived log file name=/u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_4_fp2osnvo_.arc
RECID=1 STAMP=983025999
Finished backup at 2018-08-01 14:47:18

> 以上部分备份了归档日志文件，并在备份完成后删除归档目录下的相应归档文件。

Starting backup at 2018-08-01 14:47:18
using channel ORA_DISK_1
channel ORA_DISK_1: starting full datafile backup set
channel ORA_DISK_1: specifying datafile(s) in backup set
input datafile file number=00001 name=/u01/app/oracle/oradata/orcl/system01.dbf
input datafile file number=00003 name=/u01/app/oracle/oradata/orcl/sysaux01.dbf
input datafile file number=00004 name=/u01/app/oracle/oradata/orcl/undotbs01.dbf
input datafile file number=00005 name=/u01/app/oracle/oradata/orcl/tsctl_01.dbf
input datafile file number=00007 name=/u01/app/oracle/oradata/orcl/users01.dbf
channel ORA_DISK_1: starting piece 1 at 2018-08-01 14:47:19
channel ORA_DISK_1: finished piece 1 at 2018-08-01 14:52:02
piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T144719_fp2ovrtq_.b
tag=TAG20180801T144719 comment=NONE
channel ORA_DISK_1: backup set complete, elapsed time: 00:04:43
Finished backup at 2018-08-01 14:52:02

> 在上述备份完成后，Oracle会自动发生一次日志切换，继续备份剩余的归档日志。

Starting backup at 2018-08-01 14:52:03
current log archived
using channel ORA_DISK_1
channel ORA_DISK_1: starting archived log backup set
channel ORA_DISK_1: specifying archived log(s) in backup set
input archived log thread=1 sequence=5 RECID=2 STAMP=983026323
channel ORA_DISK_1: starting piece 1 at 2018-08-01 14:52:04
channel ORA_DISK_1: finished piece 1 at 2018-08-01 14:52:06
piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_annnn_TAG20180801T145204_fp2p4o0j_.
tag=TAG20180801T145204 comment=NONE
channel ORA_DISK_1: backup set complete, elapsed time: 00:00:02
channel ORA_DISK_1: deleting archived log(s)
archived log file name=/u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_5_fp2p4mqb_.arc
RECID=2 STAMP=983026323
Finished backup at 2018-08-01 14:52:06

> 启动控制文件和服务器参数文件的自动备份。

Starting Control File and SPFILE Autobackup at 2018-08-01 14:52:06

```
piece handle=/u01/backup/c-1510722265-20180801-03 comment=NONE
Finished Control File and SPFILE Autobackup at 2018-08-01 14:52:10
```

**说明：**在备份整个数据库时，其实就是备份了数据文件，其中包含了当前的控制文件和参数文件。而重做日志文件或归档日志文件不是联机状态数据库全备份的内容，所以使用联机备份的数据库在数据库恢复时需要recover数据库，即将联机备份开始到故障点之间的所有提交的数据重新写入数据文件。

在联机备份时，可手工指定多个通道，如下：

```
RMAN> run{
2> allocate channel ch1 device type disk;
3> allocate channel ch2 device type disk;
4> backup format '/u01/backup/CH_%U.dbf' (datafile 1,3,4 channel ch1) (datafile 5,7 channel ch2);
5> sql 'alter system archive log current';
6> }

released channel: ORA_DISK_1
allocated channel: ch1
channel ch1: SID=58 device type=DISK

allocated channel: ch2
channel ch2: SID=50 device type=DISK

Starting backup at 2018-08-01 14:59:12
channel ch1: starting full datafile backup set
channel ch1: specifying datafile(s) in backup set
input datafile file number=00001 name=/u01/app/oracle/oradata/orcl/system01.dbf
input datafile file number=00003 name=/u01/app/oracle/oradata/orcl/sysaux01.dbf
input datafile file number=00004 name=/u01/app/oracle/oradata/orcl/undotbs01.dbf
channel ch1: starting piece 1 at 2018-08-01 14:59:13
channel ch2: starting full datafile backup set
channel ch2: specifying datafile(s) in backup set
input datafile file number=00005 name=/u01/app/oracle/oradata/orcl/tsctl_01.dbf
input datafile file number=00007 name=/u01/app/oracle/oradata/orcl/users01.dbf
channel ch2: starting piece 1 at 2018-08-01 14:59:13
channel ch2: finished piece 1 at 2018-08-01 14:59:17
piece handle=/u01/backup/CH_0ct9fj21_1_1.dbf tag=TAG20180801T145912 comment=NONE
channel ch2: backup set complete, elapsed time: 00:00:04
channel ch1: finished piece 1 at 2018-08-01 15:04:39
piece handle=/u01/backup/CH_0bt9fj21_1_1.dbf tag=TAG20180801T145912 comment=NONE
channel ch1: backup set complete, elapsed time: 00:05:26
Finished backup at 2018-08-01 15:04:39

Starting Control File and SPFILE Autobackup at 2018-08-01 15:04:39
piece handle=/u01/backup/c-1510722265-20180801-04 comment=NONE
Finished Control File and SPFILE Autobackup at 2018-08-01 15:04:43

sql statement: alter system archive log current
released channel: ch1
released channel: ch2
```

### 4.3 联机备份一个表空间

```
RMAN> backup tablespace users;

Starting backup at 2018-08-01 15:09:14
using channel ORA_DISK_1
channel ORA_DISK_1: starting full datafile backup set
channel ORA_DISK_1: specifying datafile(s) in backup set
input datafile file number=00007 name=/u01/app/oracle/oradata/orcl/users01.dbf
channel ORA_DISK_1: starting piece 1 at 2018-08-01 15:09:16
channel ORA_DISK_1: finished piece 1 at 2018-08-01 15:09:19
piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T150915_fp2q4wqn_
 tag=TAG20180801T150915 comment=NONE
channel ORA_DISK_1: backup set complete, elapsed time: 00:00:03
Finished backup at 2018-08-01 15:09:19

Starting Control File and SPFILE Autobackup at 2018-08-01 15:09:19
piece handle=/u01/backup/c-1510722265-20180801-06 comment=NONE
Finished Control File and SPFILE Autobackup at 2018-08-01 15:09:23
```

注：为了减少占用的存储空间，可使用压缩备份，压缩比大概是5：1。

```
RMAN> backup as compressed backupset tablespace users;
```

### 4.4 联机备份一个数据文件

```
RMAN> backup datafile 7;

Starting backup at 2018-08-01 15:13:04
using channel ORA_DISK_1
channel ORA_DISK_1: starting full datafile backup set
channel ORA_DISK_1: specifying datafile(s) in backup set
input datafile file number=00007 name=/u01/app/oracle/oradata/orcl/users01.dbf
channel ORA_DISK_1: starting piece 1 at 2018-08-01 15:13:04
channel ORA_DISK_1: finished piece 1 at 2018-08-01 15:13:05
piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T151304_fp2qd0oq_
 tag=TAG20180801T151304 comment=NONE
channel ORA_DISK_1: backup set complete, elapsed time: 00:00:01
Finished backup at 2018-08-01 15:13:05

Starting Control File and SPFILE Autobackup at 2018-08-01 15:13:05
piece handle=/u01/backup/c-1510722265-20180801-08 comment=NONE
Finished Control File and SPFILE Autobackup at 2018-08-01 15:13:09
```

# 5 RMAN增量备份

在使用BACKUP database时，都是全库备份，显然每次这样备份很耗时耗空间，而RMAN增量备份具有很大优势，它只备份自上次全备以来变化的数据。增量备份有两个级别，分别为0级增量备份和1级增加备份，其中，0级增量备份与全库备份相同，1级增量备份执行的是0级备份后变化的数据的备份。

如果指定BACKUP incremental，那么RMAN将创建增量备份，增量备份会捕获自上次增量备份之后数据块级别的变化，相比较完全数据块备份，增量备份通常更小，而且更快。增量备份的恢复会比单独使用redo日志要快。

增量备份是基于0级增量备份（level 0 incremental backup），0级增量备份和完全数据库备份一样，它备份了所有数据块。1级增量备份仅仅包含上次增量备份之后更改的数据块，如果0级备份不存在，当运行1级备份时，RMAN会自动执行0级别的备份。

1级备份可以是累积增量备份（cumulative incremental backup），它包含自最近0级备份以来所有更改的数据块；也可以是差异增量备份（differential incremental backup），它仅仅包含自最近的增量备份以来更改的数据块，默认使用差异增量备份。

在恢复增量备份时，RMAN使用0级备份作为起始点，然后根据1级备份更新已更改的块，如果增量备份可用，那么RMAN在恢复期间将会使用它们。

### 5.1 执行0级增量备份

```
RMAN> backup incremental level 0 database;

Starting backup at 2018-08-01 15:16:04
using channel ORA_DISK_1
channel ORA_DISK_1: starting incremental level 0 datafile backup set
channel ORA_DISK_1: specifying datafile(s) in backup set
input datafile file number=00001 name=/u01/app/oracle/oradata/orcl/system01.dbf
input datafile file number=00003 name=/u01/app/oracle/oradata/orcl/sysaux01.dbf
input datafile file number=00004 name=/u01/app/oracle/oradata/orcl/undotbs01.dbf
input datafile file number=00005 name=/u01/app/oracle/oradata/orcl/tsctl_01.dbf
input datafile file number=00007 name=/u01/app/oracle/oradata/orcl/users01.dbf
channel ORA_DISK_1: starting piece 1 at 2018-08-01 15:16:04
channel ORA_DISK_1: finished piece 1 at 2018-08-01 15:21:08
piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnnd0_TAG20180801T151604_fp2qknpk_
 tag=TAG20180801T151604 comment=NONE
channel ORA_DISK_1: backup set complete, elapsed time: 00:05:04
Finished backup at 2018-08-01 15:21:08

Starting Control File and SPFILE Autobackup at 2018-08-01 15:21:08
piece handle=/u01/backup/c-1510722265-20180801-09 comment=NONE
Finished Control File and SPFILE Autobackup at 2018-08-01 15:21:11
```

> 该0级备份集是增量备份的基础，后续1级备份只备份上次增量备份以来的所有变化的数据，这种级别1的增量备份称为差异备份，还有一种级别1的增量备份，每次实现增量备份时，它总是备份自0级备份以来所有变化的数据，称为累积备份。

### 5.2 执行1级差异增量备份

```
RMAN> backup incremental level 1 database;

Starting backup at 2018-08-01 15:23:01
using channel ORA_DISK_1
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/orcl/system01.dbf
input datafile file number=00003 name=/u01/app/oracle/oradata/orcl/sysaux01.dbf
input datafile file number=00004 name=/u01/app/oracle/oradata/orcl/undotbs01.dbf
input datafile file number=00005 name=/u01/app/oracle/oradata/orcl/tsctl_01.dbf
input datafile file number=00007 name=/u01/app/oracle/oradata/orcl/users01.dbf
```

channel ORA_DISK_1: starting piece 1 at 2018-08-01 15:23:02
channel ORA_DISK_1: finished piece 1 at 2018-08-01 15:26:09
piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnnd1_TAG20180801T152301_fp2qypz5_
tag=TAG20180801T152301 comment=NONE
channel ORA_DISK_1: backup set complete, elapsed time: 00:03:07
Finished backup at 2018-08-01 15:26:09

Starting Control File and SPFILE Autobackup at 2018-08-01 15:26:09
piece handle=/u01/backup/c-1510722265-20180801-0a comment=NONE
Finished Control File and SPFILE Autobackup at 2018-08-01 15:26:13

### 5.3 执行1级累积增量备份（可选）

RMAN> backup incremental level 1 cumulative database;

## 6 快速增量备份

使用增量备份大大减少了全库备份的时间，同时也节约了存储空间，但是使用增量备份必须扫描整个数据文件，因为无论在上次增量备份数据库是否发生变化，都要进行一次全扫描来确认是否有变化的数据。为了避免这一情况，Oracle提供了快速增量备份的方案，其原理是将数据库中发生变化的数据块位置记录在一个更改跟踪文件中，这样在下次实现增量备份时就可以通过该文件来备份变化的数据，减少了全库扫描的时间。

### 6.1 启用块更改跟踪

启用块更改跟踪特性后，会启动一个后台进程CTWR负责将变化的数据块位置写入块跟踪文件中：

SQL> alter database  enable block change tracking using file '/u01/app/change_tracking.log';

Database altered.

SQL> host ls /u01/app/change_tracking.log
/u01/app/change_tracking.log

> 如果该文件丢失或损坏会造成数据块无法启动，需要禁用方可启动数据库。

### 6.2 查看块更改跟踪

SQL> select * FROM v$block_change_tracking;

STATUS  FILENAME  BYTES  CON_ID
---------- ------------------------------ ---------- ----------
ENABLED  /u01/app/change_tracking.log  11599872  0

### 6.3 更改块更改跟踪文件

alter database rename file ...to...

### 6.4 禁用块更改跟踪

SQL> alter database disable block change tracking;

Database altered.

SQL> select * FROM v$block_change_tracking;

STATUS FILENAME BYTES CON_ID
---------- ------------------------------ ---------- ----------
DISABLED

# 7 在映像副本上应用增量备份

RMAN> run{
2> backup incremental level 1 for recover of copy with tag 'incr_copy_backup' database;
3> recover copy of database with tag 'incr_copy_backup';
4> }

Starting backup at 2018-08-01 15:38:36
using channel ORA_DISK_1
no parent backup or copy of datafile 1 found
no parent backup or copy of datafile 3 found
no parent backup or copy of datafile 4 found
no parent backup or copy of datafile 5 found
no parent backup or copy of datafile 7 found
channel ORA_DISK_1: starting datafile copy
input datafile file number=00001 name=/u01/app/oracle/oradata/orcl/system01.dbf
output file name=/u01/app/oracle/fast_recovery_area/orcl/ORCL/datafile/o1_mf_system_fp2rvxbk_.dbf
tag=INCR_COPY_BACKUP RECID=1 STAMP=983029291
channel ORA_DISK_1: datafile copy complete, elapsed time: 00:03:04
channel ORA_DISK_1: starting datafile copy
input datafile file number=00003 name=/u01/app/oracle/oradata/orcl/sysaux01.dbf
output file name=/u01/app/oracle/fast_recovery_area/orcl/ORCL/datafile/o1_mf_sysaux_fp2s1pfd_.dbf
tag=INCR_COPY_BACKUP RECID=2 STAMP=983029422
channel ORA_DISK_1: datafile copy complete, elapsed time: 00:02:05
channel ORA_DISK_1: starting datafile copy
input datafile file number=00004 name=/u01/app/oracle/oradata/orcl/undotbs01.dbf
output file name=/u01/app/oracle/fast_recovery_area/orcl/ORCL/datafile/o1_mf_undotbs1_fp2s5nz6_.dbf
tag=INCR_COPY_BACKUP RECID=3 STAMP=983029446
channel ORA_DISK_1: datafile copy complete, elapsed time: 00:00:26
channel ORA_DISK_1: starting datafile copy
input datafile file number=00005 name=/u01/app/oracle/oradata/orcl/tsctl_01.dbf
output file name=/u01/app/oracle/fast_recovery_area/orcl/ORCL/datafile/o1_mf_ts_ctl_fp2s6gb0_.dbf
tag=INCR_COPY_BACKUP RECID=4 STAMP=983029466
channel ORA_DISK_1: datafile copy complete, elapsed time: 00:00:15
channel ORA_DISK_1: starting datafile copy
input datafile file number=00007 name=/u01/app/oracle/oradata/orcl/users01.dbf
output file name=/u01/app/oracle/fast_recovery_area/orcl/ORCL/datafile/o1_mf_users_fp2s6y1g_.dbf
tag=INCR_COPY_BACKUP RECID=5 STAMP=983029471
channel ORA_DISK_1: datafile copy complete, elapsed time: 00:00:03
Finished backup at 2018-08-01 15:44:33

Starting recover at 2018-08-01 15:44:36
using channel ORA_DISK_1

no copy of datafile 1 found to recover
no copy of datafile 3 found to recover
no copy of datafile 4 found to recover
no copy of datafile 5 found to recover
no copy of datafile 7 found to recover
Finished recover at 2018-08-01 15:44:37

Starting Control File and SPFILE Autobackup at 2018-08-01 15:44:37
piece handle=/u01/backup/c-1510722265-20180801-0c comment=NONE
Finished Control File and SPFILE Autobackup at 2018-08-01 15:44:40

第一条语句表示要生成级别为1的tag值为incr_copy_backup，针对整库并且应用于增量备份的映像副本，第一次执行该程序时，在执行第一条语句时，没有0级备份，因此会生成整库的映像副本。

执行第二条语句时，因为没有增量备份，因此不会执行，但也不会报错。第二次执行程序时，由于已经有了第一次的0级备份，所以会生成一个1级增量备份，执行第二条语句时，会将第一条语句生成的增量备份应用到第一次所生成的映像副本上。以后的每一次都会生成一个增量备份，并将该生成的增量备份应用到映像副本上，如果需要恢复，先恢复映像副本，然后应用最近一次增量备份以来的所有归档日志，就可以实现数据库的完全恢复。

# 8 创建和维护恢复目录

恢复目录保存了RMAN信息库的信息，Oracle推荐使用恢复目录保存RMAN信息库，在信息库中保存了数据文件备份集或映像复制。表空间和数据文件信息以及RMAN的配置信息，使用恢复目录RMAN在一定条件下读取目标库的控制文件来更新恢复目录中保存的关于控制文件、数据文件等信息。

## 8.1 创建恢复目录

1）创建恢复目录表空间，用于存储RMAN备份元数据

SQL> create tablespace recv_rman datafile '/u01/app/oracle/oradata/orcl/recvrman_01.dbf' size 100M autoextend on;

Tablespace created.

2）创建恢复目录用户

SQL> create user rman identified by rman default tablespace recv_rman temporary tablespace temp quota unlimited on recv_rman;

User created.

3）授予权限

SQL> grant connect,resource,recovery_catalog_owner to rman;

Grant succeeded.

## 8.2 设置恢复目录

1）连接恢复目录和目标数据库

[oracle@strong ~]$ rman target sys/system@orcl catalog rman/rman@orcl

Recovery Manager: Release 12.2.0.1.0 - Production on Wed Aug 1 16:12:40 2018

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connected to target database: ORCL (DBID=1510722265)
connected to recovery catalog database

RMAN>

2）创建恢复目录，不需要时，可使用drop catalog删除

RMAN> create catalog tablespace recv_rman;

recovery catalog created

3）注册目标数据库，在创建了恢复目录后注册目标数据库，目的是使得恢复目录指定目标数据库的信息，并自动与目标数据库通信获得相关的元数据，要注册目标数据库，必须首先连接到目标数据库

RMAN> register database;

database registered in recovery catalog
starting full resync of recovery catalog
full resync complete

4）同步恢复目录

RMAN> resync catalog;

starting full resync of recovery catalog
full resync complete

# 9 RMAN脚本管理

创建RMAN脚本时必须连接到恢复目录和目标数据库，否则不能创建成功。

## 9.1 创建脚本

[oracle@strong ~]$ rman target sys/system@orcl catalog rman/rman@orcl

Recovery Manager: Release 12.2.0.1.0 - Production on Wed Aug 1 16:21:11 2018

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connected to target database: ORCL (DBID=1510722265)
connected to recovery catalog database

RMAN> create script backup_datafile{
2> backup datafile 7;
3> }

created script backup_datafile

### 9.2 执行脚本

```
RMAN> run{
2> execute script backup_datafile;
3> }

executing script: backup_datafile

Starting backup at 2018-08-01 16:22:25
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=61 device type=DISK
channel ORA_DISK_1: starting full datafile backup set
channel ORA_DISK_1: specifying datafile(s) in backup set
input datafile file number=00007 name=/u01/app/oracle/oradata/orcl/users01.dbf
channel ORA_DISK_1: starting piece 1 at 2018-08-01 16:22:27
channel ORA_DISK_1: finished piece 1 at 2018-08-01 16:22:28
piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T162226_fp2vg3bk_.
 tag=TAG20180801T162226 comment=NONE
channel ORA_DISK_1: backup set complete, elapsed time: 00:00:01
Finished backup at 2018-08-01 16:22:28

Starting Control File and SPFILE Autobackup at 2018-08-01 16:22:28
piece handle=/u01/backup/c-1510722265-20180801-0e comment=NONE
Finished Control File and SPFILE Autobackup at 2018-08-01 16:22:34
```

### 9.3 查看脚本

```
RMAN> print script backup_datafile;

printing stored script: backup_datafile
{
backup datafile 7;
}
```

### 9.4 转化脚本为操作系统文件

```
RMAN> print script backup_datafile to file '/home/oracle/backup_datafile.txt';

script backup_datafile written to file /home/oracle/backup_datafile.txt
```

# 10 RMAN归档模式下完全恢复

在归档模式下，使用RMAN的备份和所有归档重做日志以及当前的重做日志文件可实现数据库的完全恢复，要求在使用RMAN备份以来数据库一直运行在归档模式，且归档文件以及重做日志文件没有损坏。这种情况可以联机恢复数据库文件，不需要关闭数据库。在生产库中，联机恢复的最大好处就是不影响其他业务。

# 10.1 非系统表空间损坏的恢复

**方法一：**

1）删除users的数据文件

```
[oracle@strong ~]$ cd /u01/app/oracle/oradata/orcl/
[oracle@strong orcl]$ rm users01.dbf
```

2）重启数据库会报错

```
SQL> startup
ORACLE instance started.

Total System Global Area  788529152 bytes
Fixed Size                  8625656 bytes
Variable Size             566231560 bytes
Database Buffers          209715200 bytes
Redo Buffers                3956736 bytes
Database mounted.
ORA-01157: cannot identify/lock data file 7 - see DBWR trace file
ORA-01110: data file 7: '/u01/app/oracle/oradata/orcl/users01.dbf'
```

3）打开数据库

```
SQL> alter database datafile 7 offline;

Database altered.

SQL> alter database open;

Database altered.
```

4）还原数据文件

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

Recovery Manager: Release 12.2.0.1.0 - Production on Wed Aug 1 16:37:04 2018

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connected to target database: ORCL (DBID=1510722265)

RMAN> restore datafile 7;

Starting restore at 2018-08-01 16:37:36
using target database control file instead of recovery catalog
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=66 device type=DISK

channel ORA_DISK_1: starting datafile backup set restore
channel ORA_DISK_1: specifying datafile(s) to restore from backup set
channel ORA_DISK_1: restoring datafile 00007 to /u01/app/oracle/oradata/orcl/users01.dbf
```

channel ORA_DISK_1: reading from backup piece
/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T162226_fp2vg3bk_.bkp
channel ORA_DISK_1: piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T162226_fp2vg3bk_.
tag=TAG20180801T162226
channel ORA_DISK_1: restored backup piece 1
channel ORA_DISK_1: restore complete, elapsed time: 00:00:02
Finished restore at 2018-08-01 16:37:46

5）恢复数据文件

RMAN> recover datafile 7;

Starting recover at 2018-08-01 16:39:10
using channel ORA_DISK_1

starting media recovery
media recovery complete, elapsed time: 00:00:01

Finished recover at 2018-08-01 16:39:12

6）查看数据文件，已恢复

[oracle@strong orcl]$ ll -h users01.dbf
-rw-r-----. 1 oracle oinstall 5.1M Aug  1 16:39 users01.dbf

7）查看是否恢复

SQL> alter database datafile 7 online;

Database altered.

SQL> select file_name,file_id,tablespace_name,status,online_status from dba_data_files;

| FILE_NAME | FILE_ID | TABLESPACE_NAME | STATUS | ONLINE_ |
|---|---|---|---|---|
| /u01/app/oracle/oradata/orcl/system01.dbf | 1 | SYSTEM | AVAILABLE | SYSTEM |
| /u01/app/oracle/oradata/orcl/sysaux01.dbf | 3 | SYSAUX | AVAILABLE | ONLINE |
| /u01/app/oracle/oradata/orcl/undotbs01.dbf | 4 | UNDOTBS1 | AVAILABLE | ONLINE |
| /u01/app/oracle/oradata/orcl/users01.dbf | 7 | USERS | AVAILABLE | ONLINE |
| /u01/app/oracle/oradata/orcl/tsctl_01.dbf | 5 | TS_CTL | AVAILABLE | ONLINE |
| /u01/app/oracle/oradata/orcl/recvrman_01.dbf | 2 | RECV_RMAN | AVAILABLE | ONLINE |

6 rows selected.

**方法二：**

将恢复脚本封装在run块内作为整体执行：

[oracle@strong ~]$ rman target /

Recovery Manager: Release 12.2.0.1.0 - Production on Wed Aug 1 16:55:31 2018

```
connected to target database: ORCL (DBID=1510722265, not open)

RMAN> run{
2> alter database datafile 7 offline;
3> restore datafile 7;
4> recover datafile 7;
5> alter database datafile 7 online;
6> }

using target database control file instead of recovery catalog
Statement processed

Starting restore at 2018-08-01 16:56:48
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=43 device type=DISK

channel ORA_DISK_1: starting datafile backup set restore
channel ORA_DISK_1: specifying datafile(s) to restore from backup set
channel ORA_DISK_1: restoring datafile 00007 to /u01/app/oracle/oradata/orcl/users01.dbf
channel ORA_DISK_1: reading from backup piece
/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T162226_fp2vg3bk_.bkp
channel ORA_DISK_1: piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T162226_fp2vg3bk_.
 tag=TAG20180801T162226
channel ORA_DISK_1: restored backup piece 1
channel ORA_DISK_1: restore complete, elapsed time: 00:00:01
Finished restore at 2018-08-01 16:56:51

Starting recover at 2018-08-01 16:56:51
using channel ORA_DISK_1

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

Finished recover at 2018-08-01 16:56:52

Statement processed
```

## 10.2 系统表空间损坏的恢复

SYSTEM表空间损坏，而控制文件、重做日志文件完好，此时需要把数据库启动到mount状态，使用RMAN恢复该表空间。

1）删除系统表空间（模拟故障）

```
[oracle@strong orcl]$ rm system01.dbf
[oracle@strong orcl]$ ll -h system01.dbf
ls: cannot access system01.dbf: No such file or directory
```

2）启动数据库报错

```
SQL> shutdown abort
ORACLE instance shut down.
SQL> startup
ORACLE instance started.

Total System Global Area  788529152 bytes
Fixed Size                  8625656 bytes
Variable Size             566231560 bytes
Database Buffers          209715200 bytes
Redo Buffers                3956736 bytes
Database mounted.
ORA-01157: cannot identify/lock data file 1 - see DBWR trace file
ORA-01110: data file 1: '/u01/app/oracle/oradata/orcl/system01.dbf'
```

3）执行恢复

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

Recovery Manager: Release 12.2.0.1.0 - Production on Wed Aug 1 17:09:00 2018

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connected to target database: ORCL (DBID=1510722265, not open)

RMAN> run{
2> alter database datafile 1 offline;
3> restore datafile 1;
4> recover datafile 1;
5> alter database datafile 1 online;
6> alter database open;
7> }

using target database control file instead of recovery catalog
Statement processed

Starting restore at 2018-08-01 17:10:11
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=42 device type=DISK

channel ORA_DISK_1: restoring datafile 00001
input datafile copy RECID=1 STAMP=983029291 file
name=/u01/app/oracle/fast_recovery_area/orcl/ORCL/datafile/o1_mf_system_fp2rvxbk_.dbf
destination for restore of datafile 00001: /u01/app/oracle/oradata/orcl/system01.dbf
channel ORA_DISK_1: copied datafile copy of datafile 00001
output file name=/u01/app/oracle/oradata/orcl/system01.dbf RECID=0 STAMP=0
Finished restore at 2018-08-01 17:12:03

Starting recover at 2018-08-01 17:12:03
using channel ORA_DISK_1

starting media recovery
```

media recovery complete, elapsed time: 00:00:16

Finished recover at 2018-08-01 17:12:20

Statement processed

Statement processed

4）检查系统数据文件

[oracle@strong orcl]$ ll -h system01.dbf
-rw-r-----. 1 oracle oinstall 841M Aug  1 17:12 system01.dbf

## 10.3 所有数据文件丢失的恢复

1）删除数据文件

[oracle@strong orcl]$ rm system01.dbf sysaux01.dbf tsctl_01.dbf users01.dbf recvrman_01.dbf

2）启动数据库

SQL> shutdown abort
ORACLE instance shut down.
SQL> startup
ORACLE instance started.

Total System Global Area  788529152 bytes
Fixed Size                  8625656 bytes
Variable Size             566231560 bytes
Database Buffers          209715200 bytes
Redo Buffers                3956736 bytes
Database mounted.
ORA-01157: cannot identify/lock data file 1 - see DBWR trace file
ORA-01110: data file 1: '/u01/app/oracle/oradata/orcl/system01.dbf'

3）恢复数据文件

[oracle@strong ~]$ rman target /

Recovery Manager: Release 12.2.0.1.0 - Production on Wed Aug 1 17:22:11 2018

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connected to target database: ORCL (DBID=1510722265, not open)

RMAN> run{
2> restore database;
3> recover database;
4> alter database open;
5> }

Starting restore at 2018-08-01 17:22:43

using target database control file instead of recovery catalog
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=42 device type=DISK

creating datafile file number=2 name=/u01/app/oracle/oradata/orcl/recvrman_01.dbf
channel ORA_DISK_1: restoring datafile 00001
input datafile copy RECID=1 STAMP=983029291 file
name=/u01/app/oracle/fast_recovery_area/orcl/ORCL/datafile/o1_mf_system_fp2rvxbk_.dbf
destination for restore of datafile 00001: /u01/app/oracle/oradata/orcl/system01.dbf
channel ORA_DISK_1: copied datafile copy of datafile 00001
output file name=/u01/app/oracle/oradata/orcl/system01.dbf RECID=0 STAMP=0
channel ORA_DISK_1: restoring datafile 00003
input datafile copy RECID=2 STAMP=983029422 file
name=/u01/app/oracle/fast_recovery_area/orcl/ORCL/datafile/o1_mf_sysaux_fp2s1pfd_.dbf
destination for restore of datafile 00003: /u01/app/oracle/oradata/orcl/sysaux01.dbf
channel ORA_DISK_1: copied datafile copy of datafile 00003
output file name=/u01/app/oracle/oradata/orcl/sysaux01.dbf RECID=0 STAMP=0
channel ORA_DISK_1: restoring datafile 00004
input datafile copy RECID=3 STAMP=983029446 file
name=/u01/app/oracle/fast_recovery_area/orcl/ORCL/datafile/o1_mf_undotbs1_fp2s5nz6_.dbf
destination for restore of datafile 00004: /u01/app/oracle/oradata/orcl/undotbs01.dbf
channel ORA_DISK_1: copied datafile copy of datafile 00004
output file name=/u01/app/oracle/oradata/orcl/undotbs01.dbf RECID=0 STAMP=0
channel ORA_DISK_1: restoring datafile 00005
input datafile copy RECID=4 STAMP=983029466 file
name=/u01/app/oracle/fast_recovery_area/orcl/ORCL/datafile/o1_mf_ts_ctl_fp2s6gb0_.dbf
destination for restore of datafile 00005: /u01/app/oracle/oradata/orcl/tsctl_01.dbf
channel ORA_DISK_1: copied datafile copy of datafile 00005
output file name=/u01/app/oracle/oradata/orcl/tsctl_01.dbf RECID=0 STAMP=0
channel ORA_DISK_1: starting datafile backup set restore
channel ORA_DISK_1: specifying datafile(s) to restore from backup set
channel ORA_DISK_1: restoring datafile 00007 to /u01/app/oracle/oradata/orcl/users01.dbf
channel ORA_DISK_1: reading from backup piece
/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T162226_fp2vg3bk_.bkp
channel ORA_DISK_1: piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T162226_fp2vg3bk_.
tag=TAG20180801T162226
channel ORA_DISK_1: restored backup piece 1
channel ORA_DISK_1: restore complete, elapsed time: 00:00:01
Finished restore at 2018-08-01 17:25:46

Starting recover at 2018-08-01 17:25:46
using channel ORA_DISK_1

starting media recovery

archived log for thread 1 with sequence 7 is already on disk as file
/u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_7_fp2w7xtt_.arc
archived log for thread 1 with sequence 8 is already on disk as file
/u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_8_fp2xh9by_.arc
archived log for thread 1 with sequence 9 is already on disk as file
/u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_9_fp2ycqdd_.arc

archived log file name=/u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_7_fp2w7xtt_.arc thread=1 sequence=7
media recovery complete, elapsed time: 00:00:22
Finished recover at 2018-08-01 17:26:10

Statement processed

4）查看数据文件

[oracle@strong orcl]$ ll -h system01.dbf sysaux01.dbf tsctl_01.dbf users01.dbf recvrman_01.dbf
-rw-r-----. 1 oracle oinstall 101M Aug  1 17:26 recvrman_01.dbf
-rw-r-----. 1 oracle oinstall 571M Aug  1 17:27 sysaux01.dbf
-rw-r-----. 1 oracle oinstall 841M Aug  1 17:26 system01.dbf
-rw-r-----. 1 oracle oinstall  51M Aug  1 17:26 tsctl_01.dbf
-rw-r-----. 1 oracle oinstall 5.1M Aug  1 17:26 users01.dbf

# 11 RMAN备份维护指令

## 11.1 报告展示RMAN操作

可以使用RMAN的List和Report命令基于RMAN信息库产生备份活动的报告，使用Show all命令可以显示RMAN当前的配置。

### 11.1.1 列出备份信息

运行List backup和List copy命令，可以展示信息库中的备份、数据文件拷贝信息。对于备份，可以使用选项控制List输出的格式。

*Table 2-3 LIST Options for Backups*

| Option | Example | Explanation |
|---|---|---|
| `BY BACKUP` | `LIST BACKUP OF DATABASE BY BACKUP` | Organizes the output by backup set. This is the default mode of presentation. |
| `BY FILE` | `LIST BACKUP BY FILE` | Lists the backups according to which file was backed up. |
| `SUMMARY` | `LIST BACKUP SUMMARY` | Displays summary output. |

对于备份和拷贝，可以使用下面的选项：

*Table 2-4 Additional LIST Options*

| Option | Example | Explanation |
|---|---|---|
| `EXPIRED` | `LIST EXPIRED COPY` | Lists backups that are recorded in the RMAN repository but that were not present at the expected location on disk or tape during the last `CROSSCHECK` command. An **expired backup** may have been deleted by an operating system utility. |
| `RECOVERABLE` | `LIST BACKUP RECOVERABLE` | Lists data file backups or copies that have status `AVAILABLE` in the RMAN repository and that can be restored and recovered. |

示例：

RMAN> list backup of database;
查看备份集信息
RMAN> list backup;
查看备份集信息
RMAN> list backupset 28;
查看表空间在备份集中的信息
RMAN> list backup of tablespace users;
查看数据文件在备份集中的信息
RMAN> list backup of datafile 1;
查看归档日志文件的备份信息

RMAN> list backup of archivelog all;
RMAN> list backup of archivelog from time 'sysdate-2';
查看控制文件与参数文件信息
RMAN> list backup of controlfile;
RMAN> list backup of spfile;
RMAN> list copy of controlfile;
查看备份汇总信息
RMAN> list backup summary;

#### 11.1.2 报告数据文件和备份

Report命令可以执行比List命令更复杂的分析。
Report选项有：

| Option | Example | Explanation |
| --- | --- | --- |
| `NEED BACKUP` | `REPORT NEED BACKUP DATABASE` | Shows which files need backing up under current retention policy. Use optional `REDUNDANCY` and `RECOVERY WINDOW` parameters to specify different criteria. |
| `OBSOLETE` | `REPORT OBSOLETE` | Lists backups that are obsolete under the configured **backup retention policy**. Use the optional `REDUNDANCY` and `RECOVERY WINDOW` parameters to override the default. |
| `SCHEMA` | `REPORT SCHEMA` | Reports the tablespaces and data files in the database at the current time (default) or a different time. |
| `UNRECOVERABLE` | `REPORT UNRECOVERABLE` | Lists all data files for which an unrecoverable operation has been performed against an object in the data file since the last backup of the data file. |

示例：

列出过期的备份
RMAN> report obsolete;
查看数据库结构
RMAN> report schema;
列出需要备份的数据文件
RMAN> report need backup;

### 11.2 VALIDATE BACKUPSET指令

该命令验证备份文件的可用性，如果备份的数据文件都以备份集的形式存在，在使用该命令验证备份集时RMAN会自动找到你指定的备份集。

RMAN> validate backupset 28;

Starting validate at 2018-08-01 17:37:25
using channel ORA_DISK_1
channel ORA_DISK_1: starting validation of datafile backup set
channel ORA_DISK_1: reading from backup piece /u01/backup/c-1510722265-20180801-0c
channel ORA_DISK_1: piece handle=/u01/backup/c-1510722265-20180801-0c tag=TAG20180801T154437
channel ORA_DISK_1: restored backup piece 1
channel ORA_DISK_1: validation complete, elapsed time: 00:00:02
Finished validate at 2018-08-01 17:37:30
验证完成说明成功，此备份集是有效的，可用于恢复操作；

### 11.3 RESTORE...VALIDATE指令

该指令验证数据库对象是否在当前的备份集中，这样在用户恢复数据文件或表空间时，可以首先确认该对象备份信息是否存在。

```
RMAN> restore tablespace users validate;

Starting restore at 2018-08-01 17:38:36
using channel ORA_DISK_1

channel ORA_DISK_1: starting validation of datafile backup set
channel ORA_DISK_1: reading from backup piece
/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T162226_fp2vg3bk_.bkp
channel ORA_DISK_1: piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T162226_fp2vg3bk_.
 tag=TAG20180801T162226
channel ORA_DISK_1: restored backup piece 1
channel ORA_DISK_1: validation complete, elapsed time: 00:00:02
Finished restore at 2018-08-01 17:38:39

RMAN> restore datafile 7 validate;

Starting restore at 2018-08-01 17:39:17
using channel ORA_DISK_1

channel ORA_DISK_1: starting validation of datafile backup set
channel ORA_DISK_1: reading from backup piece
/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T162226_fp2vg3bk_.bkp
channel ORA_DISK_1: piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T162226_fp2vg3bk_.
 tag=TAG20180801T162226
channel ORA_DISK_1: restored backup piece 1
channel ORA_DISK_1: validation complete, elapsed time: 00:00:02
Finished restore at 2018-08-01 17:39:20
```

### 11.4 RESTORE...PREVIEW指令

用户在备份数据库前或许想知道执行恢复的所有文件是否存在，如当恢复表空间时想知道该表空间中的所有数据文件是否在备份集中，在恢复全库时刻的数据文件、归档日志文件是否存在等等。该指令可以完成这项功能。

```
RMAN> restore datafile 2 preview;

Starting restore at 2018-08-01 17:41:20
using channel ORA_DISK_1

datafile 2 will be created automatically during restore operation

List of Archived Log Copies for database with db_unique_name ORCL
=====================================================================

Key     Thrd Seq     S Low Time
------- ---- ------- - -------------------
4       1    7       A 2018-08-01 15:04:43
        Name: /u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_7_fp2w7xtt_.arc

5       1    8       A 2018-08-01 16:36:13
        Name: /u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_8_fp2xh9by_.arc
```

6 1 9 A 2018-08-01 16:57:13
Name: /u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_9_fp2ycqdd_.arc

7 1 10 A 2018-08-01 17:12:22
Name: /u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_10_fp2z5mr7_.arc

recovery will be done up to SCN 1676120
Media recovery start SCN is 1676120
Recovery must be done beyond SCN 1676120 to clear datafile fuzziness
Finished restore at 2018-08-01 17:41:21

### 11.5 CROSSCHECK备份

CROSSCHECK命令将RMAN备份和拷贝的逻辑记录与存储介质上的文件同步，如果备份在磁盘上，那么CROSSCHECK将确定文件头是否有效；如果备份在磁带上，那么RMAN将查询RAMN信息库，以查找备份片的名称和位置。删除备份和拷贝前，使用CROSSCHECK命令校验下是个不错的主意。

1）CROSSCHECK备份

RMAN> crosscheck backup;

2）CROSSCHECK映像

RMAN> crosscheck copy;

### 11.6 删除过期（obsolete）的备份

Delete命令可以从磁盘或磁带移除RMAN备份和拷贝、更新控制文件信息库中文件的状态为DELETED，如果使用恢复目录的话，会移除恢复目录中对应的记录。如果交互式使用RMAN，不必指定NOPROMPT选项，Delete将会展示文件的清单并在删除之前提示确认是否删除。

RMAN> delete obsolete;

## 12 数据恢复顾问（Data Recovery Advisor）诊断和修复故障

诊断和修复数据库问题的最简单的方式是使用数据恢复顾问，该Oracle数据库工具提供了一个用于诊断持久数据故障的基础设施，并为用户提供修复选项，并且自动执行修复。

### 12.1 列出故障和确定修复选项

故障（Failure）是有健康监视器（Health Monitor）检测到的持久数据损坏，包括物理和逻辑的数据块损坏，以及数据文件丢失。每个故障都有一个故障优先级和故障状态，优先级可以是Critical、high或者low，状态可以是open或closed。

可以使用LIST Failure命令显示所有已知的故障，如果故障存在，然后运行advise failure命令确定手动和自动修复选项，下面进行演示。

1）删除users数据文件（模拟故障）

[oracle@strong orcl]$ rm users01.dbf
[oracle@strong orcl]$ ll -h users01.dbf
ls: cannot access users01.dbf: No such file or directory

2）使用恢复顾问

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

Recovery Manager: Release 12.2.0.1.0 - Production on Wed Aug 1 17:45:07 2018

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connected to target database: ORCL (DBID=1510722265)

RMAN> list failure;

using target database control file instead of recovery catalog
Database Role: PRIMARY

List of Database Failures
=========================

Failure ID Priority Status    Time Detected       Summary
---------- -------- --------- ------------------- -------
782        HIGH     OPEN      2018-08-01 16:37:46 One or more non-system datafiles need media recovery
742        HIGH     OPEN      2018-08-01 16:34:13 One or more non-system datafiles are missing

RMAN> advise failure;

Database Role: PRIMARY

List of Database Failures
=========================

Failure ID Priority Status    Time Detected       Summary
---------- -------- --------- ------------------- -------
782        HIGH     OPEN      2018-08-01 16:37:46 One or more non-system datafiles need media recovery
742        HIGH     OPEN      2018-08-01 16:34:13 One or more non-system datafiles are missing

analyzing automatic repair options; this may take some time
allocated channel: ORA_DISK_1
channel ORA_DISK_1: SID=66 device type=DISK
analyzing automatic repair options complete

Mandatory Manual Actions
========================
no manual actions available

Optional Manual Actions
=======================
1. If you restored the wrong version of data file /u01/app/oracle/oradata/orcl/users01.dbf, then replace it with the correct one
2. If file /u01/app/oracle/oradata/orcl/users01.dbf was unintentionally renamed or moved, restore it

Automated Repair Options
========================
```

```
Option Repair Description
------ ------------------
1      Restore and recover datafile 7
  Strategy: The repair includes complete media recovery with no data loss
  Repair script: /u01/app/oracle/diag/rdbms/orcl/orcl/hm/reco_2130240480.hm
```

## 12.2 修复故障

在RMAN会话运行List Failure和advise failure后，使用repair failure执行修复选项。如果在没有其他命令选项的情况下执行repar failure，那么RMAN将使用当前会话中最接近advise failure的第一个修复选项，或者，指定从最近的advise failure包含的修复选项号。

```
RMAN> repair failure;

Strategy: The repair includes complete media recovery with no data loss
Repair script: /u01/app/oracle/diag/rdbms/orcl/orcl/hm/reco_2130240480.hm

contents of repair script:
   # restore and recover datafile
   sql 'alter database datafile 7 offline';
   restore ( datafile 7 );
   recover datafile 7;
   sql 'alter database datafile 7 online';

Do you really want to execute the above repair (enter YES or NO)? yes
executing repair script

sql statement: alter database datafile 7 offline

Starting restore at 2018-08-01 17:48:54
using channel ORA_DISK_1

channel ORA_DISK_1: starting datafile backup set restore
channel ORA_DISK_1: specifying datafile(s) to restore from backup set
channel ORA_DISK_1: restoring datafile 00007 to /u01/app/oracle/oradata/orcl/users01.dbf
channel ORA_DISK_1: reading from backup piece
/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T162226_fp2vg3bk_.bkp
channel ORA_DISK_1: piece
handle=/u01/app/oracle/fast_recovery_area/orcl/ORCL/backupset/2018_08_01/o1_mf_nnndf_TAG20180801T162226_fp2vg3bk_.
 tag=TAG20180801T162226
channel ORA_DISK_1: restored backup piece 1
channel ORA_DISK_1: restore complete, elapsed time: 00:00:01
Finished restore at 2018-08-01 17:48:56

Starting recover at 2018-08-01 17:48:56
using channel ORA_DISK_1

starting media recovery

archived log for thread 1 with sequence 7 is already on disk as file
/u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_7_fp2w7xtt_.arc
archived log for thread 1 with sequence 8 is already on disk as file
/u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_8_fp2xh9by_.arc
```

archived log for thread 1 with sequence 9 is already on disk as file
/u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_9_fp2ycqdd_.arc
archived log for thread 1 with sequence 10 is already on disk as file
/u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_10_fp2z5mr7_.arc
archived log file name=/u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_7_fp2w7xtt_.arc
thread=1 sequence=7
archived log file name=/u01/app/oracle/fast_recovery_area/orcl/ORCL/archivelog/2018_08_01/o1_mf_1_8_fp2xh9by_.arc
thread=1 sequence=8
media recovery complete, elapsed time: 00:00:01
Finished recover at 2018-08-01 17:48:58

sql statement: alter database datafile 7 online
repair failure complete

### 12.3 查看恢复结果

[oracle@strong orcl]$ ll -h users01.dbf
-rw-r-----. 1 oracle oinstall 5.1M Aug  1 17:48 users01.dbf