CONTENTS

1. Introduction ............................................................................................................. 1

2. Overview of Data Replication and DDR/RDR......................................................... 4
   2.1 What is data replication? ....................................................................................... 4
   2.2 Software for data replication ............................................................................... 4
   2.3 Data Replication states ......................................................................................... 5
   2.4 Operations of Data Replication ............................................................................. 6

3. System Configuration for OSCP ............................................................................ 8
   3.1 Hardware configuration ...................................................................................... 8
   3.2 Software configuration ....................................................................................... 8

4. Summary of OSCP Test ......................................................................................... 9
   4.1 Backup and Restore ............................................................................................ 9
   4.2 Startup of a replicated database ......................................................................... 9

5. Details of the verification tests based on the OSCP Tests ..................................... 10
   5.1 Database Construction for Verification and Setting of Replication Function .......... 10
      5.1.1 Oracle Database construction for verification tests ....................................... 10
      5.1.2 Settings of iStorageManager/ReplicationControl ........................................... 10
   5.2 Backup and Restore ............................................................................................ 10
      5.2.1 Cold backup .................................................................................................. 12
      5.2.2 Hot backup .................................................................................................. 17
   5.3 Startup of a replicated database .......................................................................... 22
      5.3.1 Starting up a replicated database using cold backup processing ..................... 23
      5.3.2 Starting up a replicated database using hot backup processing ....................... 25

6. Supplementary information for iStorage S2100 .................................................. 29

7. Reference ................................................................................................. 29

Acknowledgement ............................................................................................... 29
1. Introduction

Growth of internet business makes amounts of data to be processed in companies increase at an extremely rapid rate. In addition, globalization requires companies to operate business 24 hours a day 365 days a year. ‘iStorage-series disk array system (S4100 / S2100)’ provided from NEC Corporation centrally manages massive amounts of accumulated business information, achieves high performance, large capacity and high reliability to promote effective and efficient use of the information and is here to assist in clearing customers’ many requirements.

The iStorage-series disk array system has a data replication function that creates separable replication volumes. This function enables to bring about the following effects:

As explained above, data replication enables simplification of system construction and system operation, increase of system efficiency, and improvement of system availability.

Based on the Oracle Storage Compatibility Program (OSCP), Oracle provides snapshot tests guideline to verify a disk array system to be used for the Oracle database [1]. This document describes how to create snapshots for backup and how to use the snapshots for recovery for the Oracle database by using the OSCP test kit provided from Oracle Corporation and the data replication function of the iStorage-series disk array system, and also shows the verification results followed by the OSCP snapshot tests.

Terminology

Cold Backup

Creating a backup copy of the production data while the production system is in suspended state. → Hot Backup.

DDR

Dynamic Data Replication. One of the data replication functions of the iStorage-series disk array system provided from NEC Corporation. Creates RV in the same disk array system.

FC

Fibre Channel

Hot Backup

Creating a backup copy of the production data while the production system is operating. Also the function. Since backup processing is performed while the production server is operating (= online), hot backup is also called as online backup. → Cold Backup.

iStorage S2100-series disk array system

A product of iStorage-series disk array system, which is provided for mid-range use. The iStorage S2100-series disk array system has a capacity of 9TB in the maximum configuration and has 4 FC ports (transfer rate: 2 Gb/s). The replication function of the iStorage S2100-series disk array system does not include the RDR (RemoteDataReplication) function for linkage with other systems.

iStorage S4100-series disk array system
A product of iStorage-series disk array system, which is provided for high-end use. The iStorage S4100-series disk array system has a capacity of 31TB in the maximum configuration and has 32 FC ports (transfer rate: 2 Gb/s). The replication function of the iStorage S4100-series disk array system includes the RDR function for linkage with other systems (S4100-series models only) in addition to the DDR (DynamicDataReplication) function used in the same enclosure. The iStorage S4100-series disk array system is highly reliable providing not only the RAID but all the components (power supply and control function) in dual configuration.

**LDN (LD Number)**

The number corresponding to a logical device managed in the disk array system.

**LD Name**

The unique name corresponding to a logical device within one FC connection managed in the disk array system.

**Management Server**

A computer system responsible for managing iStorage-series disk array systems. The management server has various functions (e.g., configuring RAID, setting access control (S2100 series only), and getting/displaying performance information) in addition to functions for replication-related operations. The management server as well as the production server should be needed for applying the iStorage-series disk array system.

A management server enables to manage more than one iStorage-series disk array system. Thus, centralized management is available.

Some operating systems enable the production server to perform management server functions.

**Master Volume**

A source volume in replication processing. Since this volume is mainly used for production of actual business operation, it is also called Production Volume. → RV

**MV**

→ Master volume

**Online Backup**

→ Synonym for Hot Backup

**OSCP**

Oracle Storage Compatibility Program

**Pair**

A pair of volumes for creating replication volumes by the replication function of the iStorage-series disk array system.

**Pairing**

Defining a pair of volumes for creating replication volumes by the replication function of the iStorage-series disk array system. Replication processing should be operated from the management server.
Production Server

A user-oriented computer system. For example, a computer system with a database operating.

Production Volume

Same as Master Volume.

RDR

Remote Data Replication. One of the data replication functions of the iStorage-series disk array system provided from NEC Corporation. Creates RV into the different disk array systems.

Remote Storage

A disk array system located in a distance from a disk array system for production use. Connect two disk array systems directly with FC connection, without host computer.

Replication

Creating a copy of data. Especially, replication indicates creating a copy of data on the storage system without related to the computer system the storage system is connected. → Snapshot

Replication Volume

A volume replicated data by replication function. → RV

RV

Replication volume.

Snapshot

Creating a copy of the storage at one point. iStorage-series disk array system is available to create Snapshot applying the data replication function
2. Overview of Data Replication and DDR/RDR

An overview of the data replication functions provided on the iStorage-series disk array system is described.

2.1 What is data replication?

The iStorage-series disk array system has a data replication function. The data replication function creates a replication volume (RV) for a master volume (MV). An RV is able to be synchronized with or separated from an MV at an arbitrary point. Synchronization gets the MV and RV to have the same contents, and update for the MV immediately reflects into the RV. Separating the RV from the MV at an arbitrary point enables the RV to retain the MV data. Use of this RV enables the system to concurrently perform backup or search processing without stopping the online processing.

Followings are the effects for applying the data replication function to the system:

- Great reduction of the system operation time during data backup processing
- Prevention of performance drop accessing to the production database during data backup processing while system operates
- Easy and quick startup for test environment using actual production data
- Increase of processing efficiency by concurrently operating production data update processing and replication data reference processing, also called load balancing
- Measures for disaster by creating replication data on remote sites

2.2 Software for data replication

DDR and RDR

The iStorage-series disk array system has two types of data replication functions: the Dynamic Data Replication (DDR) function that creates RV in the same disk array system, and the Remote Data Replication (RDR) function that creates RV into the different disk array systems. The DDR and RDR functions are provided as additional software with the iStorage-series disk array system.

Only the difference between the DDR and RDR functions is that the RV paired with the MV is in the same disk array system or in another disk array system with remote connection. As for operation, both functions provide the same visibility (operability). This enables users to easily change from DDR to RDR only with minimum modifications of parameters and without any additional usage or tools, when users expand the system configurations and would change the replication processing by applying from DDR to RDR.

If the RDR function is applied, FC-AL connection is available for remote connection between disk array systems. This FC-AL connection enables a high speed transfer rated of 2 Gbps equivalent to that of the host interface. Use of repeaters with the FC-AL connection enables the system to realize the maximum inter-system connection distance of 10 km.

Usage of data replication

The following additional software products are needed for applying the data replication function to the iStorage-series disk array system:

- DynamicDataReplication
RemoteDataReplication

The production server needs the following software product to perform replication processing for disk array systems:

- iStorageManager/ReplicationControl (available for each operating system)

In addition, a management server is needed for managing the overall storage system, and the management server needs the following product:

- iStorageManager

### 2.3 Data Replication states

Operation to select a pair of MV and RV and to create replicated data is called replication. Three types of major operations are provided by the DDR/RDR functions.

**REPLICATE**

Performs replication processing. REPLICATE copies data from the MV into RV. The RV is updated with the MV contents when REPLICATE is executed. (rpl/exec state) After that, update to the MV is synchronously reflected into the RV. (rpl/sync state) In each state during processing of REPLICATE, the RV responds ‘Not Ready’ when being accessed. This explains that the RV is unable to be applied directly for another production use.

**RESTORE**

Restores replicated data. RESTORE copies data from the RV into MV. For a pair of the MV and RV once SEPARATEd, the MV is updated with the RV contents. (rst/sync state) In other words, the MV contents at the point when SEPARATE was executed are restored. After the restore processing is completed, update to the MV is synchronously reflected into the RV in the same manner as for REPLICATE. (rst/sync state) This state is virtually equivalent to the REPLICATE/sync state.

Access to the MV at a point during reverse update processing is switched to access to the RV, and correct access is performed. In other words, the MV is available even during processing of RESTORE, which reduces execution time of the RESTORE.

In a RESTORE state, the RV responds ‘Not Ready’ when being accessed. This explains that the RV is unable to be applied directly for another production use.

**SEPARATE**

Makes the replicated data be applied for another use. Creates snapshots. This operation frees the MV and RV from REPLICATE or RESTORE state. Update to the MV after completed for SEPARATE (separated state) is not reflected into the RV. However, even in this separated state, accumulating the updates in the MV enables quick synchronization of the RV with the MV when REPLICATE or RESTORE is operated next time.

The RV is available for applying directly to another production use only when it is the separated state. The RV makes normal response when being accessed.

The history for the updates to MV would be canceled by breaking pairing.

The above operation instructions to iStorage-series disk array systems are available on a production server installed iStorageManager/ReplicationControl or a storage system management server installed iStorageManager.
2.4 Operations of Data Replication

Followings are the brief explanations of the instruction commands regarding data replication in the iStorageManager/ReplicationControl. Details for installation and command descriptions are omitted here. Please refer to the manuals.

**iSMrc_replicate**

Executes REPLICATE for a pair of MV and RV.

The RV is changed to ‘Not Ready’ state, and is unable to be accessed from the host.

**iSMrc_separate**

Executes SEPARATE for a pair of MV and RV.

The RV as well as the MV is changed to be accessible from the host.

**iSMrc_restore**

Executes RESTORE from RV to MV for a pair of MV and RV.

The RV is changed to ‘Not Ready’ state, and unable to be accessed from the host.

Updating to the MV is concurrently reflected to the RV. After completion of RESTORE, the state is the same as the REPLICATE state.

**iSMrc_query**

Displays the MV and RV states.

Replication status transition diagram is shown in Figure 2-1 on the next page.
Figure 2-1: Replication status transition diagram

- IV stands for Isolated Volume, which is not defined as MV or RV in replication processing.
3. System Configuration for OSCP

Hardware and software configurations applied for the verification tests on replication processing are shown here.

3.1 Hardware configuration

Production server (Oracle Database Server)
- Host: Sun Ultra60 (1 CPU, 512MB memory, 8GB local disk)
- Storage: iStorage S4100 or iStorage S2100
  (Two servers were used in the same hardware configurations.)

Management server (iStorageManager Management Server)
- Host: NEC Express5800/120Ra
  A management server is needed for performing replication processing.

3.2 Software configuration

Production server
- OS: Solaris 8
- Database: Oracle8i(8.1.7)
- Storage Control: iStorageManager/Replication Control

Management server
- OS: Microsoft® Windows®NT 4.0 Server
- Storage Control: iStorageManager
4. Summary of OSCP Test

Summaries of several verification tests results to utilize the backup data and to startup the replicated database based on the OSCP test are shown here.

4.1 Backup and Restore

At first, create the backup of data file / table space on RV, then restore the backup data into MV, and finally check the Oracle database operates normally.

<table>
<thead>
<tr>
<th>Location</th>
<th>Backup Method</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>local</td>
<td>cold</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>hot</td>
<td>✓</td>
</tr>
<tr>
<td>remote</td>
<td>cold</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>hot</td>
<td>✓</td>
</tr>
</tbody>
</table>

*Table 4-1: Backup and Restore*

4.2 Startup of a replicated database

At first, create the backup of necessary files on RV, then startup Oracle database using the backup data from another server, and finally check the Oracle database operates normally.

<table>
<thead>
<tr>
<th>Backup Method</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>cold backup</td>
<td>✓</td>
</tr>
<tr>
<td>hot backup</td>
<td>✓</td>
</tr>
</tbody>
</table>

*Table 4-2: Startup of a replicated database*
5. Details of the verification tests based on the OSCP Tests

In this chapter, details of the verification tests, its system configuration, the operations and some notes are described for each case of the table shown in the previous chapter with picking up an effective and typical combination of variations in the practical use. Also some extensions for each case are shown.

5.1 Database Construction for Verification and Setting of Replication Function

5.1.1 Oracle Database construction for verification tests

Installation of Oracle Database

We installed the Oracle database according to the Oracle installation guide. In general, the values of parameters are as recommended, except that we modified some parameters.

Note that the same SID is used for verification of replicated database creation by dividing the execution server of the replicated database. (That is, we have not verified for the replicated database with another SID of the same host.)

5.1.2 Settings of iStorageManager/ReplicationControl

On the normal status installed the iStorageManager/ReplicationControl, an authority of ‘super user’ is needed to operate commands. If there is no problem for operating the database, set the authority to the users such as ‘Oracle users’ to manage the Oracle environment (DBA users) for operating commands. Consult the system administrator about setting of the execution authority.

```
# usermod -G sys oracle
# cd /opt/NECiSMrc
# chmod g+x sbin
# cd sbin
# chmod g+x iSMrc_*
# chmod u+s iSMrc_*
```

(Above example shows the case that Oracle users’ (DBA user) name is ‘Oracle’.)

5.2 Backup and Restore

The procedures for using the replication function on the iStorage-series disk array system to back up the Oracle database are described. Additional enhancement method such that a replicated RV is saved on a tape should be taken in actual operation. Of course, there is no problem to use the replicated RV as a backup media.

Configuration example (with raw devices used) is shown in Figure 5-1 on the next page.
The volume to be replicated (indicated by arrow line) varies depending on the backup mode in actual operation.

<table>
<thead>
<tr>
<th>LDN</th>
<th>raw device</th>
<th>slice</th>
<th>usage</th>
<th>(mount point)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDN7</td>
<td>/dev/rdsk/c2t16d7</td>
<td>s4</td>
<td>datafile</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>s5</td>
<td>roll back seg</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>s6</td>
<td>temp</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>s7</td>
<td>system</td>
<td></td>
</tr>
<tr>
<td>LDN8</td>
<td>/dev/rdsk/c2t16d8</td>
<td>s4</td>
<td>control 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>s5</td>
<td>control 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>s6</td>
<td>Online Redo 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>s7</td>
<td>Online Redo 1</td>
<td></td>
</tr>
<tr>
<td>LDN12</td>
<td>/dev/rdsk/c2t16d12</td>
<td>s6</td>
<td>init&lt;SID&gt;.ora,archived log</td>
<td>/u02</td>
</tr>
</tbody>
</table>

**Table 5-1  Details on volumes used**

The volume for installing the execution files of the Oracle database (files that are referred to by the ORACLE_HOME environment variable) is not to be replicated.
5.2.1 Cold backup

This section explains the procedures for applying the DDR/RDR function to perform cold backup processing. The following descriptions are for the cases assuming to apply DDR function to backup volumes for data file/table space located in a raw device. Other types of operations are also described as an extension.

1) Operation status

Place a pair of volumes for which the DDR function is to be applied for cold backup processing in REPLICATE state. The following shows the results of operation commands for backup as well as for confirmation of the status:

Outline of the procedure

1-1) Confirm the SEPARATE state.

1-2) Specify the start point of REPLICATE operation.

1-3) Confirm the REPLICATE state.

1-1) Confirming the SEPARATE state

The following is an example of status display before REPLICATE operation. The command is issued to the MV.

```
1  left8% isMrc_query -mv /dev/rdsk/c2t16d7 -mvflg sfn
2
3  MV: Special File /dev/rdsk/c2t16d7
4     LD Name 200000004C517B0E0007
5     Type
6  RV: Special File /dev/rdsk/c2t16d5
7     LD Name 200000004C517B0E0005
8     Type
9  Activity State separate
10 Sync State separated
11 Copy Control State -
12 Separate Start Time 2001/07/09 18:54:28
13 Separate End Time 2001/07/09 18:54:31
14 Separate Diff 1024128KB
15 Copy Diff 0KB
16 RV Access rw
17 Previous Active sep/exec
18 left8%
```

‘Separate Diff’ on line 14 indicates the amount of write access to RV in the SEPARATE status. This is the same as the amount of actual copied data by the next REPLICATE operation.

1-2) Specifying the start point of REPLICATE operation

Before specifying the start point of REPLICATE operation, confirm that the system (including another server) does not use the volume to be defined as RV. Return to shell is delayed by the -wait option until processing is completed. In other words, when the shell prompt is displayed next time, the update for the initial difference to the RV has completed and the REPLICATE status is placed. Subsequently, update for the MV reflects into the RV immediately.
1 left8% iSMrc_replicate -mv /dev/rdsk/c2t16d7 -mvflg sfn -wait
2
3 Replicate Start 2001/07/18 15:55:24
4 MV:/dev/rdsk/c2t16d7 200000004C517B0E0007 -
5 RV:/dev/rdsk/c2t16d5 200000004C517B0E0005 -
6 Replicating...
7 Replicate Normal End 2001/07/18 15:56:14
8 MV:/dev/rdsk/c2t16d7 200000004C517B0E0007 -
9 RV:/dev/rdsk/c2t16d5 200000004C517B0E0005 -
10 left8%

1-3) Confirming the REPLICATE state

1 left8% iSMrc_query -mv /dev/rdsk/c2t16d7 -mvflg sfn
2
3 MV: Special File /dev/rdsk/c2t16d7
4 LD Name 200000004C517B0E0007
5 Type
6 RV: Special File /dev/rdsk/c2t16d5
7 LD Name 200000004C517B0E0005
8 Type
9 Activity State replicate
10 Sync State rpl/sync
11 Copy Control State foreground copy(sync)
12 Replicate Start Time 2001/07/18 15:37:52
13 Replicate End Time 2001/07/18 15:38:41
14 Separate Diff 0KB
15 Copy Diff 0KB
16 RV Access nr
17 Previous Active rpl/exec
18
19 left8%

Confirm that lines 9, 10, and 14 have changed as shown in the above. To perform cold backup processing for multiple volumes, repeat the procedure for each volume. The above operations (including status display) may be specified through iStorageManager, using the GUI tool that operates on the management server, etc. Explanation of the usage of the GUI tool is omitted here.

2) Creation of cold backup data

Outline of the procedure

2-1) Stop the Oracle database.
2-2) Execute SEPARATE.
2-3) Restart the Oracle database.

2-1) Stopping the Oracle database

Cold backup is a backup solution while the database is not operating. Thus, stop the Oracle database. Issue the command from SQL*Plus or SVRMGR. (The following is an example using SQL*Plus.)

% sqlplus
Enter user-name: internal
SQL> shutdown normal
SQL> exit
%
Command output image is omitted here. (Similarly, it is omitted in the subsequent explanation if a note is not shown.)

The Oracle database has stopped when the SQL*Plus (or SVRMGR) prompt is displayed after issuing the command.

2-2) Executing SEPARATE

Separate the volumes, which were paired by the DDR or RDR function, from each other. In other words, stop reflecting the update on MV into RV.

```
% iSMrc_separate -mv /dev/rdsk/c2t16d7 -mvflg sfn -wait
```

Return to shell is delayed by the -wait option until processing is completed. In other words, when the shell prompt is displayed next time, the MV and RV are freed from the REPLICATE status and the update on MV is not reflected into RV any more.

2-3) Restarting the Oracle database

Place the database in normal operation status. After that, a backup copy of the RV can be made on a tape, etc. Even if creation of cold backup data takes a long time because of a huge database, a backup copy to tapes is available after restart of production. In other words, the time for stopping the database operation would be minimized.

Issue the command from SQL*Plus or SVRMGR. (The following is an example using SQL*Plus.)

```
% sqlplus
Enter user-name: internal
SQL> startup pfile=/u03/snapdata/initSNAP1.ora
SQL> exit
%
```

Note that the description /u03/snapdata/initSNAP1.ora should be modified in accordance with the actual configuration.

3) Use of cold backup data

**Outline of the procedure**

3-1) Execute RESTORE.

3-2) Recovery and restart of the Oracle database.

Because this is a recovery of database, the original database is in halted state.

3-1) Executing RESTORE

Restore the data by using the DDR/RDR function.

```
% iSMrc_restore -mv /dev/rdsk/c2t16d7 -mvflg sfn -wait
% iSMrc_separate -mv /dev/rdsk/c2t16d7 -mvflg sfn -wait
```

In the above example, the purpose of SEPARATE operation continuing after RESTORE is to save the whole RV created for backup without modifying the contents. The RESTORE status for the iStorage-
series disk array system is completely the same as the REPLICATE status when the RESTORE operation is completed (difference = 0), and starts copying updated data on the MV to the RV. Thus the RV also may be updated in case of without issuing the SEPARATE command. Of course, if the RV is not needed to save because of an existence of backup to tapes, the SEPARATE operation is not needed too. In this case, note that the status display through iSMrc_query shows ‘rst/sync’. Even in the status, the system operates in the same manner as the ‘rpl/sync’ state.

3-2) Recovering and restarting the Oracle database

By the operation in step 3-1, the contents of the volume containing the data file and table space for the Oracle database are recovered to the backed-up point. To start the Oracle database, just apply the archived log and online redo log in another volume to this data file.

Outline of the procedure for SQL operation

- a) Start the database without opening.
- b) Recover the database. (Apply the logs.)
- c) Open the database.

Example in the verification test

```bash
% sqlplus
Enter user-name: internal
SQL> startup mount pfile=/u02/snapfile/initSNAP1.ora; --- a)
SQL> recover automatic database; --- b)
SQL> alter database open; --- C)
SQL> exit
%
```

In this verification test, because both logs (Archived/Online redo) are set to be securely stored in another volume, the database could be restored with minimum operation.

Extension 1) Creation of cold backup on remote storage

iStorageS4100 has a function to use volumes on remote storage as RVs for cold backup. The REPLICATE, RESTORE, and SEPARATE instructions and the commands for status display used in the above procedures are available regardless of the configuration of the defined pair of volumes. Therefore RDR is available with completely the same operations as DDR if only to define a pair of volumes for remote storage. See the following example for RDR displayed by the status display command:

```bash
1  left8% iSMrc_query -mv /dev/rdsk/c2t16d1 -mvflg sfn
2 3 MV: Special File /dev/rdsk/c2t16d1
4   LD Name 200000004C517B0E0001
5   Type
6 RV: Special File -
7   LD Name 200000004C517B580001
8   Type
9 Activity State separate
10 Sync State separated
11 Copy Control State -
12 Separate Start Time 2001/07/13 09:33:05
13 Separate End Time 2001/07/13 09:33:05
14 Separate Diff 0KB
15 Copy Diff 0KB
```
Displayed are the different volumes from the ones on the previous test. No special file name is displayed for the RV on line 6 because the RV is not connected to this server, and the LD name displayed on line 7 is different from the one managed in the disk array system. This is because you can find this volume pair setting for the case of RDR.

**Figure 5-2 : Configuration example for remote storage**

**Extension 2) Cold backup and restore for the whole database**

In addition to the above example, the following shows notes on using the DDR/RDR function to back up all the related files in the database as cold backup:

Files to be backed up are:

- Data file and table space (same as for the above example)
- Archived logs
- Control files
- Online Redo logs

The advantages to apply the DDR or RDR function compared with the case for applying general copy tool are as follows:
- Less load to the host computer because DDR/RDR is executed within disk array systems
- High speed

The procedure for creating cold backup data is the same as the one for only the data file and table space. Apply the SEPARATE procedure to volumes for backup besides the data file also. Since the Oracle database is stopped, consistency among the files or data items is maintained.

Note that database restore for not only data files but the control files, archived logs, and Online Redo logs means that the data is rolled back to the point when the backup data was created.

Recovery processing is not needed for restarting the restored database. (It is the same as to restart from the point when it stopped for backup data creation.)

5.2.2 Hot backup

This section explains the procedures for applying the DDR/RDR function to perform hot backup (or online backup) processing. The following descriptions are for the cases assuming to apply DDR function to backup volumes for data file / table space located in a raw device. Other types of operations are also described as an extension.

System configurations are the same as Cold backup (see Figure 5-1 and Table 5-1)

1) Operation status

Place a pair of volumes for which the DDR function is to be applied for hot backup processing. The following shows the results of operation commands for backup as well as for confirmation of the status:

Outline of the procedure

1-1) Confirm the SEPARATE state.
1-2) Specify the start point of REPLICATE operation.
1-3) Confirm the REPLICATE state.

1-1) Confirming the SEPARATE state

The following is an example of status display before REPLICATE operation. The command is issued to the MV.

```
1 left8% iSMrc_query -mv /dev/rdsk/c2t16d7 -mvflg sfm
2
3   MV: Special File /dev/rdsk/c2t16d7
4     LD Name 200000004C517B0E0007
5     Type
6   RV: Special File /dev/rdsk/c2t16d5
7     LD Name 200000004C517B0E0005
8     Type
9   Activity State separate
10   Sync State separated
11   Copy Control State -
12   Separate Start Time 2001/07/09 18:54:28
13   Separate End Time 2001/07/09 18:54:31
14   Separate Diff 1024128KB
```
‘Separate Diff’ on line 14 indicates the amount of write access to RV in the SEPARATE status. This is the same as the amount of actual copied data by the next REPLICATE operation.

1-2) Specifying the start point of REPLICATE operation

Before specifying the start point of REPLICATE operation, confirm that the system (including another computer) does not use the volume to be defined as RV. Return to shell is delayed by the -wait option until processing is completed. In other words, when the shell prompt is displayed next time, the update for the initial difference to the RV has completed and the REPLICATE status is placed. Subsequently, update for the MV reflects into the RV immediately.

```
1 left8% iSMrc_replicate -mv /dev/rdsk/c2t16d7 -mvflg sfn -wait
2
3  Replicate Start 2001/07/18 15:55:24
4  MV:/dev/rdsk/c2t16d7 200000004C517B0E0007 -
5  RV:/dev/rdsk/c2t16d5 200000004C517B0E0005 -
6  Replicating...
7  Replicate Normal End 2001/07/18 15:56:14
8  MV:/dev/rdsk/c2t16d7 200000004C517B0E0007 -
9  RV:/dev/rdsk/c2t16d5 200000004C517B0E0005 -
10 left8%
```

1-3) Confirming the REPLICATE state

```
1 left8% iSMrc_query -mv /dev/rdsk/c2t16d7 -mvflg sfn
2
3  MV: Special File /dev/rdsk/c2t16d7
4       LD Name 200000004C517B0E0007
5       Type
6  RV: Special File  /dev/rdsk/c2t16d5
7       LD Name 200000004C517B0E0005
8       Type
9  Activity State replicate
10  Sync State rpl/sync
11  Copy Control State foreground copy(sync)
12  Replicate Start Time 2001/07/18 15:37:52
13  Replicate End Time 2001/07/18 15:38:41
14  Separate Diff 0KB
15  Copy Diff 0KB
16  RV Access nr
17  Previous Active rpl/exec
18
19 left8%
```

Confirm that lines 9, 10, and 14 have changed as shown in the above. To perform hot backup processing for multiple volumes, repeat the procedure for each volume. The above operations (including status display) may be specified through iStorageManager, using the GUI tool that operates on the management server, etc. Explanation of the usage of the GUI tool is omitted here.
2) Creation of hot backup data

Outline of the procedure

2-1) Begin the hot backup mode.
2-2) Execute SEPARATE.
2-3) End the hot backup mode.

2-1) Beginning the hot backup mode

Place each table space of the operating database in hot backup mode. Issue the command from SQL*Plus or SVRMGR. (The following is an example using SQL*Plus.)

```
% sqlplus
Enter user-name: internal
SQL> alter tablespace rbs begin backup;
SQL> alter tablespace temp begin backup;
SQL> alter tablespace system begin backup;
SQL> alter tablespace snapdata begin backup;
SQL> exit
```

The above example performs hot backup processing for all the table spaces of the database. If a volume is divided for each table space, backup processing for each table space is also available.

2-2) Executing SEPARATE

Separate the volumes, which were paired by the DDR or RDR function, from each other. In other words, stop reflecting the update on MV into RV.

```
% isMrc_separate -mv /dev/rdsk/c2t16d7 -mvflg sfn -wait
```

Return to shell is delayed by the -wait option until processing is completed. In other words, when the shell prompt is displayed next time, the MV and RV are freed from the REPLICATE status and the update on MV is not reflected into RV any more.

2-3) Ending the hot backup mode

The database returns into a normal operation status. At this time, a backup copy of the RV on tapes etc. is available. If the replication function is applied, the hot backup mode need not to be continued until completion of backup processing for tapes, which makes it possible to minimize the time for hot backup mode. That is, influence on production would be minimized.

Issue the command from SQL*Plus or SVRMGR. (The following is an example using SQL*Plus.)

```
% sqlplus
Enter user-name: internal
SQL> alter tablespace snapdata end backup;
SQL> alter tablespace system end backup;
SQL> alter tablespace temp end backup;
SQL> alter tablespace rbs end backup;
SQL> exit
```

Be sure to perform ‘end backup’ processing for all the table spaces that were placed in hot backup.
mode at the beginning of hot backup.

3) Use of hot backup data

Outline of the procedure

3-1) Execute RESTORE.

3-2) Recovery and restart the Oracle database.

Database restoration is carried out while the source database is in stopped state.

3-1) Executing RESTORE

Restore the data by using the DDR/RDR function.

```
% iSMrc_restore -mv /dev/rdsk/c2t16d7 -mvflg sf -wait
% iSMrc_separate -mv /dev/rdsk/c2t16d7 -mvflg sf -wait
```

In the above example, the purpose of SEPARATE operation continuing after RESTORE is to save the whole RV created for backup without modifying the contents. The RESTORE status for the iStorage-series disk array system is completely the same as the REPLICATE status when the RESTORE operation is completed ( difference = 0 ), and starts copying updated data on the MV to the RV. Thus the RV also may be updated in case of without issuing the SEPARATE command. Of course, if the RV is not needed to save because of an existence of backup to tapes, the SEPARATE operation is not needed too. In this case, note that the status display through iSMrc_query shows ‘rst/sync’. Even in the status, the system operates in the same manner as the ‘rpl/sync’ state.

3-2) Recovering and restarting the Oracle database

By the operation in step 3-1, the contents of the volume containing the data file and table space for the Oracle database are recovered to the backed-up point. To start the Oracle database, just apply the archived logs and online redo logs in another volume to this data file.

Outline of the procedure for processing SQL operation

- a) Start the database without opening.
- b) Recover the database. (Apply the logs.)
- c) Open the database.

Example in the verification test

```
% sqlplus
Enter user-name: internal
SQL> startup mount pfile=/u02/snapfile/initSNAP1.ora;       --- a)
SQL> recover automatic database;                        --- b)
SQL> alter database open;                                --- c)
SQL> exit
%
```

In this verification test, because both logs (Archived/Online redo) are set to be securely stored in another volume, the database could be restored with minimum operation.
Extension 1) Creation of hot backup on remote storage

iStorageS4100 has a function to use volumes on remote storage as RVs for hot backup. The REPPLICATE, RESTORE, and SEPARATE instructions and the commands for status display used in the above procedures are available regardless of the configuration of the defined pair of volumes (see Figure 5-2). Therefore RDR is available with completely the same operations as DDR if only to define a pair of volumes for remote storage. See the following example for RDR displayed by the status display command:

```
 1 left8% iSMrc_query -mv /dev/rdsk/c2t16d1 -mvflg sf
 2
 3   MV: Special File /dev/rdsk/c2t16d1
 4       LD Name 200000004C517B0E0001
 5       Type
 6   RV: Special File -
 7       LD Name 200000004C517B580001
 8       Type
 9       Activity State separate
10       Sync State separated
11       Copy Control State -
12       Separate Start Time 2001/07/13 09:33:05
13       Separate End Time 2001/07/13 09:33:05
14       Separate Diff 0KB
15       Copy Diff 0KB
16       RV Access rw
17       Previous Active sep/exec
18
19  left8%
```

Displayed are the different volumes from the ones on the previous test. No special file name is displayed for the RV on line 6 because the RV is not connected to this server, and the LD name displayed on line 7 is different from the one managed in the disk array system. This is because you can find this volume pair setting for the case of RDR.

For the example of system configuration on this case, refer to the case for cold backup on remote storage as described in Extension 1) Fig. 5-2 in the 'cold backup' section.
5.3 **Startup of a replicated database**

Startup of a replicated database by using the replicated data is available as one of the applications for a replicated database.

A replicated database is used for the followings:

- Divide of production (such as load balancing by assigning the replicated database as a search-only database)
- Simulation on the replicated database
- Startup of a backup database

Procedure to startup a replicated database is as follows:

- **Creation of backup data**
  1) Stop database operation.
  2) Backup data of the database on a backup media.
  3) Restart database operation.

- **Startup of the replicated database** (Followings are the operations on the production server for the replicated database)
  1) Prepare the volumes on the replicated database.
  2) Startup the replicated database.

The conventional method took much more time because the backup data was saved on tapes, etc. in step 2 in creation of backup data. Also the method was not applicable and practical because of a huge amount of data. iStorage-series disk array systems now provide the replication functions for solving the conventional problems. The replication functions enable creation of a replicated database with only a brief stop of production database or without stopping the production database by applying the hot backup function. And also iStorage-series disk array systems provide a solution to startup the replicated database as a ‘copied’ database parallel to the production database. This section explains the procedures, and shows the results of the verification tests.

The production server for the replicated database may be called as a backup server.

Configuration example for copied database (with raw devices used) is shown in Figure 5-3 on the next page.
**Figure 5-3**: Configuration example for copied database (with raw devices used)

**Table 5-2**: Details on volumes used

<table>
<thead>
<tr>
<th>LDN</th>
<th>raw device(left8)</th>
<th>slice</th>
<th>usage</th>
<th>(mount point)</th>
<th>raw device (right8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDN7</td>
<td>/dev/rdsk/c2t16d7</td>
<td>s4</td>
<td>datafile</td>
<td></td>
<td>/dev/rdsk/c2t0d5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>s5</td>
<td>roll back seg</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>s6</td>
<td>temp</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>s7</td>
<td>system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDN8</td>
<td>/dev/rdsk/c2t16d8</td>
<td>s4</td>
<td>control 1</td>
<td></td>
<td>/dev/rdsk/c2t0d6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>s5</td>
<td>control 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>s6</td>
<td>Online Redo 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>s7</td>
<td>Online Redo 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDN12</td>
<td>/dev/rdsk/c2t16d12</td>
<td>s6</td>
<td>init&lt;SID&gt;.ora,.archived Log</td>
<td>/u02</td>
<td>/dev/rdsk/c2t0d22</td>
</tr>
</tbody>
</table>

### 5.3.1 Starting up a replicated database using cold backup processing

Stop the Oracle database, and create a replicated database by applying the replication function of the iStorage-series disk array system. Use of the replication function enables to minimize the time for stopping the production database.

It is easy and certain for the installation and settings of Oracle on the replicated database to be the
same as on the production database. The procedure up to create the replicated database is the same as for the procedure for cold backup processing. However, note that not only data files but all the volumes of archived logs, control files, and Online Redo logs are also to be replicated.

The Oracle database SW (e.g., execution files) should be installed on the backup server beforehand. The replication function does not copy any files of the Oracle database SW.

1) Starting up a replicated database using cold backup processing

The same procedure as for creating cold backup data (already explained) is applied for creating backup data. Archived logs and control files are to be backed up as well as data files and table spaces. The backup data is not applied for the restore procedure, but is applied as the MV on the other production server (backup server), which makes the Oracle database on the other production server to start up. For our iStorage-series disk array system, each RV is available to be accessed directly even from another server on SEPARATE status.

Outline of the procedure

■ Creation of backup data
  1) Same as for normal cold backup procedure

■ Startup of a replicated database (Following are the operations on the production server for the replicated database)
  1) Mount the archived log volume.
  2) Change the path names of control files included in init<SID>.ora (if necessary).
  3) Startup the database.

Operation for database startup

If the paths for device names or file names on production database and the paths for those on replicated database are different because of the access from different servers, it is needed to change the names of files (e.g., data file) through SQL*Plus or SVRMGR.

Outline of the procedure for SQL operation

■ a) Start the database without opening.
■ b) Change the path to the data files.
■ c) Open the database.

Example for the case of applying a raw device for data files is shown below.

```sql
% sqlplus
Enter user-name: internal
SQL> startup restrict mount pfile=/u02/snapfile/initSNAP1.ora      --- a)
SQL> alter database rename file '/dev/rdsk/c2t16d7s4' to '/dev/rdsk/c2t0d5s4';
2> alter database rename file '/dev/rdsk/c2t16d7s5' to '/dev/rdsk/c2t0d5s5';
3> alter database rename file '/dev/rdsk/c2t16d7s6' to '/dev/rdsk/c2t0d5s6';
4> alter database rename file '/dev/rdsk/c2t16d7s7' to '/dev/rdsk/c2t0d5s7';
5> alter database rename file '/dev/rdsk/c2t16d8s6' to '/dev/rdsk/c2t0d6s6';
6> alter database rename file '/dev/rdsk/c2t16d8s7' to '/dev/rdsk/c2t0d6s7';      --- b)
6> alter database open;              --- c)
SQL> exit
```
Caution

In the above example, the copied RV is applied as a production volume for the replicated database. This environment makes the production database to operate without RV. (Which is not a good operation.) iStorage-series disk array system also has a function to create multiple RVs for MV simultaneously. Therefore this function would enable a replicated volume to keep as late a status as possible by alternately applying two RVs for the replicated database.

The replication functions of the iStorage-series disk array systems operate at a high speed. Thus, even if SEPARATE is executed after REPLICATE during creation of a replicated database, the systems enable to complete processing in a much shorter time than saving to other tape devices. This is because the operations as explained here are well practical.

5.3.2 Starting up a replicated database using hot backup processing

Create a replicate database by using the replication function of the iStorage-series disk array system with the Oracle database in hot backup mode. Combination of the replication function and the hot backup function of the Oracle database enables to create the replicated database without stopping the production database.

It is easy and certain for the installation and settings of Oracle on the replicated database to be the same as on the production database. The procedure up to create the replicated database is the same as for the procedure for hot backup processing. However, note that not only data files but all the volumes of archived logs are also to be replicated.

The Oracle database SW (e.g., execution files) should be installed on the backup server beforehand. The replication function does not copy any files of the Oracle database SW.

1) Starting up a replicated database using hot backup processing

The same procedure as for creating hot backup data (already explained) is applied for creating backup data. Archived logs are to be backed up as well as data files and table spaces. The backup data is not applied for the restore procedure, but is applied as the MV on the other production server (backup server), which makes the Oracle database on the other production server to start up. For our iStorage-series disk array system, each RV is available to be accessed directly even from another server on SEPARATE status.

For the case of creating backup data including log files on hot backup mode, same as the case of creating backup data for overall database on cold backup mode, the database should be restored at a specific point. The specific point should be selected from the following 3 cases.

- Apply whole archived logs that are effective until the last
- Time specification
- SCN specification

For any case of the above selected, it is needed to confirm the results of backup when creating the backup data and to specify the above when restoring.

In addition, because the control files restored from the backup data are not available on hot backup mode, the control files need to be created at startup of the replicated database. Also only archived logs are applicable for logs. As a result, it may cause "incomplete recovery", however this would not be a problem considering the purpose of this procedure. (This is not the case for data loss on disaster
Outline of the procedure

- Creation of backup data
  1) Setting of hot backup mode
  2) Hot backup for data files and table spaces.
  3) Terminate the hot backup mode.
  4) Specify the restore point and confirm the results of hot backup

- Startup of a replicated database (Following are the operations on the production server for the replicated database)
  1) Separate the archived log volumes and mount to the server for copied database.
  2) Change the path names of control files included in init<SID>.ora.
  3) Apply the archived log volumes confirmed on the 4) step of the ‘Creation of backup data’ to the replicated database.
  4) Startup the replicated database.

Operation for backup data creation

The following explains the procedure for the case of applying whole archived logs that are effective until the last point. To confirm the archived log numbers, the procedure to switch logfile should be applied. Consequently, it is sure to obtain all available archived log numbers.

Outline of the procedure for SQL operation

- a) Switch logfile.
- b) Confirm the archived log number.

Example in the verification test

```
SQL> alter system switch logfile;        --- a)
System altered
SQL> archive log list
Database log mode Archive Mode
Automatic archival Enabled
Archive destination /u02/snapfile/arch
Oldest online log sequence 489       --- b)
Next log sequence to archive 490
Current log sequence 490
SQL>
```

489 is the last archived log number to be obtained.

Operation for database startup

If the paths for device names or file names on production database and the paths for those on replicated database are different because of the access from different servers, it is needed to change the names of files (e.g., data file) through SQL*Plus or SVRMGR.

Control files should be newly created when starting up the replicated database. Also specify the RESETLOGS option to open the database.
Outline of the procedure for SQL operation

- a) Start the database without opening.
- b) Create the control files for the replicated database.
- c) Recover the database. (Apply the logs.)
- d) Open the database specifying the RESETLOGS option.

Example in the verification test. This is for SVRMGR operation.

```sql
% svrmgrl
SVRMGR> connect internal
Connected.
SVRMGR> startup nomount pfile=/u02/snapfile/initSNAP1.ora --- a)
SVRMGR> create controlfile resetlogs database "SNAP1" archivelog --- b)
2> logfile group 1 ('/u04/snapredo/log1SNAP1.ora') size 1M,
3> group 2 ('/u04/snapredo/log2SNAP1.ora') size 1M,
4> group 3 ('/u04/snapredo/log3SNAP1.ora') size 1M
5> datafile '/dev/rdsk/c2t0d5s4', '/dev/rdsk/c2t0d5s5',
6> '/dev/rdsk/c2t0d5s6', '/dev/rdsk/c2t0d5s7';
Statement processed.
SVRMGR> recover database until cancel using backup controlfile --- c)
ORA-00279: change 88804 generated at 07/09/2001 19:11:08 needed for thread 1
ORA-00289: suggestion : /u02/snapfile/arch/arc0000000482.0001
ORA-00280: change 88804 for thread 1 is in sequence #482
Specify log: {<RET>=suggested | filename | AUTO | CANCEL}
(<RET>)
Log applied.
ORA-00279: change 89655 generated at 07/09/2001 19:11:27 needed for thread 1
ORA-00289: suggestion : /u02/snapfile/arch/arc0000000482.0001
ORA-00280: change 88804 for thread 1 is in sequence #482
Specify log: {<RET>=suggested | filename | AUTO | CANCEL}
(<RET>)
Log applied.
ORA-00279: change 89838 generated at 07/09/2001 19:11:30 needed for thread 1
ORA-00289: suggestion : /u02/snapfile/arch/arc0000000489.0001
ORA-00280: change 88804 for thread 1 is in sequence #489
ORA-00278: log file '/u02/snapfile/arch/arc0000000488.0001' no longer needed for this recovery
Specify log: {<RET>=suggested | filename | AUTO | CANCEL}
(<RET>)
Log applied.
ORA-00279: change 89838 generated at 07/09/2001 19:11:30 needed for thread 1
ORA-00289: suggestion : /u02/snapfile/arch/arc0000000490.0001
ORA-00280: change 89838 for thread 1 is in sequence #490
ORA-00278: log file '/u02/snapfile/arch/arc0000000489.0001' no longer needed for this recovery
Specify log: {<RET>=suggested | filename | AUTO | CANCEL}
cancel
Media recovery cancelled.
SVRMGR> alter database open resetlogs; --- d)
Statement processed.
SVRMGR> exit
```

As shown in the above, after applying the logs until 489 and operating CANCEL, then opening the database with the RESETLOGS option, the Oracle database is activated normally.

Examples of two other selections are omitted here. The operation to confirm SCN is given here for reference.

```sql
SQL> select * from v$log_history;
```
Caution

In the above example, the copied RV is applied as a production volume for the replicated database. This environment makes the production database to operate without RV. (Which is not a good operation.) iStorage-series disk array system also has a function to create multiple RVs for MV simultaneously. Therefore this function would enable a replicated volume to keep as late a status as possible by alternately applying two RVs for the replicated database.

The replication functions of the iStorage-series disk array systems operate at a high speed. Thus, even if SEPARATE is executed after REPLICATE during creation of a replicated database, the systems enable to complete processing in a much shorter time than saving to other tape devices. This is because the operations as explained here are well practical.
6. Supplementary information for iStorage S2100

We applied iStorage-series S4100 as storage device in the above verification tests. For local backup procedures applied by DDR functions, iStorage S2100 series is also available with completely the same manner as described above applying iStorage S4100 series. However, since the S2100 series doesn’t have the RDR functions, backup procedures to the remote site is not available.

Followings are the summary of main differences between S4100 series and S2100 series.

<table>
<thead>
<tr>
<th></th>
<th>S4100 Series</th>
<th>S2100 Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Replication</td>
<td>DDR and RDR</td>
<td>Only DDR</td>
</tr>
<tr>
<td>Max. Num. Of FC ports</td>
<td>32ports</td>
<td>4ports</td>
</tr>
<tr>
<td>Max. Volumes Capacity</td>
<td>31TB</td>
<td>9TB</td>
</tr>
</tbody>
</table>

7. Reference


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