

RmanJ

A Java-based Control Utility for Oracle® Recovery Manager

User Guide for RmanJ Version 2.0

April 16, 2017

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Synopsis

RmanJ is a feature-rich Java-based control utility for Oracle Recovery Manager (RMAN). It works with both Oracle Database Standard Edition (SE) and Oracle Database Enterprise Edition (EE). RmanJ is a general purpose control utility for RMAN-based copy, backup, recover, and restore operations – in fact it is capable of dispatching all the commands that RMAN supports. RmanJ excels when used to enable parallel copy, backup, and restore operations with Oracle Database Standard Edition thus allowing RMAN-based operations to complete orders of magnitude faster than serial operations offered by Oracle RMAN in a Standard Edition environment.

Moreover RmanJ includes a comprehensive set of locking, monitoring and reporting features rarely, if ever, found in backup scripts that invoke Oracle RMAN. Typically each company or site that operates Oracle RDBMS instances codes its own control script for Oracle RMAN. Over the years the creators of RmanJ have encountered many such scripts at customer sites with significant numbers of those scripts exhibiting shortcomings such as:

- Failure to check the return code from RMAN.
- Highly sensitive passwords such as the password for the omnipotent user SYS stored in clear text either in the backup script itself or in a configuration file.
- No locking to prevent concurrent execution of the same or similar copy or backup operation.
- No notification of backup failures via e-mail.
- Backup performed after connecting to an RMAN backup catalog which makes the backup fail should the catalog become unavailable.

All the shortcomings mentioned above are addressed and resolved by RmanJ. However RmanJ doesn't stop there. It includes many more useful features and removes the burden of coding and maintaining a company or site-specific backup script.

Parallel Operations in an Oracle Standard Edition Environment

Any RMAN-based copy, backup, or restore operation requires a so-called channel to transfer data between a database file and an RMAN backup piece (i. e. part of a larger backup) and vice versa. While Oracle EE places no practical restriction on the number of parallel channels used by a single invocation of RMAN¹, Oracle SE does not allow parallel use of channels per RMAN invocation at all. Hence RMAN operations in an Oracle SE environment cannot leverage the speed of today's CPUs as well as the data transfer bandwidths of today's disk storage subsystems. RmanJ overcomes the single channel limitation of Oracle SE by controlling many invocations of RMAN in parallel using Java's support for multithreading. Load balancing across many invocations of RMAN occurs at the data file level. All the data files involved in an RMAN operation are enqueued into a thread-safe queue. Multiple threads then dispatch individual data files to available RMAN invocations. Whenever an RMAN invocation finishes handling one of the data files it signals completion using the message code RMAN-03091. The message is received by one of RmanJ's threads which then hands off the next data file to RMAN until all data files have been processed. Note that RMAN invocations are reused to optimize performance and to avoid the overhead of starting and stopping RMAN processes.

Features

The following is a list of the most prominent features of RmanJ.

- Parallel copy, backup, duplicate², and restore operations for Oracle Standard Edition (SE).

1 There is a limitation of about 64 concurrent RMAN processes. See errors RMAN-06900 and ORA-19921: maximum number of 64 rows exceeded

2 The RMAN command DUPLICATE cannot be parallelized by RmanJ. However a manual parallel database duplication

- Password encryption
- Reporting
- Support for the SYSBACKUP privilege introduced in Oracle 12c
- Monitoring of RMAN status and progress (including throughput when feasible)
- Archived log backups on an as-needed basis depending either on the fill level or the remaining free space of all archive destinations to avoid unnecessary use of resources such as tape drives while sufficient free space is available within all archive destinations
- Notification via e-mail
- Parser for RMAN output that recognizes RMAN error stacks and maintains a counter of errors.
- Support for archived log shipping and immediate or delayed archive log apply to a standby database in non Enterprise Edition environments where Oracle Data Guard is not available.

Terminology

Oracle RMAN supports connections to three different categories of Oracle RDBMS instances:

- Auxiliary instance
- Catalog instance
- Target instance

A target instance is an RDBMS instance that has mounted or opened a database where a copy, backup, or restore operation will be undertaken. A catalog instance is an RDBMS instance that has opened a database containing an RMAN catalog in read-write mode. An RMAN catalog is a collection of tables and views that replicate information in the control file of a target database.

An auxiliary instance is an RDBMS instance used for duplicating a database. The designations target and catalog also apply to the databases mounted or opened by the respective instances. As suggested by the adjective auxiliary, an auxiliary instance is used only temporarily during database duplication. Once duplication is complete the same instance may be used as a standby instance that mounts a standby database – a duplicate of the target database that is kept more or less current using archived logs shipped from the so-called primary database (former target database during duplication). Note that Oracle RMAN also supports database duplication without a connection to a target instance.

In the context of the Oracle RDBMS an OSDBA group is an operating system group whose members can connect to an RDBMS instance through operating system authentication using the syntax `CONNECT / AS SYSDBA` without entering a password. An OSOPER group is used in a similar fashion except that it enables `CONNECT / AS SYSOPER` without entering a password. Oracle documentation suggests the group names `dba` and `oper` for the OSDBA and OSOPER group names respectively. Starting with Oracle12 it is also possible to configure password-less connectivity using the command `CONNECT / AS SYSBACKUP`. The `SYSBACKUP` privileges is much more restrictive than the `SYSDBA` privilege.

System Requirements

RmanJ is written in the Java programming language. It requires a Java run-time environment to execute the code.

Operating System

RmanJ runs on any operating system that supports a Java Standard Edition (SE) run-time environment. RmanJ has been tested successfully on the following operating system platforms:

can be implemented using RMAN commands and RmanJ.

- Linux x86_64
- Windows 7
- Windows Server 2008 R2 Enterprise

ORADBPRO GmbH is confident that RmanJ will work equally well on AIX, HP-UX, and Solaris due to the portability of Java.

Java

RmanJ runs with Java 1.8 or newer run-time environment. To determine the version of Java on your system use the command `java -version`:

```
$ java -version
java version "1.8.0_73"
Java(TM) SE Runtime Environment (build 1.8.0_73-b02)
Java HotSpot(TM) 64-Bit Server VM (build 25.73-b02, mixed mode)
```

Any Unix-like platform supported by the Oracle RDBMS is also suitable for RmanJ. RmanJ has been verified to run on Linux. It should also run on IBM AIX, Hewlett-Packard HP-UX, and Oracle Solaris (both Sparc and Intel based).

Note that each Oracle RDBMS installation includes a Java SDK. However the version of the included SDK is 1.6 even in a 12c Oracle home with release 12.1.0.2. Thus a Java installation separate from the one in an Oracle home is required.

JDBC

RmanJ uses the JDBC OCI driver to connect to the target RDBMS instance. It locates a suitable JDBC driver file within the same Oracle home where the rman executable resides and automatically adds the JDBC driver file to the Java virtual machine's class path.

Oracle RDBMS Installation

Since RmanJ invokes Oracle RMAN both need to reside on the same system. An Oracle Database Client installation is sufficient as long as it includes Oracle Recovery Manager. In other words there is no requirement to run RmanJ locally on the same system where the target instance resides. The version of RMAN used by RmanJ must be compatible with the RDBMS versions of all instances accessed with RMAN. Please refer to the RMAN compatibility matrix in the *Backup and Recovery Reference*.

Installation

RmanJ is distributed as a Zip file. To install RmanJ simply unzip the Zip file in a directory of your preference, e. g. /opt or /usr/local on a Unix system:

```
$ unzip rmanj-1.0-2016-02-15.zip
```

The Zip file contains a sub-directory called `rmanj`. This is the base directory for the entire installation of RmanJ. Please do not rename the top level directory extracted from the zip file. Also please do not use `unzip -j` to extract all files into a single directory.

Installation Directory Structure

An RmanJ installation contains the following subdirectories:

```
$ ls -F rmanj
bin/  doc/  lib/  license/  samples/
```

The directory `bin` contains an executable shell script wrapper for invoking RmanJ. Thus RmanJ is invoked using the command `rmanj/bin/rmanj` (or an absolute path that ends in the same directory and file names). The directory `doc` contains the RmanJ User Guide in PDF format. The directory `lib` contains Java class li-

braries. RmanJ will work only if a valid license file by the name of license.lic is present in the subdirectory license. The subdirectory samples contains several examples of RmanJ property files that may be used as a starting point to configure your own copy, backup, or restore operations with RmanJ.

Environment Variables

RmanJ does not require any environment variables as long as the directory where the program java (version 1.8 or newer) resides is already part of the command search path. In other words as long as the environment variable PATH contains a directory where a java binary with version 1.8 or newer resides, no further environment variables need to be set. However RmanJ can use the environment variables ORACLE_HOME, ORACLE_SID, NLS_LANG, NLS_DATE_FORMAT, RMANJ_JAVA_HOME, and TEMP. Yet these environment variables are not mandatory.

The environment variables ORACLE_HOME, ORACLE_SID, NLS_LANG, NLS_DATE_FORMAT have all been supported by the Oracle RDBMS for years, so I will present them only briefly here and ask the reader to look up further information in the *Oracle Database Reference* and the *Oracle SQL Language Reference* manuals.

ORACLE_HOME is the installation directory of an Oracle RDBMS release. ORACLE_SID is the system identifier of an Oracle RDBMS instance. NLS_LANG has three components – language, territory, and character set, e. g. AMERICAN_AMERICA.WE8ISO8859P1. NLS_DATE_FORMAT is a format specification for data and time, e. g. on the first day of the year 2016 at 12 noon the specification DD-Mon-YYYY HH24:MI:SS would yield 1-Jan-2016 12:00:00.

If the environment variable RMANJ_JAVA_HOME is set it will be used to locate the executable for starting a Java virtual machine, i. e. java on Unix-like systems and java.exe on Windows.

If the environment variable TEMP is set it will be used as the base directory for creating a lock file to guard against concurrent execution of multiple instances of RmanJ against the same database (identified by database ID). If TEMP is not set the default directory on Unix-like systems is “/tmp”. On Windows TEMP is usually set to something like “C:\Users\\AppData\Local\Temp”. If TEMP is not set on Windows then RmanJ will use “C:\temp”.

Obtaining a License

RmanJ only works in conjunction with a valid license file that encodes certain characteristics of each customer site. To obtain a license file, three pieces of information must be provided to the vendor:

1. The company name of the licensee.
2. The database identifiers (DBIDs) of one or more databases. RmanJ operations are restricted to database IDs incorporated into the license file.
3. The name of the operating system platform where RmanJ runs.

Item two is obtained by querying V\$DATABASE.

```
SELECT dbid
FROM sys.v_$database;
```

Item three is obtained by invoking RmanJ with the command `rmanj -h` and noting the operating system platform name within the banner printed as part of RmanJ start-up. An RmanJ banner looks as shown below:

```
RmanJ startup on 24-Feb-2016 19:39:57 - Version 1.0 (RCS revision 1.32) built by
ORADBPRO GmbH on 2016/02/24 17:02:17 is executed by JVM with PID 16751 on host devsrv
running operating system Linux
```

The operating system platform as seen by Java is the last piece of information on the line above.

A license file is a plain text file named license.lic. A sample license file is reproduced below:

```

licensee=Company Inc.
license_version=1
licensor=ORADBPRO GmbH
rmanj_version=1.0
lic_db_id_list=1641612861
lic_os_platform=Linux
Expiration=2116-3-9

```

```

Signature=302C02140A188F9375C29D7917C5CC4D1A2B024CCAEE275602143EFC5E0A41269F4EB9FE6A6
25BE3A41ACEE46BA1

```

The license file contains the three pieces of information that characterize the customer's environment (company name, database ID, platform), an expiration date, and some further information.

Configuration

RmanJ requires access to a Java property file that contains several property names and values.

Property File

The file `rmanj/samples/sample-rmanj.properties` may be used as a template to create a customized property file. See Table 1 for the supported property names and their meanings. Note that each property that appears in a property file must have a value. In other words a line that ends in an equality sign (=) is considered incorrect syntax.

Property Name	Meaning
<code>archlog_backup_cmd</code>	RMAN command specification for an archived log backup (BACKUP ARCHIVELOG)
<code>auxiliary_connect_string</code>	Oracle Net connect string for an auxiliary instance
<code>auxiliary_connect_string2</code>	Oracle Net connect string for a second auxiliary instance (RAC only). This property name is reserved for future use and is currently ignored.
<code>auxiliary_encrypted_passwd</code>	Encrypted password for the user specified with property 'auxiliary_user'
<code>auxiliary_user</code>	Database user for connecting to an auxiliary instance (intended for database duplication). Note that the user name must be specified within double quotes if it contains any lowercase letters.
<code>backup_cmd</code>	RMAN command specification for a database or data file backup; Executed when the argument to switch -o is 'backup'
<code>backup_epilogue</code>	RMAN script to be executed after the commands specified with property 'backup_cmd'
<code>backup_prologue</code>	RMAN script to be executed before the commands specified with property 'backup_cmd'
<code>catalog_connect_string</code>	Oracle Net connect string for a catalog instance (used for RESYNC CATALOG)
<code>catalog_encrypted_passwd</code>	Encrypted password for the user specified with property 'catalog_user'
<code>catalog_user</code>	Database user for connecting to an RDBMS instance where a recovery catalog resides. Note that the user name must be specified within double quotes if it contains any lowercase letters.
<code>copy_cmd</code>	RMAN command specification for a BACKUP AS COPY or COPY (deprecated) command; Executed when the argument to switch -o is 'copy'
<code>copy_epilogue</code>	RMAN script to be executed after the commands specified with property 'copy_cmd'

Property Name	Meaning
copy_prologue	RMAN script to be executed before the commands specified with property 'copy_cmd'
ifile	Include file; Path to an additional property file for reusing property names and values stored therein
internal_logon	Privilege to use when connecting to a target or auxiliary instance; Default: SYSDBA (Oracle11g supports only 'SYSDBA'; 12c also supports 'SYSBACKUP')
log_directory	Absolute path to a directory where RmanJ creates log files (all backslashes in Windows path names must be escaped using a backslash as the escape character, i. e. 'C:\\temp'). Logging to a file is disabled unless log_directory is specified. As an alternative output redirection (> and >> in most shells) may be used to preserve the output from RmanJ. Note that errors are written to the standard error stream such that it too needs to be redirected by naming its file descriptor number 2 (2>>).
log_file	Log file name specification. All placeholders may be used. It is recommended to use the placeholders ORACLE_SID and START_DATE or START_DATE_TIME. The log file is opened in append mode. Thus using the placeholder START_DATE implies that logging information from several RmanJ invocations on a single day end up in the same log file. If you prefer a separate log file for each invocation of RmanJ then use the placeholder START_DATE_TIME. The property log_file is ignored unless log_directory is also set.
nls_date_format	Date format specification for setting the environment variable NLS_DATE_FORMAT (default 'dd-Mon-yyyy hh24:mi:ss')
nls_lang	Specification for setting the environment variable NLS_LANG (default 'AMERICAN_AMERICA.WE9ISO8859P1 on Unix-like systems)
oracle_home	Absolute path of an Oracle RDBMS software installation home for setting the environment variable 'ORACLE_HOME'
oracle_sid	Specification for setting the environment variable ORACLE_SID (only mandatory when no connect string for an instance is specified).
parallelism	Parallel degree for copy, backup, or restore operations, i. e. the number of RMAN invocations with at least one channel per RMAN process; Default value: 1 (no parallelism).
restore_cmd	RMAN command specification for a RESTORE command; Executed when the argument to switch -o is 'restore'.
restore_epilogue	RMAN script to be executed after the commands specified with property 'restore_cmd'.
restore_file_id_list	List of data file numbers for use with a restore command (property 'restore_cmd'); A separate task that may run in parallel is created for each file. The placeholder FILE_ID must be used to instruct RmanJ to create a restore task for each of the data files. The value ALL instructs RmanJ to construct a list of data files for an entire database by querying the view V\$DATAFILE. Hence restore_file_id_list=ALL is the recommended setting for restoring an entire database in parallel.
restore_prologue	RMAN script to be executed before the commands specified with property 'restore_cmd'.
restore_tablespace_list	A list of tablespaces to be restored. RmanJ retrieves the data file numbers of

Property Name	Meaning
	all files that belong to the specified tablespaces and makes the list available through the placeholder FILE_ID. The properties 'restore_file_id_list' and 'restore_tablespace_list' are mutually exclusive. Tablespace names in a 12c Multitenant environment are not unique. RmanJ restores only files that belong to the same container ID as the database session established with the user name that was specified using the property 'target_user' (see column CON_ID in V\$ views such as V\$SESSION, V\$DATAFILE, V\$TABLESPACE).
shutdown_cmd	RMAN 'SHUTDOWN' command to execute before taking an offline backup (e. g. 'SHUTDOWN IMMEDIATE').
smtp_notification	Specifies under what condition an SMTP e-mail message is sent; Valid values are either 'always' or 'error' (default).
smtp_recipient	SMTP e-mail recipient address
smtp_sender	SMTP e-mail sender address
smtp_server	SMTP server host name
smtp_subject	SMTP e-mail subject
startup_cmd	RMAN 'STARTUP' command to execute before taking an offline backup (e. g. 'STARTUP MOUNT'). Note that a static service in listener.ora (SID_LIST_listener_name) is required when connecting to an idle instance over TCP/IP.
target_connect_string	Oracle Net connect string for a target instance
target_connect_string2	Oracle Net connect string for a second target instance (RAC only)
target_encrypted_passwd	Encrypted password for the user specified with property 'target_user'
target_user	Database user for connecting to a target instance. Note that the user name must be specified within double quotes if it contains any lowercase letters.

Table 1: Property Names, Meanings, and Types

Note that RmanJ does not use a fixed key to encrypt passwords. Hence attempts to use a stolen property file will result in an error.

Execution Stages

RmanJ execution is divided into several stages whereof merely the main backup, copy, or restore stage is mandatory. All other stages are optional and depend on which properties are used. All the available execution stages are listed in the order of execution below:

1. shutdown_cmd (optional)
2. startup_cmd (optional)
3. backup_prologue, copy_prologue, or restore_prologue (optional)
4. backup_cmd, copy_cmd, or restore_cmd (mandatory)
5. backup_epilogue, copy_epilogue, or restore_epilogue (optional)
6. RMAN catalog resynchronization (optional)

Thus RmanJ supports up to six separate execution stages. Execution of stages 1, 2, 3, 5, and 6 only occurs if one or more associated properties are set. For stages 1 to 5 the associated property is included in the list above. Stages 1 and 2 are required only for offline backups. For stage 6 to occur, the properties catalog_user, catalog_encrypted_passwd, and catalog_connect_string must be set. The commands exe-

cuted against an optional RMAN backup catalog are:

```
RESYNC CATALOG;
DELETE NOPROMPT OBSOLETE;
```

The first command explicitly synchronizes backup-related information in the control file with the RMAN catalog. The second command ensures that obsolete backups that are cataloged in the RMAN catalog but not in the control file are deleted. Usually such backups do not exist but they may exist if backups are preserved for a period longer than the setting of the Oracle RDBMS parameter `control_file_record_keep_time`. Note that the RMAN KEEP option may be used to preserve backups for several months or even years by exempting them from the configured retention period. For further information please refer to the manual *Oracle® Database Backup and Recovery Reference*.

Backup and Recovery Reference.

Placeholders

RmanJ supports several placeholders that may be used in conjunction with property values. Each placeholder is substituted by an actual value to form the final value used either as an RMAN command or for other purposes. Placeholders must be enclosed with percent signs (%) on both sides in order to be recognized and substituted by an actual value.

Placeholder	Purpose and Actual Value
EXIT_CODE	The exit code that RmanJ will use when it terminates. This placeholder can only be used within the value of the property <code>smtp_subject</code> .
FILE_ID	Replaced by a data file number; Each file is handled by a separate task that may run in parallel depending on the value of the property <code>'parallelism'</code> .
HOSTNAME	Name of the system where RmanJ runs.
INC_LEVEL	Incremental backup level; Derived from switch <code>-i</code> (if present); Default value 0.
ORACLE_SID	The value of either the environment variable <code>ORACLE_SID</code> or the property <code>oracle_sid</code> .
START_DATE	Date of an RmanJ invocation using the Java date format ³ <code>yyyyMMdd</code> ; Intended for use as an RMAN TAG name, backup piece name, or log file name component.
START_DATE_TIME	Time-stamp of an RmanJ invocation using the Java date format <code>yyyyMMdd-'HH'h'mm'm'ss's'</code> ; Intended for use as an RMAN TAG name or log file name component.

Table 2: Supported Placeholders

Password Encryption

Run RmanJ with the command line switch `-e` as indicated below to encrypt a password:

```
$ rmanj -e
Password:
Password (verification):
cleartext password length: 14 bytes; encrypted password: '1U6aoceHjcuuntj6YdfFwg=='
```

RmanJ asks for a password to encrypt. The password is not echoed to the terminal window and needs to be typed twice for verification. The encrypted password is then displayed between single quotes. The final step consists of saving the encrypted password (without single quotes around it) as the value of one of the properties `auxiliary_encrypted_passwd`, `catalog_encrypted_passwd`, or `target_encrypted_passwd`.

³ For details see documentation on Java class `SimpleDateFormat` (google: 'site:docs.oracle.com SimpleDateFormat').

Thanks to the password encryption features of RmanJ there is no longer any requirement to use the RMAN command `CONNECT TARGET /`. RmanJ also removes the risk of using a secure external password store⁴, an Oracle DBMS feature that offers encrypted storage of passwords in a wallet that must have auto-login enabled in order to be useful.

Loss of a wallet with auto-login enabled compromises security since anyone who knows which connect string from a wallet is referenced by a backup script for example can use `CONNECT /@<connect string>` to connect without supplying a user name and a password. With RmanJ the loss of an encrypted password does not compromise security assuming that the security of the operating system account and system environment where the encryption has been done is intact. In other words a secure external password store may be used universally whereas a password encrypted with RmanJ can only be decrypted in the same system environment where it has been encrypted.

Authentication

Many sites routinely operate RDBMS instances with a password file (`remote_login_passwordfile = EXCLUSIVE`) although this makes the account SYS vulnerable to attacks over TCP/IP. By default all RDBMS instances created using the database configuration assistant (DBCA) use a password file that grants the user SYS permission to connect with the SYSDBA privilege.

```
SYS@ELEVEN:SQL> SELECT * FROM v$pwfile_users;
```

USERNAME	SYSDBA	SYSOPER	SYSASM
SYS	FALSE	TRUE	FALSE

When the user SYS lacks the privilege SYSDBA in the password file it is impossible to connect as SYS using a password. This holds for connections using IPC, Bequeath, and TCP/IP protocols. Of course operating system authentication using the OSDBA group is unaffected and remains functional. The advantage is that all attempts to break into the account SYS by using brute force password guessing are thwarted. Even knowing the correct password for SYS will not help since only operating system authentication for members of the OSDBA group will work. Attempts to connect as SYS with the correct password return ORA-01031: insufficient privileges since the SYSDBA privilege for SYS is not present in the password file.

Keep in mind that Oracle Corp. changed the RDBMS code such that the user SYS is exempted from any password complexity checking that may be in place through the use of user profiles. This change was introduced in Oracle11g and has been retained in Oracle12c⁵. The feature is documented in Oracle® Database Security Guide 12c Release 1 (12.1) E17607-19 on page 3-10⁶:

When enabled, password complexity checking is not enforced for user SYS; it only applies to non-SYS users.

In other words since Oracle11g the password for the most powerful user can be a single character even when the (pluggable) database as a whole is set up for password complexity checking. The password file creation utility `orapwd` also does not provide any password complexity checking. This creates an incentive to disable the use of user SYS and to make the use of personal accounts with SYSDBA privilege mandatory within organizations. Since such personal accounts have user names other than SYS password

⁴ See Oracle Database Security Guide

```
5 SYS@TWELVE:SQL> SELECT limit FROM dba_profiles WHERE profile='DEFAULT' and
  resource_name='PASSWORD_VERIFY_FUNCTION';
```

```
LIMIT
-----
ORA12C_VERIFY_FUNCTION
```

```
SYS@TWELVE:SQL> ALTER USER SYS IDENTIFIED BY p;
User altered.
```

⁶ See also page 3-12 in Oracle® Database Security Guide 11g Release 2 (11.2) E36292-05

complexity checking is enforced.

Note that the 12c version of `orapwd` ignores the switch `nosysdba` unless `format=legacy` is used:

```
$ orapwd format=legacy nosysdba=y file=orapw$ORACLE_SID
SYS@TWELVE:SQL> select * from v$pwfile_users

USERNAME                                SYSDB SYSOP SYSAS SYSBA SYSDG SYSKM      CON_ID
-----
SYS                                     FALSE TRUE  FALSE FALSE FALSE FALSE      1
SYS@TWELVE:SQL> exit
Disconnected from Oracle Database 12c Enterprise Edition Release 12.1.0.2.0 - 64bit
Production
```

As shown above SYS does not have the SYSDBA privilege in the password file created with the above command.

Also note that it is impossible to grant the SYSBACKUP privilege introduced with Oracle12c when a legacy format password file is being used. To avoid the error *ORA-28017: The password file is in the legacy format* while ensuring that the SYSDBA privilege remains disabled for SYS in the password file it is necessary to explicitly convert a legacy password file to the 12c format. This is achieved as shown below (assuming the environment variable `ORACLE_SID` is set correctly for the intended RDBMS instance):

```
$ cp orapw$ORACLE_SID orapw${ORACLE_SID}-legacy
$ orapwd file=orapw$ORACLE_SID force=y input_file=orapw${ORACLE_SID}-legacy
```

After the conversion granting the SYSBACKUP privilege succeeds.

It is feasible to disable operating system authentication too such that connections with SYSDBA and SYSBACKUP privileges will succeed only by supplying the correct password. This way even the user root won't be able to open a connection to an RDBMS instance unless he or she knows the correct password.

However the built-in resource type for Oracle databases as well as the `srvctl` command in Oracle Grid Infrastructure (GI) are incompatible with this kind of setup since GI lacks the feature to use a password to connect with SYSDBA or SYSOPER privilege in order to perform instance start-up, shutdown, or monitoring. For detailed steps on how to disable operating system authentication for the SYSDBA and SYSBACKUP privileges please refer to Appendix A.

Multitenant Option

RmanJ may be used to execute any command supported by Oracle RMAN. Consequently RmanJ also works in Oracle12c Multitenant environments. Please refer to the manuals *Oracle Database Concepts*, *Backup and Recovery Reference*, and *Database Administrator's Guide* for further information on using RMAN in a Multitenant environment.

The example below is from an Oracle12c Multitenant environment where the technical user name "c##ora\$rman_bkp" (user name is all lower case) is used to process RMAN commands. Oracle Multitenant requires that all users created in the root container CDB\$ROOT have C## or c## as the first three characters of their user names⁷.

```
SYS@TWELVE:SQL> CREATE USER "c##ora$rman_bkp" IDENTIFIED EXTERNALLY CONTAINER=ALL;
User created.
SYS@TWELVE:SQL> PASSWORD "c##ora$rman_bkp"
Changing password for "c##ora$rman_bkp"
New password:
Retype new password:
Password changed
SYS@TWELVE:SQL> GRANT CREATE SESSION, SYSBACKUP TO "c##ora$rman_bkp";
```

⁷ See Oracle RDBMS error message *ORA-65096: invalid common user or role name*

Grant succeeded.

The test below confirms that the technical user `c##ora$rman_bkp` is able to connect with the SYSBACKUP privilege without the operating system user having the right to connect as SYSBACKUP using operating system authentication.

```
$ id
uid=500(oracle) gid=501(oinstall) groups=501(oinstall),500(dba),505(oraoper)
$ rman
Recovery Manager: Release 12.1.0.2.0 - Production on Thu Feb 11 23:26:09 2016
Copyright (c) 1982, 2014, Oracle and/or its affiliates. All rights reserved.
RMAN> CONNECT TARGET '/ AS SYSBACKUP'
```

```
RMAN-00571: =====
RMAN-00569: ===== ERROR MESSAGE STACK FOLLOWS =====
RMAN-00571: =====
ORA-01017: invalid username/password; logon denied
RMAN> CONNECT TARGET '"c##ora$rman_bkp" AS SYSBACKUP'
target database Password:
connected to target database: TWELVE (DBID=1641612861)
```

Command Line Switches

RmanJ accepts several command line switches, some of which have already been presented in the sections above. Please refer to Table 3 for detailed information on all the command line switches.

Command Line Switch	Purpose
-a {only, yes, ng, n%}	The placeholder <i>n</i> represents an integer ≥ 0 . Execute the script defined with property <code>archlog_backup_cmd</code> . If the switch argument is “only” then skip the backup command (property <code>backup_cmd</code>) and execute the archived log backup command as the only backup command. If the switch argument is “yes” then execute the archived log backup command along with the other commands. If the switch argument ends with the lower case letter “g” then execute the archived log backup command only if the remaining free space in any of the archive destinations is less than <i>n</i> gigabytes. If the switch arguments ends with a percent sign then execute the archived log backup command only if the fill level of any archive destination is higher then <i>n</i> percent. Both file systems and ASM disk groups are supported as archive destinations.
-e	Invoke interactive password encryption.
-f <i>property_file</i>	Load RmanJ settings from the named property file.
-h	Print RmanJ usage information (online help) and exit.
-i <i>inc_level</i>	Use <i>inc_level</i> as the actual value for the placeholder <code>%INC_LEVEL%</code> in <code>backup_cmd</code> .
-m <i>monitoring_interval</i>	The <i>monitoring_interval</i> specifies the interval at which the status and progress of all RMAN sessions spawned by RmanJ is checked and reported. The default value is 300 seconds (five minutes).
-o {backup, copy, restore}	Perform a backup, copy, or restore operation, i. e. use the script defined with <code>backup_cmd</code> , <code>copy_cmd</code> , or <code>restore_cmd</code> as the main operation.
-p <i>parallel_degree</i>	Use <i>parallel_degree</i> as the degree of parallelism.
-v <i>verbosity</i>	Use verbosity level <i>verbosity</i> (between 0 and 5) for RmanJ output. Default value is 2.

Table 3: Overview of Command Line Switches

Verbosity Levels

RmanJ writes errors to the standard error stream and to a log file (if specified with `log_directory` and `log_file`) irrespective of the verbosity level (switch `-v`). Acceptable values for the logging verbosity are in the range 0 to 5. Please refer to Table 4 for detailed information on the amount of logging for each verbosity level.

Verbosity Level	Description
0	Very terse logging. Only the RmanJ banner, exit code, and number of errors are logged.
1	Additionally, information on license file and lock file handling is logged. Furthermore all the output from RMAN processing is logged. Reporting on the data volume processed by RMAN is also enabled. Timing data on the individual stages of RmanJ execution is logged.
2	Additionally, property names and values as well as environment variable names and values are logged. Detailed information on the database such as force logging mode, flashback status, etc. is logged. The default verbosity level is 2.
3	Additionally, information on task queue handling is logged. This provides more detailed information on the tasks that are enqueued for processing by Java threads and finally RMAN.
4	Additionally, the list of data files that RmanJ will handle as a result of expanding the placeholder <code>%FILE_ID%</code> is logged.
5	Additionally, more detailed information on the control of RMAN sub-processes by RmanJ is logged. RMAN commands are logged as specified in a property file and after substituting placeholders.

Table 4: Verbosity Levels

At verbosity level 0 logging is very terse. An example is shown below:

```
rmanj -o backup -f rmanj.properties -i 1 -a only -v 0
RmanJ startup on 25-Feb-2016 13:21:39 - Version 1.0 (RCS revision 1.32) built by
ORADBPRO GmbH on 2016/02/24 17:02:17 is executed by JVM with PID 21416 on host devsrv
running operating system Linux
RmanJ is terminating with exit code 0 (0 RMAN errors encountered)
```

Under normal circumstances default verbosity level 2 is sufficient. Several excerpts from an RmanJ log file at verbosity level 2 are reproduced below. The command invoked was:

```
$ rmanj -o backup -f rmanj.properties -i 0 -a yes -v 2
```

Omissions from the log file are represented by an ellipsis character (...).

```
RmanJ startup on 25-Feb-2016 14:08:12 - Version 1.0 (RCS revision 1.32) built by
ORADBPRO GmbH on 2016/02/24 17:02:17 is executed by JVM with PID 22818 on host devsrv
running operating system Linux
Trying to verify license file /home/ndebes/dist/rmanj/license/license.lic
License verified: true days left: 36537
Using environment variable ORACLE_HOME=/opt/oracle/product/12.1
Using environment variable ORACLE_SID=TWELVE
archlog_backup_cmd=BACKUP TAG "%START_DATE_TIME%" ARCHIVELOG ALL DELETE INPUT;
backup_cmd=BACKUP AS COMPRESSED BACKUPSET CUMULATIVE INCREMENTAL LEVEL %INC_LEVEL%
TAG "%START_DATE_TIME%" (DATAFILE %FILE_ID%);
backup_prologue=SHOW ALL;
REPORT SCHEMA;
DELETE NOPROMPT OBSOLETE;
catalog_connect_string=dp-asdb:1526/dpp
catalog_user=backup
ifile=/home/ndebes/src/rmanj.common.properties
internal_logon=SYSBACKUP
log_directory=/home/ndebes/src/log
log_file=devsrv-TWELVE-Inc0-2016Feb25-14h08m12s.log
```

```
nls_date_format=dd-Mon-yy hh24:mi:ss
nls_lang=american_america.WE8ISO8859P1
oracle_sid=ORCL
parallelism=4
smtp_notification=error
smtp_recipient=ndebes@devsrv.oradbpro.com
smtp_sender=oracle@devsrv.oradbpro.com
smtp_server=localhost
smtp_subject=RmanJ finished on host %HOSTNAME% with exit code %EXIT_CODE%
target_connect_string=twelve_bkp_ipc
target_encrypted_passwd=***
target_user="c##ora$rman_bkp"
JDBC driver version: 12.1.0.2.0
Connected to target RDBMS instance TWELVE on host devsrv.oradbpro.com using JDBC URL
'jdbc:oracle:oci8:@twelve_bkp_ipc' as user SYSBACKUP (Oracle EE version 12.1.0.2.0)
Database name: TWELVE
Unique database name: TWELVE
Database ID: 1641612861
Log mode: ARCHIVELOG
Controlfile type: CURRENT
Open mode: READ WRITE
Force logging: NO
Flashback: NO
Instance number: 1
Instance name: TWELVE
Acquired lock (Success: Obtained valid file lock on file /tmp/1641612861.lck at
position 0)
Thread 10: RMAN output for task 1:
```

Recovery Manager: Release 12.1.0.2.0 - Production on Thu Feb 25 14:08:13 2016

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RMAN>

RMAN-03029: echo set on

RMAN> CONNECT TARGET *

RMAN-06005: connected to target database: TWELVE (DBID=1641612861)

RMAN> SET COMMAND ID TO '2016Feb25-14h08m12s22818T=1F=0BS=0';

RMAN-03023: executing command: SET COMMAND ID

RMAN> SHOW ALL;

RMAN-06009: using target database control file instead of recovery catalog

RMAN-06607: RMAN configuration parameters for database with db_unique_name TWELVE are:

RMAN-01005: CONFIGURE RETENTION POLICY TO RECOVERY WINDOW OF 6 DAYS;

RMAN-01005: CONFIGURE BACKUP OPTIMIZATION OFF; # default

RMAN-01005: CONFIGURE DEFAULT DEVICE TYPE TO DISK; # default

RMAN-01005: CONFIGURE CONTROLFILE AUTOBACKUP OFF;

RMAN-01005: CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK TO
'/oradata/backup/%F';

RMAN-01005: CONFIGURE DEVICE TYPE DISK PARALLELISM 1 BACKUP TYPE TO COMPRESSED
BACKUPSET;

RMAN-01005: CONFIGURE DATAFILE BACKUP COPIES FOR DEVICE TYPE DISK TO 1; # default

RMAN-01005: CONFIGURE ARCHIVELOG BACKUP COPIES FOR DEVICE TYPE DISK TO 1; # default

RMAN-01005: CONFIGURE CHANNEL DEVICE TYPE DISK FORMAT '/oradata/backup/%d-%U.bkp';

RMAN-01005: CONFIGURE MAXSETSIZE TO UNLIMITED; # default


```

RMAN-01005: CONFIGURE ENCRYPTION FOR DATABASE OFF; # default
RMAN-01005: CONFIGURE ENCRYPTION ALGORITHM 'AES128'; # default
RMAN-01005: CONFIGURE COMPRESSION ALGORITHM 'BASIC' AS OF RELEASE 'DEFAULT' OPTIMIZE
FOR LOAD TRUE ; # default
RMAN-01005: CONFIGURE RMAN OUTPUT TO KEEP FOR 7 DAYS; # default
RMAN-01005: CONFIGURE ARCHIVELOG DELETION POLICY TO NONE; # default
RMAN-01005: CONFIGURE SNAPSHOT CONTROLFILE NAME TO '/oradata/TWELVE/snapcf_TWELVE.f';

```

```
RMAN> REPORT SCHEMA;
```

```
RMAN-06290: Report of database schema for database with db_unique_name TWELVE
```

```
RMAN-07006: List of Permanent Datafiles
```

```
RMAN-07007: =====
```

RMAN-06291:	File	Size (MB)	Tablespace	RB segs	Datafile Name
RMAN-06292:	----	-----	-----	-----	-----
RMAN-06293:	1	400	SYSTEM	YES	/oradata/TWELVE/TWELVE/datafile/o1_mf_system_cchb7k35_.dbf
RMAN-06293:	2	210	PDB\$SEED:SYSTEM	NO	/oradata/TWELVE/TWELVE/2B34ED9740924B7FE0531684ED6DC853/datafile/o1_mf_system_cchb7o96_.dbf
RMAN-06293:	3	460	SYSAUX	NO	/oradata/TWELVE/TWELVE/datafile/o1_mf_sysaux_cchb7vqt_.dbf
RMAN-06293:	4	165	PDB\$SEED:SYSAUX	NO	/oradata/TWELVE/TWELVE/2B34ED9740924B7FE0531684ED6DC853/datafile/o1_mf_sysaux_cchb7yj8_.dbf
RMAN-06293:	5	590	UNDOTBS	YES	/oradata/TWELVE/TWELVE/datafile/o1_mf_undotbs_cchb80p7_.dbf
RMAN-06293:	6	5	USERS	NO	/oradata/TWELVE/TWELVE/datafile/o1_mf_users_cchb922p_.dbf
RMAN-06293:	7	210	PDBONE:SYSTEM	NO	/oradata/TWELVE/TWELVE/2B35E145405C5043E0531684ED6DD146/datafile/o1_mf_system_cchg79m3_.dbf
RMAN-06293:	8	165	PDBONE:SYSAUX	NO	/oradata/TWELVE/TWELVE/2B35E145405C5043E0531684ED6DD146/datafile/o1_mf_sysaux_cchg79mn_.dbf
RMAN-06293:	9	5	PDBONE:USERS	NO	/oradata/TWELVE/TWELVE/datafile/o1_mf_users_cdvh8ndg_.dbf

```
RMAN-07008: List of Temporary Files
```

```
RMAN-07009: =====
```

RMAN-07010:	File	Size (MB)	Tablespace	Maxsize (MB)	Tempfile Name
RMAN-07011:	----	-----	-----	-----	-----
RMAN-07012:	1	20	TEMP	32767	/oradata/TWELVE/TWELVE/datafile/o1_mf_temp_cchb834z_.tmp
RMAN-07012:	2	20	PDB\$SEED:TEMP	32767	/oradata/TWELVE/TWELVE/2B34ED9740924B7FE0531684ED6DC853/datafile/o1_mf_temp_cchb8366_.tmp
RMAN-07012:	3	20	PDBONE:TEMP	32767	/oradata/TWELVE/TWELVE/2B35E145405C5043E0531684ED6DD146/datafile/o1_mf_temp_cchg79mq_.dbf

```
RMAN> DELETE NOPROMPT OBSOLETE;
```

```
RMAN-06524: RMAN retention policy will be applied to the command
```

```
RMAN-06510: RMAN retention policy is set to recovery window of 6 days
```

```
RMAN-08030: allocated channel: ORA_DISK_1
```

```
RMAN-08500: channel ORA_DISK_1: SID=26 device type=DISK
```

```
RMAN-06147: no obsolete backups found
```

RMAN> EXIT;

Recovery Manager complete.

Thread 10: RMAN exit code: 0 (0 RMAN errors)
Elapsed time 00:00:03.008 for backup prologue
Database has 9 data files that are suitable for backup.
Thread 15: RMAN output for task 5:

Recovery Manager: Release 12.1.0.2.0 - Production on Thu Feb 25 14:08:16 2016

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RMAN>

RMAN-03029: echo set on

RMAN> CONNECT TARGET *

RMAN-06005: connected to target database: TWELVE (DBID=1641612861)

RMAN> SET COMMAND ID TO '2016Feb25-14h08m12s22818T=5F=6BS=8192';
RMAN-03023: executing command: SET COMMAND ID

RMAN> BACKUP AS COMPRESSED BACKUPSET CUMULATIVE INCREMENTAL LEVEL 0 TAG "2016Feb25-14h08m12s" (DATAFILE 6);

RMAN-03090: Starting backup at 25-Feb-16 14:08:19
RMAN-06009: using target database control file instead of recovery catalog
RMAN-08030: allocated channel: ORA_DISK_1
RMAN-08500: channel ORA_DISK_1: SID=29 device type=DISK
RMAN-08047: channel ORA_DISK_1: starting compressed incremental level 0 datafile backup set
RMAN-08010: channel ORA_DISK_1: specifying datafile(s) in backup set
RMAN-08522: input datafile file number=00006
name=/oradata/TWELVE/TWELVE/datafile/ol_mf_users_cchb922p_.dbf
RMAN-08038: channel ORA_DISK_1: starting piece 1 at 25-Feb-16 14:08:21
RMAN-08044: channel ORA_DISK_1: finished piece 1 at 25-Feb-16 14:08:22
RMAN-08530: piece handle=/oradata/backup/TWELVE-sbquqkal_1_1.bkp tag=2016FEB25-14H08M12S comment=NONE
RMAN-08540: channel ORA_DISK_1: backup set complete, elapsed time: 00:00:01
RMAN-03091: Finished backup at 25-Feb-16 14:08:22

Thread 15: encountered 0 errors during task 5

...

Thread 14: RMAN output for task 10:

RMAN> SET COMMAND ID TO '2016Feb25-14h08m12s22818T=10F=1BS=8192';
RMAN-03023: executing command: SET COMMAND ID

RMAN> BACKUP AS COMPRESSED BACKUPSET CUMULATIVE INCREMENTAL LEVEL 0 TAG "2016Feb25-14h08m12s" (DATAFILE 1);

RMAN-03090: Starting backup at 25-Feb-16 14:08:45
RMAN-12016: using channel ORA_DISK_1
RMAN-08047: channel ORA_DISK_1: starting compressed incremental level 0 datafile backup set
RMAN-08010: channel ORA_DISK_1: specifying datafile(s) in backup set
RMAN-08522: input datafile file number=00001
name=/oradata/TWELVE/TWELVE/datafile/ol_mf_system_cchb7k35_.dbf

RMAN-08038: channel ORA_DISK_1: starting piece 1 at 25-Feb-16 14:08:46
RMAN-08044: channel ORA_DISK_1: finished piece 1 at 25-Feb-16 14:09:01
RMAN-08530: piece handle=/oradata/backup/TWELVE-siquqkbe_1_1.bkp tag=2016FEB25-14H08M12S comment=NONE
RMAN-08540: channel ORA_DISK_1: backup set complete, elapsed time: 00:00:15
RMAN-08047: channel ORA_DISK_1: starting compressed incremental level 0 datafile backup set
RMAN-08010: channel ORA_DISK_1: specifying datafile(s) in backup set
RMAN-08011: including current control file in backup set
RMAN-08113: including current SPFILE in backup set
RMAN-08038: channel ORA_DISK_1: starting piece 1 at 25-Feb-16 14:09:02
RMAN-08044: channel ORA_DISK_1: finished piece 1 at 25-Feb-16 14:09:03
RMAN-08530: piece handle=/oradata/backup/TWELVE-sjquqkbt_1_1.bkp tag=2016FEB25-14H08M12S comment=NONE
RMAN-08540: channel ORA_DISK_1: backup set complete, elapsed time: 00:00:01
RMAN-03091: Finished backup at 25-Feb-16 14:09:03

Thread 14: encountered 0 errors during task 10
Thread 14: RMAN output for task 10:

RMAN> EXIT;

Recovery Manager complete.

Thread 14: RMAN exit code: 0
Thread 14: encountered a total of 0 errors
Elapsed time 00:00:47.177 for command backup
Thread 19: RMAN output for task 11:

Recovery Manager: Release 12.1.0.2.0 - Production on Thu Feb 25 14:09:04 2016

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RMAN>

RMAN-03029: echo set on

RMAN> CONNECT TARGET *

RMAN-06005: connected to target database: TWELVE (DBID=1641612861)

RMAN> SET COMMAND ID TO '2016Feb25-14h08m12s22818T=11F=0BS=0';
RMAN-03023: executing command: SET COMMAND ID

RMAN> BACKUP TAG "2016Feb25-14h08m12s" ARCHIVELOG ALL DELETE INPUT;
RMAN-03090: Starting backup at 25-Feb-16 14:09:05
RMAN-03033: current log archived
RMAN-06009: using target database control file instead of recovery catalog
RMAN-08030: allocated channel: ORA_DISK_1
RMAN-08500: channel ORA_DISK_1: SID=289 device type=DISK
RMAN-08049: channel ORA_DISK_1: starting compressed archived log backup set
RMAN-08014: channel ORA_DISK_1: specifying archived log(s) in backup set
RMAN-08504: input archived log thread=1 sequence=99 RECID=89 STAMP=904745345
RMAN-08038: channel ORA_DISK_1: starting piece 1 at 25-Feb-16 14:09:06
RMAN-08044: channel ORA_DISK_1: finished piece 1 at 25-Feb-16 14:09:07
RMAN-08530: piece handle=/oradata/backup/TWELVE-skquqkc2_1_1.bkp tag=2016FEB25-14H08M12S comment=NONE
RMAN-08540: channel ORA_DISK_1: backup set complete, elapsed time: 00:00:01
RMAN-08071: channel ORA_DISK_1: deleting archived log(s)

```

RMAN-08514: archived log file name=/oradata/TWELVE/arch/1_99_903216509.dbf RECID=89
STAMP=904745345
RMAN-03091: Finished backup at 25-Feb-16 14:09:07

```

```
RMAN> EXIT;
```

Recovery Manager complete.

```

Thread 19: RMAN exit code: 0 (0 RMAN errors)
Elapsed time 00:00:04.261 for archived log backup command
Successfully released lock (Success: Released valid lock on file /tmp/1641612861.lck)
RmanJ invoked on 25-Feb-2016 14:08:12 and finished on 25-Feb-2016 14:09:07 (total
elapsed time 00:00:55.702)

```

Status	Operation	Object Type	Input GB	Output GB	Input/Output GB
COMPLETED	BACKUP	ARCHIVELOG	0.002706	0.001452	0.004158
COMPLETED	BACKUP	DATAFILE INCR	1.448181	0.310371	1.758553
Any	Any	Any	1.450887	0.311824	1.762711

RmanJ is terminating with exit code 0 (0 RMAN errors encountered)

Monitoring

RmanJ monitors the progress of RMAN operations and reports the data volume and if possible the throughput in MB/s (megabytes per seconds). Unless the switch -m is used to specify a different value, progress reporting occurs every 300 seconds (five minutes). The format is shown in Illustration 1 on page 21. As shown in Illustration 1 RmanJ reports session identification information (V\$SESSION.SID, V\$SESSION.SERIAL#, V\$PROCESS.SPID), the type of RMAN operation, the degree of completion, the current wait event, the time remaining (data is of type INTERVAL DAYS TO SECOND), and more. The column with heading "Spid" shows the operating system process identifier which may be used to kill the server process that handles a certain RMAN channel if deemed necessary.

Limitations

Data File List

The property `restore_file_id_list` is implemented using a SELECT statement with a list of data file numbers. Such lists are limited to a length of 1000 list items. Thus RmanJ cannot restore more than 1000 data files in a single run when the `restore_file_id_list` is used. Very few databases have anywhere near 1000 data files. Thus it is unlikely that this restriction will affect the use of RmanJ in the field.

License Check

RmanJ currently requires a database to be mounted in order to check the database ID in V\$DATABASE. Hence a database needs to be mounted already before RmanJ can be used to perform a parallel or serial restore. Execute the commands required to restore and mount a control file using Oracle RMAN. Continue with the restore using RmanJ in order to benefit from its parallel restore, reporting, or error counting features.

Maximum Degree of Parallelism

The Oracle RDBMS has a built-in limitation regarding the bookkeeping performed by each invocation of RMAN. The status of RMAN operations is recorded in the controlfile and data access is provided via the view V\$RMAN_STATUS. Access to the underlying storage area in the controlfile is limited to 64 concurrent RMAN processes. Data loss occurs when this limit is exceeded. As a result reports provided by RmanJ will not reflect the correct amount of data handled by all concurrent RMAN sessions. To avoid data loss a parallel degree greater than 60 should not be used. In practice it is quite unlikely to observe

Sid	Serial #	Spid	Start Time	Operation	Compl.	Wait Status	Days Remaining	Elas. (s)	MB/s
295	56398	2994	2017-02-26 12:15:40.0	incremental datafile backup	72.6%	RMAN backup & recovery I/O=.001031s (0s ago)	0 0:0:3.0	7	
263	42296	2988	2017-02-26 12:14:42.0	aggregate input	42.0%	SQL*Net message from client>8s	0 0:0:59.0	43	23.26
Status									
			Operation	Object Type	Input GB	Output GB	Input/Output GB		
RUNNING			BACKUP	DB INCR	1.420891	0.294113	1.715004		
Any			Any	Any	1.420891	0.294113	1.715004		

Illustration 1: RmanJ monitoring section displaying data volume and throughput in MB/s

any speedup beyond a parallel degree between 30 and 40 if not at a much lower parallel degree.

The following error messages will be observed when the parallel degree is too high:

```
RMAN-06900: WARNING: unable to generate V$RMAN_STATUS or V$RMAN_OUTPUT row
RMAN-06901: WARNING: disabling update of the V$RMAN_STATUS and V$RMAN_OUTPUT rows
RMAN-06003: ORACLE error from target database:
ORA-19921: maximum number of 64 rows exceeded
```

Monitoring and Multiple Block Sizes

An Oracle database may have tablespaces with multiple block sizes. Note that the block size of archived logs is always 512 bytes. The ensuing discussion applies solely to data files and not to archived logs. Oracle RMAN does not provide information on the block size of the data files it is processing via the view `v$session_longops`. In order to report the throughput of an RMAN operation in MB/s (megabytes per second), RmanJ needs the block size of the data files that RMAN is processing. There are two scenarios where the block size can be determined. They are:

- Single block size database (i.e. the database has only one block size that is specified using the initialization parameter `db_block_size`)
- Multiple block size database with parallelization performed by RmanJ.

When parallelization is performed by RMAN itself as in Oracle Enterprise Edition, RmanJ will not be able to calculate throughput metrics for operations against databases with multiple block sizes. As a work-around use RmanJ parallelization instead of multiple channels in RMAN itself. Thus throughput metrics will be available for parallel backups of multiple block size databases using Oracle Enterprise Edition.

Case Studies

All Oracle RMAN-based backup strategies need to provide answers to a few simple questions. Some of them are:

- What type of device will store backups (disk or tape)?
- What is the retention policy for backups?
- Will incremental backups be used and on which days of the week or other period?
- Will automatic backups of the control-file be enabled?
- Will backups be compressed?
- What is the parallel degree for backup operations?
- What is the frequency for backing up archived redo logs?

Of course the list above is incomplete. For example it does not address monthly or yearly backups that need to be retained longer (`KEEP UNTIL TIME` in RMAN syntax) than normal backups due to legal regulations or other reasons.

Once the answers to the questions above are available RMAN can be configured to comply with the requirements. Let's assume that the answers to the six questions above are as shown in Table 5.

Configuration Option	Setting
Device type	Disk
Retention	Six days (if necessary incremental level 0 backups are automatically retained longer than six days since they are required as the starting point of any restore)
Incremental backup strategy	Level 0 on Sunday, cumulative level 1 on all other days of the week
Automatic control-file backup	Enabled

Compression	Enabled
Parallel degree	2
Archived log backup frequency	Every 4 hours

Table 5: Some aspects of a backup strategy

For demonstration purposes RmanJ's own backup parallelization will be used. Thus parallelism 1 will be used in RMAN. Remember that Oracle Standard Edition does not provide parallel RMAN operations and that this limitation is removed by using RmanJ to control several RMAN invocations.

The following RMAN configure commands implement most of the aspects of the backup strategy in Table 5:

```
CONFIGURE RETENTION POLICY TO RECOVERY WINDOW OF 6 DAYS;
CONFIGURE DEFAULT DEVICE TYPE TO DISK;
CONFIGURE CONTROLFILE AUTOBACKUP ON;
CONFIGURE DEVICE TYPE DISK PARALLELISM 1 BACKUP TYPE TO COMPRESSED BACKUPSET;
CONFIGURE CHANNEL DEVICE TYPE DISK FORMAT '/oradata/backup/%I-%d-%T-%U.bkp';
CONFIGURE SNAPSHOT CONTROLFILE NAME TO '/oradata/TWELVE/snapcf_TWELVE.f';
CONFIGURE CONTROLFILE AUTOBACKUP OFF;
```

Note that the standard location for the snapshot control-file is \$ORACLE_HOME/dbs. This should be changed such that the snapshot control-file resides with other database files. When the database is in ASM storage the snapshot control-file should also be in ASM storage (i. e. in a disk group).

When parallelizing backups with RmanJ automatic control-file backups should be disabled. Otherwise a control-file (and probably SPFILE) backup will occur after each BACKUP command completes. That would cause unnecessary delays and wasted disk or tape storage.

The incremental backup strategy needs to be implemented using scheduling software and by using the desired type of backup on certain days of the week. For demonstration purposes cron will be used to schedule backups.

Online Backup

The RmanJ sample configuration file rmanj/samples/online-backup.properties is used as a starting point for the online backup case study. We will copy this file to a suitable directory and amend it according to the requirements.

```
$ cp rmanj/samples/online-backup.properties /opt/oracle/admin
```

We will use Oracle12c and the SYSBACKUP privilege. Hence we need to set the RmanJ property internal_logon=SYSBACKUP instead of the default value SYSDBA.

A crontab file that schedules incremental backups and archived log backups is reproduced below:

```
# incremental level 0 backup each Sunday at 22:00
0 22 * * 0 /opt/rmanj/bin/rmanj -f /opt/oracle/admin/online-backup.properties -o
backup -i 0 -a yes > /dev/null 2>>/var/log/oracle/rmanj/rmanj-error.log
# incremental level 1 backup each each day except Sunday at 22:00
0 22 * * 1-6 /opt/rmanj/bin/rmanj -f /opt/oracle/admin/online-backup.properties -o
backup -i 1 -a yes > /dev/null 2>>/var/log/oracle/rmanj/rmanj-error.log
# archived log backup every day every four hours at 30 minutes past the full hour
30 */4 * * * /opt/rmanj/bin/rmanj -f /opt/oracle/admin/online-backup.properties -o
backup -a only > /dev/null 2>>/var/log/oracle/rmanj/rmanj-error.log
```

The output redirection used in the crontab file discards the logging to standard output and preserves logging to standard error. This is useful since RmanJ startup may fail if the shell script wrapper rmanj/bin/rmanj cannot locate an Oracle home (ORACLE_HOME) or a JDBC driver in an Oracle home.

Note that you need to set the property oracle_sid when running RmanJ through cron since both ORACLE_SID and ORACLE_HOME won't be set when a process is started by the cron daemon (unless envi-

environment variables are specified in the crontab which is not possible on all platforms). It is recommended to maintain the oratab file (/etc/oratab or /var/opt/oracle/oratab depending on the platform) such that the shell script wrapper rmanj/bin/rmanj can determine ORACLE_HOME by using oratab. Thus the path for the Oracle home used by an instance needs to be changed in one place only (in oratab) when an upgrade that results in a new Oracle home is performed.

Offline Backup

The property file rmanj/samples/offline-backup.properties is distributed with RmanJ as a starting point for implementing an offline backup using Oracle RMAN.

The contents of the file are reproduced below:

```
#oracle_sid=? # set oracle_sid when invoking RmanJ through cron
log_directory=/var/tmp/oracle
log_file=%HOSTNAME%-%ORACLE_SID%-Inc%INC_LEVEL%-%START_DATE_TIME%.log
backup_prologue=DELETE NOPROMPT OBSOLETE;
backup_cmd=BACKUP AS COMPRESSED BACKUPSET CUMULATIVE INCREMENTAL LEVEL %INC_LEVEL%
TAG "%START_DATE_TIME%" (DATAFILE %FILE_ID%);
backup_epilogue=LIST BACKUP OF DATABASE TAG "%START_DATE_TIME%";
ALTER DATABASE OPEN;
parallelism=2
shutdown_cmd=SHUTDOWN IMMEDIATE
startup_cmd=STARTUP MOUNT
target_user=/
```

The following command may be used to take an offline backup, assuming that the environment variables ORACLE_HOME and ORACLE_SID are set as required,:

```
$ rmanj -o backup -f offline-backup.properties
```

Point in Time Recovery Using Partial Database Restore

Occasionally human error results in data loss. A table that has been dropped by mistake or rows that have been modified by mistake are examples of situations where a backup may be the only way to regain access to the lost data. In order to save time only data files that are required to gain access to the lost data should be restored. To this end the name of the affected tablespace must be used to find out which data files need to be restored. The files of the tablespaces SYSTEM and SYSAUX as well as all files of the undo tablespace are always required. The following SELECT statement may be used to build a list of the required data file numbers. In the example shown below it is assumed that a table in tablespace DATA_WAREHOUSE has been dropped by mistake. In order to use the query for a specific case the list of tablespaces needs to be amended as necessary.

```
SELECT d.file#, t.name
FROM v$datafile d, v$tablespace t
WHERE
d.ts#=t.ts#
AND
(
    t.name IN ('SYSTEM', 'SYSAUX', 'DATA_WAREHOUSE')
    OR
    t.name IN (SELECT upper(value) FROM v$system_parameter WHERE
name='undo_tablespace')
)
ORDER BY file#;
      FILE# NAME
-----
         1 SYSTEM
         2 UNDOTBS
         9 SYSAUX
        42 UNDOTBS
```



```

44 UNDOTBS
53 DATA_WAREHOUSE
59 DATA_WAREHOUSE
67 DATA_WAREHOUSE
94 SYSAUX
100 SYSTEM
110 SYSTEM
114 DATA_WAREHOUSE
116 SYSTEM
117 SYSTEM
120 SYSTEM
121 SYSTEM
125 SYSTEM
131 SYSTEM
133 SYSTEM

```

The list of data file numbers is used to set the RmanJ property `restore_file_id_list` and RmanJ is then invoked with the switch and argument `-o restore`. The property `restore_file_id_list` requires a comma-separated list of file numbers. The entire specification can easily be generated by using the `LISTAGG` SQL function:

```

SELECT 'restore_file_id_list=' || listagg(d.file#, ',') WITHIN GROUP (ORDER BY
d.file#) AS restore_file_id_list
FROM v$datafile d, v$tablespace t
WHERE
d.ts#=t.ts#
AND
(
    t.name IN ('SYSTEM', 'SYSAUX', 'DATA_WAREHOUSE')
    OR
    t.name IN (SELECT upper(value) FROM v$system_parameter WHERE
name='undo_tablespace')
)
ORDER BY file#;
RESTORE_FILE_ID_LIST
-----
restore_file_id_list=1,2,9,42,44,53,59,67,94,100,110,114,116,117,120,121,125,131,133

```

Files that are not required for the restore have to be dropped before opening the database with the `resetlogs` option. For this purpose RMAN offers the command `RECOVER DATABASE ... SKIP FOREVER TABLESPACE`. RMAN will perform an offline drop of all datafiles belonging to the skipped tablespaces. For additional information please consult the *Oracle® Database Backup and Recovery Reference*.

Summary

RmanJ is a feature-rich, platform-independent control utility for Oracle RMAN that drastically reduces the effort required to implement an RMAN based Oracle backup solution. RmanJ completely removes the requirement to create and maintain a custom RMAN control utility using shell programming, Perl, or any other programming language. With RmanJ it is now sufficient to set a few properties in a property file.

Per se shell scripts and Perl programs cannot keep passwords safe. RmanJ's password encryption feature allows organizations to overcome these limitations thanks to the strong encryption algorithms available with Java.

Appendix A—Operating System Authentication on Unix-like Systems

Appendix A provides detailed instructions on how to disable operating system authentication for the SYS-DBA, SYSBACKUP (version 12.1.0.1 and later) and remaining privileges that are controlled by operating system group membership. Please note that Oracle12c supports more privileges than Oracle11g. The information below is included for the sake of companies that wish to harden their Oracle database envi-

ronments by removing password-less access to the user account SYS or other accounts with elevated privileges.

Operating system authentication hinges on the file config.c on Linux and config.s (assembler language) on all other Unix-like systems. The mechanism on Windows is entirely different and will not be discussed here.

The files config.c and config.s define which operating system group is used to allow password-less connection with a certain privilege. Either file resides in \$ORACLE_HOME/rdbms/lib. On Linux, C language code was used to control group names in versions prior to 12c whereas assembler code was and still is being used on all other platforms. In Oracle11g the relevant C preprocessor code in config.c looked like this (group names vary):

```
#define SS_DBA_GRP "dba"
#define SS_OPER_GRP "oraoper"
#define SS_ASM_GRP ""
#define SS_BKP_GRP "dba"
#define SS_DGD_GRP "dba"
#define SS_KMT_GRP "dba"
```

Oracle12c on Linux uses both C and assembler code while retaining the C language conformant file name config.c. Which section of the file is compiled depends on the way the make command is invoked. You can use `make -n` to find out which commands are used to rebuild the machine language file config.o (object file) from either config.c using a C language compiler or from config.s (or config.c in 12c on Linux) using an assembler.

```
$ mv config.o config.o.bak; make -n -f ins_rdbms.mk config.o
/usr/bin/gcc -O3 -trigraphs -fPIC -I/opt/oracle/product/12.1/rdbms/demo
-I/opt/oracle/product/12.1/rdbms/public -I/opt/oracle/product/12.1/plsql/public
-I/opt/oracle/product/12.1/network/public -DLINUX -DORAX86_64 -D_GNU_SOURCE
-D_LARGEFILE64_SOURCE=1 -D_LARGEFILE_SOURCE=1 -DSLTS_ENABLE -DSLMMX_ENABLE
-D_REENTRANT -DNS_THREADS -DLONG_IS_64 -DSS_64BIT_SERVER -DLDP_CM -c -o
config.o config.c
```

Note that config.o is a new make target in 12c. In prior versions the absolute path to config.o had to be used. When this is done on Linux with 12c the assembler is used to generate config.o:

```
$ mv config.o config.o.bak
$ make -n -f ins_rdbms.mk $ORACLE_HOME/rdbms/lib/config.o
```

Thus the relevant section to modify in config.c (config.s on platforms other than Linux) becomes the assembler code section that looks as show below:

```
.Ldba_string:      .string "dba"
.Loper_string:    .string "oraoper"
.Lasm_string:     .string ""
.Lbkgp_string:    .string "dba"
.Ldgd_string:    .string "dba"
.Lkmt_string:    .string "dba"
```

As a consequence care must be taken to edit the correct section of the file and to use the corresponding make command when both C language and assembler code are present. Of course it is in order to modify both code sections simultaneously to keep them synchronized.

Important note: After rebuilding the Oracle kernel with `make` the previously compiled kernel remains available as \$ORACLE_HOME/bin/oracleO:

```
$ file $ORACLE_HOME/bin/oracleO
/opt/oracle/product/12.1/bin/oracleO: setuid setgid ELF 64-bit LSB executable, x86-
64, version 1 (SYSV), dynamically linked (uses shared libs), for GNU/Linux 2.6.32,
BuildID[sha1]=aa7aa721789627eb243a85eb9990a7ealdeleld1, not stripped
```

It is absolutely mandatory to remove this file to prevent someone from using the old kernel to circumvent the disabled operating system authentication in the new kernel. So after executing `make run` the following

command:

```
$ rm $ORACLE_HOME/bin/oracleO
```

Note that both `SS_ASM_GRP` (C language) and `.Lasm_string` (assembler) in the code sections above are defined as empty strings. The reason being that the `SYSASM` privilege introduced in Oracle11g is not used by an RDBMS instance. In order to disable further privileges, make a backup copy of either `config.c` or `config.s` and set all the group names for privileges you wish to disable for operating system authentication to an empty string. The change will become effective when the new code is translated into machine language and incorporated into the executable that implements the Oracle RDBMS kernel, namely `$ORACLE_HOME/bin/oracle`.

All the RDBMS instances running from the modified Oracle home need to be shut down before relinking the oracle executable⁸. To rebuild the Oracle RDBMS kernel with the changed settings, enter the following commands as the RDBMS software owner:

```
$ cd $ORACLE_HOME/rdbms/lib
$ cp config.c config.c.orig # or cp config.s config.s.orig
$ rm config.o
$ make -f ins_rdbms.mk config.o ioracle
```

Let's assume that operating system authentication has been disabled in the code for all privileges except `SYSOPER`. On Linux the C preprocessor code in `config.c` would look something like this:

```
#define SS_DBA_GRP ""
#define SS_OPER_GRP "oraoper"
#define SS_ASM_GRP ""
#define SS_BKP_GRP ""
#define SS_DGD_GRP ""
#define SS_KMT_GRP ""
```

After the Oracle kernel has been rebuilt it will only be possible to successfully use `CONNECT / AS SYSOPER`. The `SYSOPER` privileges enables, among other actions, starting and stopping instances and handling server parameter files. Contrary to `SYSDBA` it does not provide access to `RMAN` commands and it does not give access to any customer data in a database.

Password-less connection attempts with all privileges other than `SYSOPER` will now fail:

```
$ sqlplus / AS SYSOPER
```

```
SQL*Plus: Release 12.1.0.2.0 Production on Sat Feb 13 22:32:55 2016
```

```
Copyright (c) 1982, 2014, Oracle. All rights reserved.
```

```
Connected to an idle instance.
```

Note that the RDBMS software owner `oracle` still has the former `ODSBA` group `dba` that used to allow `CONNECT / AS SYSDBA`. However the group membership is now useless since there is no longer any group name defined for the `SYSDBA` privilege.

```
$ id
uid=500(oracle) gid=501(oinstall) groups=501(oinstall),500(dba),505(oraoper)
$ sqlplus -s -l / AS SYSDBA
ERROR:
ORA-01017: invalid username/password; logon denied
```

```
SP2-0751: Unable to connect to Oracle. Exiting SQL*Plus
[oracle@devsrv samples]$ sqlplus -s -l / AS SYSBACKUP
ERROR:
```

⁸ Technically the running kernel can be replaced by running `make` but this results (among possibly severe malfunctions) in the following warning in the alert log:

```
WARNING: Oracle executable binary mismatch detected.
Binary of new process does not match binary which started instance
```

ORA-01017: invalid username/password; logon denied

SP2-0751: Unable to connect to Oracle. Exiting SQL*Plus
[oracle@devsrv samples]\$ sqlplus -s -l / AS SYSDG

ERROR:

ORA-01017: invalid username/password; logon denied

SP2-0751: Unable to connect to Oracle. Exiting SQL*Plus
[oracle@devsrv samples]\$ sqlplus -s -l / AS SYSKM

ERROR:

ORA-01017: invalid username/password; logon denied

SP2-0751: Unable to connect to Oracle. Exiting SQL*Plus