Quick answers to common problems

Oracle Database 12c Security Cookbook

Secure your Oracle Database 12c with this valuable Oracle support resource, featuring more than 100 solutions to the challenges of protecting your data

Zoran Pavlović   Maja Veselica

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BIRMINGHAM - MUMBAI

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First published: May 2016

Production reference: 1270516

Published by Packt Publishing Ltd.

Livery Place

35 Livery Street

Birmingham B3 2PB, UK.

ISBN 978-1-78217-212-3

www.packtpub.com

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Zoran Pavlović has worked on various complex database environments including RAC, ASM, Data Guard, GoldenGate, and so on. Areas of his expertise are security, performance/SQL tuning and high availabilty/disaster recovery of Oracle database. He has been working as an instructor for Oracle University since 2010 and during that time he has trained more than 200 students in Europe. In the last couple of years, Zoran has also been working on projects for Oracle Consulting. He is an Oracle ACE and he has been featured speaker/author at many conferences/magazines. He was actively engaged in beta testing Oracle Database 12c. Currently, Zoran is working as an Oracle Technical Architect in Parallel d.o.o. Belgrade.

I would like to take this opportunity to acknowledge some important people in my life who continuously inspire and support me. First, I want to say thank you to my parents Milenko and Stanojka Pavlovic, for everything they taught me, and for all the support they gave me during all these years. Second, I would like to say thank you to my family and my good friends, who helped me become a better person and a better professional. I am very thankful to our excellent team of technical reviewers: Arup Nanda, Gokhan Atil, Dmitri Levin, Osama Mustafa, and Kenneth Roth for their great suggestions and a very helpful feedback. I am also very thankful to Maja Veselica (it was a pleasure writing this book with you), all the editors, and everyone involved in this book.

Maja Veselica, MSc in software engineering, is currently working for Parallel d.o.o., Belgrade, as an Oracle Database consultant (security, performance tuning, and so on). She has been working as an instructor for Oracle University since 2010. In the last couple of years, she has also been working for Oracle Consulting. Also, Maja is a member of Oracle ACE Program and has more than 20 Oracle certificates. She enjoys (beta) testing Oracle products and participating in other Oracle-related activities.

This is the first book I've written, and because of that, it will always be special to me. I would like to thank my entire family and friends for their patience and support. I am especially grateful to my parents, Mirko and Sanja Veselica, who informally reviewed most parts of the book, and to my uncle Dušan, aunt Zora, and my best friend Mirjana Marković for very creative suggestions.

I am very thankful to the technical reviewers: Arup Nanda, Gokhan Atil, Dmitri Levin, Osama Mustafa, and Kenneth Roth for spending their spare time reviewing this book and for providing us with very valuable feedback (corrections, suggestions, ideas, and opinions). Also, this book couldn't have been written without the Packt Publishing team - thank you all!

Zoran, I always enjoy working with you. Hopefully someday, we'll write another book together.

About the Reviewers

Gokhan Atil is an Oracle ACE Director and DBA team lead at Bilyoner.com in Istanbul, Turkey. He has more than 15 years of experience in the IT industry, working with Oracle, PostgreSQL, Microsoft SQL Server, MySQL, and NoSQL databases. He has a strong background in software development and UNIX systems. Gokhan is an Oracle Certified Professional (OCP), and he specializes in high availability solutions, performance tuning, and monitoring tools.

Gokhan is a founding member and current vice president of Turkish Oracle User Group (TROUG). He's also a member of Independent Oracle User Group (IOUG). Gokhan has presented at various conferences, and he is a coauthor of *Expert Oracle Enterprise Manager 12c* book.

Gokhan shares his experience of working with Oracle products by blogging at `www.gokhanatil.com` since 2008 and on Twitter with the handle `@gokhanatil`.

Dmitri Levin has been working as a database administrator for more than 20 years.

His areas of interest include the database design, replication, and performance tuning. Dmitri has spoken at several national and international conferences.

He is currently working as senior database architect and administrator at alphabroder co.

Dmitri has an MS degree in Mathematics from St. Petersburg University, Russia, Oracle Database 11g OCA, and MS SQL Server 2012 certified DBA.

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Osama Mustafa (Oracle ACE Director) has progressive experience in the Oracle products community. He recently served as an Oracle DBA team leader and is certified in Oracle products, such as Fusion middleware, and is a database professional, Oracle Certified Implementation Specialist, and certified Solaris System Administrator. He loves to share his learning with the Oracle community, so when he is not delivering an Oracle-related session, he spends a lot of his time participating in OTN (Oracle Technology Network) discussion forums.

Osama Mustafa is a popular speaker at many Oracle conferences around the world. He is also the President and Director of JAOUG (Jordan Amman Oracle User Group, which is the first group in Jordan). He worked as an Oracle database developer and Oracle database administrator, and now he is a Fusion middleware security specialist and certified in multiple oracle products.

In addition to this, Osama is a volunteer in Oracle User Group, an author for Oracle penetration testing books, and a reviewer for Oracle books such as *Oracle Data Guard 11gR2 Administration Beginner's Guide* and *Oracle 11g Anti-hacker's Cookbook*. He also organizes RAC Attack around the world, publishes online articles on his blog https://osamamustafa.blogspot.com, and his articles are published in Oracle Magazine and OTech magazine. Osama Mustafa is active on Twitter as `@osamaoracle` and his blog.

First and foremost, I would like to thank my parents and my family for allowing me to follow my ambitions throughout my childhood and for standing beside me throughout my career. Special thanks to the girl who changed my life for the better and taught me a lot of things in life.

They have all been the inspiration and motivation for continuing to improve my knowledge and move my career forward and having the patience with me for having taken yet another challenge, which decreases the amount of time I can spend with them, and I hope that one day they can understand why I spent so much time in front of my computer.

Thanks to my friends and Oracle community friends around the world who support me and guide me to be the person I am today.

Arup Nanda has been an Oracle DBA for more than 20 years with experience spanning all aspects from modeling to performance tuning and Exadata. He gives speeches frequently; he has authored about 500 articles and coauthored 5 books. He also blogs at arup.blogspot.com and mentors new and seasoned DBAs. He won the Oracle's DBA of the Year in 2003 and Enterprise Architect of the Year awards in 2012. He is also an Oracle ACE director and a member of Oak Table Network.

He is the author of *Oracle Privacy Security Auditing*, *Rampant TechPress* (2005), *Oracle PL/SQL for DBAs*, *O'Reilly* (2005), *Oracle 10g New Features*, *Oracle Press* (2007), *Oracle RMAN Recipes*, *Apress* (2007 and 2013), *Expert Oracle Practices*, *Apress* (2013), and *Expert PL/SQL Practices*, *Apress* (2014). He has reviewed many books but prefers not to mention all of them here due to lack of space.

To my beautiful wife Anu and son Anish for putting up with me during the review of this book.

Kenneth Roth is an Oracle Certified Professional with over 25 years of IT experience primarily focused on Oracle database products. Ken has worked in a variety of IT-related roles and industries, including financial services, transportation, pharmaceutical, manufacturing, and the public sector. Based in Chicago, he currently enjoys the freedom, variety, and challenges associated with being an independent technology consultant.

Table of Contents

Preface

This book covers most of the Oracle Database 12c Security features and solutions that exist in Oracle Database 12c. Oracle Database 12c Security Cookbook will help you better understand database security challenges. It will guide you through the process of implementing appropriate security mechanisms, helping you to ensure that you are taking proactive steps to keep your data safe. Because the book features solutions for common security problems in the new Oracle Database 12c, it will make you confident about securing your database from a range of different threats and problems.

What this book covers

`Chapter 1`, *Basic Database Security*, introduces you to the different authentication methods supported by Oracle Database 12c and also provides a brief overview about creating and using database roles.

`Chapter 2`, *Security Considerations in Multitenant Environment*, focuses on some of the security considerations concerning common and local: users, roles, and privileges.

`Chapter 3`, *PL/SQL Security*, helps you understand the differences and usages of definer and invoker rights procedures as well as usages of code-based access control. It gives required information about authorization.

`Chapter 4`, *Virtual Private Database*, introduces you to the Oracle Virtual Private Database, which is a security feature introduced in Oracle Database 8i, which enables you to have a more granular control over security of your data.

`Chapter 5`, *Data Redaction*, introduces you to the new security feature Oracle Data Redaction, which helps you mask (hide/redact) some (sensitive) data from end users in a production environment.

`Chapter 6`, *Transparent Sensitive Data Protection*, teaches you ways to create classes of sensitive data and helps you gain more centralized control over how sensitive data is protected.

`Chapter 7`, *Privilege Analysis*, it shows how to create and enable privilege analysis policies. It also covers how to generate reports and revoke both used and unused Object/System privileges.

`Chapter 8`, *Transparent Data Encryption*, explains key concepts and tasks such as: two-key architecture, key management, message authentication code (MAC), salt, encrypting columns in a table, encrypting a tablespace, creating an encrypted RMAN backup, and so on.

`Chapter 9`, *Database Vault*, covers basic concepts of Oracle Database Vault. It teaches you how to create and appropriately use realms, rules, rule sets, command rules, factors, and secure application roles.

`Chapter 10`, *Unified Auditing*, introduces a new auditing architecture.

`Chapter 11`, *Additional Topics*, covers more advanced topics and teaches you how to perform everyday administration tasks in Database Vault environment.

`Chapter 12`, *Appendix - Application Contexts*, will cover how to retrieve values from built-in contexts and to create, set, and use an application context.

What you need for this book

Software required (with version)- Oracle Database 12c, Enterprise Manager Cloud Control 12c R4, Oracle Enterprise Manager Database Express 12c

Hardware specifications- OS required- Linux (Preferred Oracle Linux 6.5)

Who this book is for

This book is for DBAs, developers, and architects who are keen to know more about security in Oracle Database 12c. This book is best suited for beginners and intermediate-level database security practitioners. Basic knowledge of Oracle Database is expected, but no prior experience of securing a database is required.

Sections

In this book, you will find several headings that appear frequently (Getting ready, How to do it, How it works, There's more, and See also).

To give clear instructions on how to complete a recipe, we use these sections as follows:

Getting ready

This section tells you what to expect in the recipe and describes how to set up any software or any preliminary settings required for the recipe.

How to do it…

This section contains the steps required to follow the recipe.

How it works…

This section usually consists of a detailed explanation of what happened in the previous section.

There's more…

This section consists of additional information about the recipe in order to make the reader more knowledgeable about the recipe.

See also

This section provides helpful links to other useful information for the recipe.

Conventions

In this book, you will find a number of text styles that distinguish between different kinds of information. Here are some examples of these styles and an explanation of their meaning.

Code words in text, database table names, folder names, filenames, file extensions, pathnames, dummy URLs, user input, and Twitter handles are shown as follows: "Create a local user (for example, `mike`)."

Any command-line input or output is written as follows:

```
c##zoran@CDB1> create user c##maja identified by oracle1
container=all;
```

New terms and important words are shown in bold. Words that you see on the screen, for example, in menus or dialog boxes, appear in the text like this: "Click on the **Create** button."

Warnings or important notes appear in a box like this.

Tips and tricks appear like this.

For this book we have outlined the shortcuts for the Mac OX platform if you are using the Windows version you can find the relevant shortcuts on the WebStorm help page `https://www.jetbrains.com/webstorm/help/keyboard-shortcuts-by-category.html`.

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The code bundle for the book is also hosted on GitHub at `https://github.com/PacktPublishing/Oracle-Database-12c-Security-Cookbook`. We also have other code bundles from our rich catalog of books and videos available at `https://github.com/PacktPublishing/`. Check them out!

Errata

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Questions

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1
Basic Database Security

In this chapter, we will cover the following tasks:

- Creating a password profile
- Creating password-authenticated users
- Changing a user's password
- Creating a user with the same credentials on another database
- Locking a user account
- Expiring a user's password
- Creating and using OS-authenticated users
- Creating and using proxy users
- Creating and using database roles
- The `sysbackup` privilege – how, when, and why should you use it?
- The `syskm` privilege – how, when, and why should you use it?
- The `sysdg` privilege – how, when, and why should you use it?

Introduction

Authentication is a very important process, whose purpose is to determine whether someone or something is, in fact, who or what it claims to be.

In this chapter, you'll learn basic stuff about some of the different authentication methods supported by **Oracle Database 12c**. Also, a brief overview about creating and using database roles will be given.

There are three new administrative privileges introduced in Oracle Database 12c (`sysbackup`, `syskm`, and `sysdg`). Their purpose is to enable better separation of duties and they are designed in such a way to also enable implementation of the least privilege principle. Although it may seem that implementation of this principle in systems is easy or straightforward, usually it's quite tricky.

For all recipes in this chapter, you will use non-CDB 12c. We assume that the database is up and running and each user has at least the `create session` privilege.

In this set of recipes, you will learn to perform, mostly basic, user administration tasks.

Creating a password profile

You can use a profile to implement your password policy.

Getting ready

To complete this recipe, you'll need an existing user who has `create profile` privilege (such as an OS-authenticated user who has **database administrators** (**dba**) role, for example, `ops$zoran`). Also, you'll need an unlocked user account named `scott`.

Make sure that the `resource_limit` parameter is set to `true`.

How to do it…

1. Connect to the database as a user who has `create profile` privilege:

   ```
   sqlplus /
   ```

2. Create a password profile:

   ```
   create profile userprofile limit
   failed_login_attempts 4
   password_lock_time 2
   password_life_time 180;
   ```

3. Alter the user to use a newly created password profile:

    ```
    alter user scott profile userprofile;
    ```

4. Alter the default password profile:

    ```
    alter profile default limit
    failed_login_attempts 4;
    ```

How it works…

In step 1, you used OS authentication to connect to the database.

In step 2, you created a password profile with the name `userprofile` that has the following restrictions:

- The system allows four login attempts before locking a user account (`failed_login_attempts`)
- After locking a user account, it will remain locked for two days (`password_lock_time`)
- A password for the user can remain unchanged for 180 days – after which the password will expire, and the user will have to change the password for his next login (`password_life_time`)

In step 3, we assigned a newly created password profile to the user `scott`. If we don't assign a password profile to the user, that user uses the default password profile.

In step 4, we altered the default password profile with the `failed_login_attempts` restriction.

There's more…

You can create different password profiles for different users in the database. There are a lot of restrictions that can be applied to a password profile.

In Oracle Database 12c, there are three password verify functions, out of which, two are new and improved:

- `verify_function_11G` (carried over)
- `ora12c_verify_function` (new)
- `ora12c_strong_verify_function` (new)

If password complexity checking is not enabled, and you want to use it, you should run the `utlpwdmg.sql` script provided by Oracle. It's located in `$ORACLE_HOME/rdbms/admin`. The `ora12c_verify_function` function is the default function that the `utlpwdmg.sql` script uses. If you want, you can customize password verify functions.

Password complexity checking, even when enabled, doesn't apply to `sys` user.

If you want to choose which verify function will be used in the default profile, you can achieve that by using the following statement:

```
alter profile default limit password_verify_function
ora12c_strong_verify_function;
```

In subsequent recipes, it is assumed that default values are set for the default profile and the password verify function is not used.

See also

- *Creating password-authenticated users*
- *Locking a user account*
- *Creating and using OS-authenticated users*

Creating password-authenticated users

In this task, you will create several users.

Getting ready

To complete this recipe, you'll need an existing user who has `create user` privilege (you may use the OS-authenticated user who has the DBA role).

You'll use **Oracle Enterprise Manager Database Express 12c** (**EM Express**). To learn more about it (for example, how to configure an HTTPS port for EM Express and how to start it), see the third chapter of the official Oracle guide –*Oracle Database 2 Day DBA, 12c Release 1*.

How to do it…

1. Connect to the database as a user who has `create user` privilege:

   ```
   $ sqlplus /
   ```

2. Create a password-authenticated user (for example, username: `jessica`, password: `oracle_1`) as follows:

   ```
   SQL> create user jessica identified by oracle_1;
   ```

3. Create a password-authenticated user with a more complex password:

   ```
   SQL> create user tom identified by "Qax7UnP!123*";
   ```

4. Create a user that uses a specific password profile:

   ```
   SQL> create user mike identified by test1 profile
   userprofile;
   ```

5. Create a user and force it to change password upon the first login:

   ```
   SQL> create user john identified by password1
   password expire;
   ```

6. Create a user `richard`, whose default tablespace is `users`, temporary tablespace is `temp`, and who has their quota set to `unlimited` on the `users` tablespace:

   ```
   SQL> create user richard identified by oracle_2 default
   tablespace users temporary tablespace temp quota unlimited
   on users;
   ```

How it works…

In step 1, you used OS authentication to connect to the database.

In step 2, you created a password-authenticated user `jessica` with simpler password.

In step 3, you created a password-authenticated user `tom` with more complex password. In this case (because a password contains special characters), you are using quotation marks (`"`) to enclose the password.

Both of these users are using the default password profile.

In step 4, you created a password-authenticated user with the assigned password profile `userprofile`.

In step 5, you created user `john`. This user has to change his password at the first database login.

In step 6, you created the user `richard`. In the `create user` statement, `quota unlimited on users` means that you want to let the user allocate space in the tablespace without bound. The `quota` clause lets you define the maximum amount of space the user can allocate in the tablespace. You can have multiple `quota` clauses for multiple tablespaces within one `create user` statement. The `unlimited tablespace` system privilege enables users to have an `unlimited quota` on all tablespaces in the database.

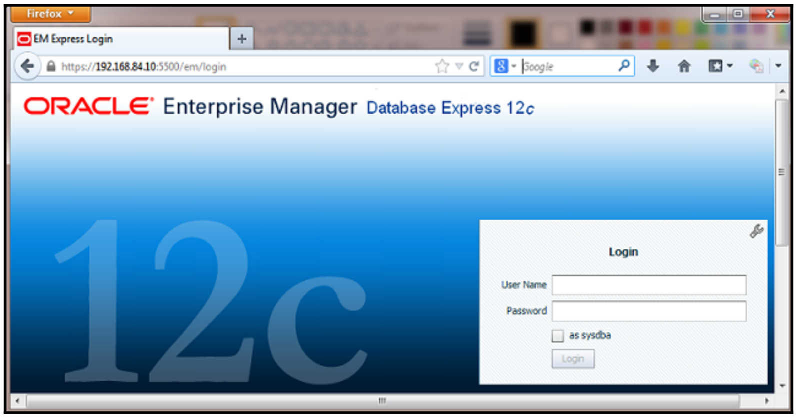
If you grant unlimited tablespace system privilege to a user and afterwards you revoke it, all explicitly granted quotas will also be revoked.

There's more…

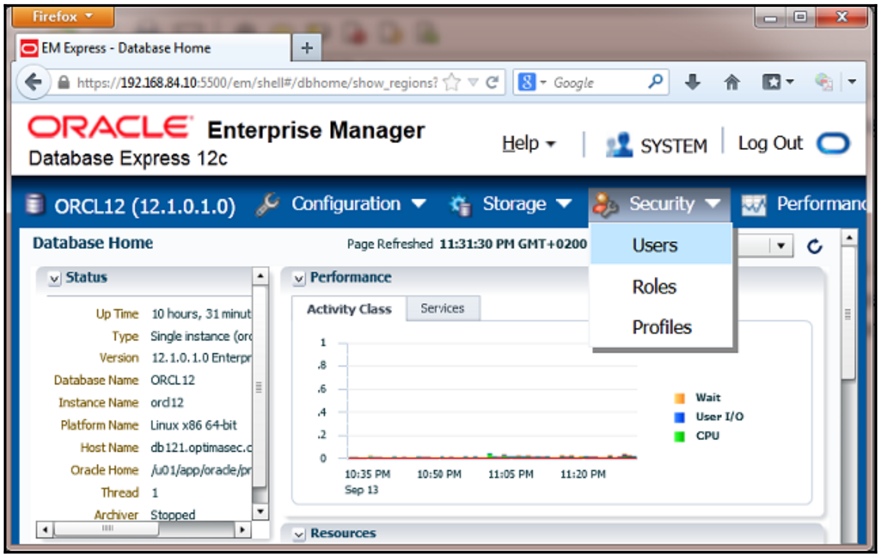
You can also create users using **Oracle Enterprise Manager Cloud Control 12c** or Oracle Enterprise Manager Database Express 12c (EM Express). Oracle Enterprise Manager Database Control is no longer available in Oracle Database 12c.

How to create a user using EM Express

1. Start EM Express and log in to it using the user that has either `EM_EXPRESS_BASIC` or `EM_EXPRESS_ALL` role (you can use `sys` or `system` users, but that isn't recommended):

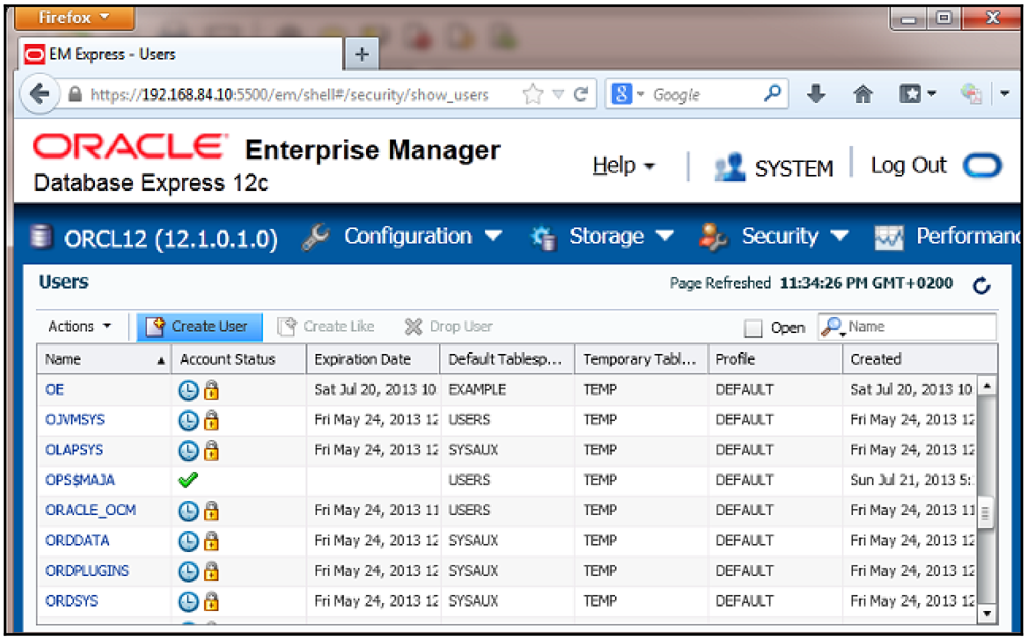

EM Express Login
https://192.168.84.10:5500/em/login
ORACLE Enterprise Manager Database Express 12c
12c
Login
User Name
Password
as sysdba
Login

2. Select **Users** from the **Security** drop-down menu:



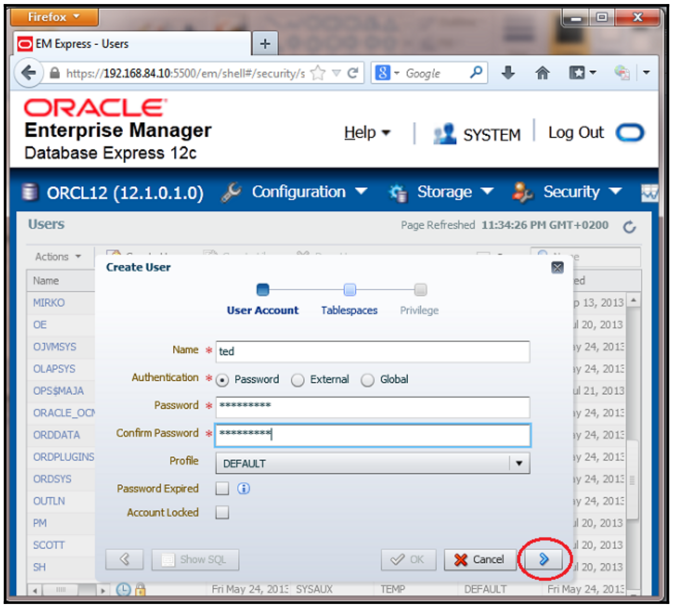
Up Time	10 hours, 31 minut
Type	Single instance (orc
Version	12.1.0.1.0 Enterpr
Database Name	ORCL12
Instance Name	orcl12
Platform Name	Linux x86 64-bit
Host Name	db121.optimasec.c
Oracle Home	/u01/app/oracle/pr
Thread	1
Archiver	Stopped

3. Click on the **Create User** tab:



Name	Account Status	Expiration Date	Default Tablesp...	Temporary Tabl...	Profile	Created
OE	🕒🔒	Sat Jul 20, 2013 10	EXAMPLE	TEMP	DEFAULT	Sat Jul 20, 2013 10
OJVMSYS	🕒🔒	Fri May 24, 2013 12	USERS	TEMP	DEFAULT	Fri May 24, 2013 12
OLAPSYS	🕒🔒	Fri May 24, 2013 12	SYSAUX	TEMP	DEFAULT	Fri May 24, 2013 12
OPS$MAJA	✓		USERS	TEMP	DEFAULT	Sun Jul 21, 2013 5:
ORACLE_OCM	🕒🔒	Fri May 24, 2013 11	USERS	TEMP	DEFAULT	Fri May 24, 2013 11
ORDDATA	🕒🔒	Fri May 24, 2013 12	SYSAUX	TEMP	DEFAULT	Fri May 24, 2013 12
ORDPLUGINS	🕒🔒	Fri May 24, 2013 12	SYSAUX	TEMP	DEFAULT	Fri May 24, 2013 12
ORDSYS	🕒🔒	Fri May 24, 2013 12	SYSAUX	TEMP	DEFAULT	Fri May 24, 2013 12

4. Enter user details in the pop-up dialog (for example, username: `ted`, password: `oracle_123`, here you can also choose the authentication method, password profile, lock account, expire password) leave the default values and click on the **Next** button (see image here) as follows:



Name
MIRKO
OE
OJVMSYS
OLAPSYS
OPS$MAJA
ORACLE_OCM
ORDDATA
ORDPLUGINS
ORDSYS
OUTLN
PM
SCOTT
SH

Name * ted

Authentication * [✓ Password] External Global

Password * **********

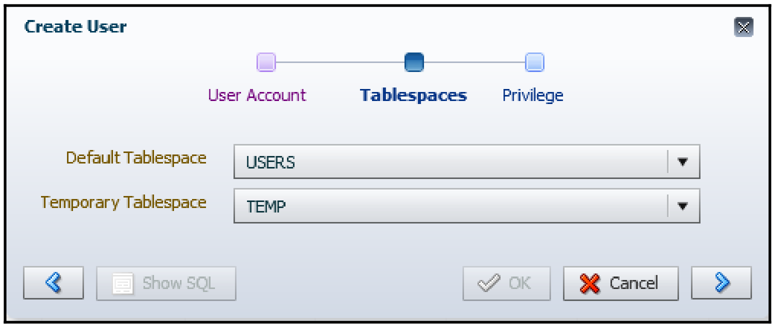
Confirm Password * **********

Profile DEFAULT

Password Expired ☐

Account Locked ☐

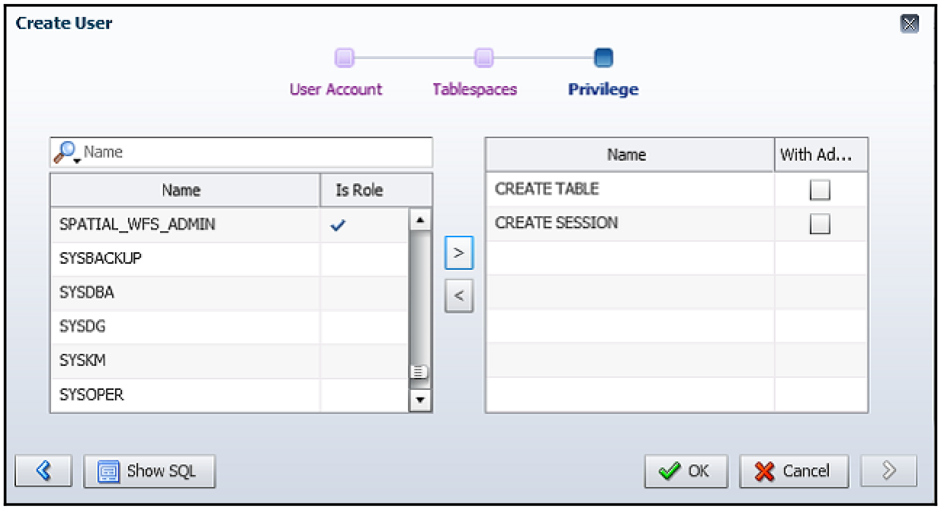
5. In this step, you can choose default tablespace and temporary tablespace from the drop-down lists. Leave the default values, as shown in the following screenshot:



Default Tablespace USERS

Temporary Tablespace TEMP

6. In this step, you can grant privileges to user `ted` by selecting them in the left pane and moving them to the right pane (use **>** button). If you want to revoke privileges, do the opposite (select them in right pane and use **<** button). When you are satisfied with the list of privileges in the right pane (the ones you are going to grant to user `ted`), click on the **OK** button as follows:



Name	Is Role
SPATIAL_WFS_ADMIN	✓
SYSBACKUP	
SYSDBA	
SYSDG	
SYSKM	
SYSOPER	

Name	With Ad...
CREATE TABLE	☐
CREATE SESSION	☐

7. A pop-up window confirmation should appear with the following message: **SQL statement has been processed successfully.**

Click on the **OK** button to close the window.

See also

- *Creating and using OS-authenticated users*

Changing a user's password

Changing a user's password is easy. You will practice it by changing passwords for several users in this recipe.

Getting ready

To complete this recipe, you'll need an existing user who has `alter user` privilege (you may use OS-authenticated user who has the DBA role) and other existing users (for example, `jessica` and `tom`).

How to do it…

1. Connect to the database as a user who has `alter user` privilege:

   ```
   $ sqlplus /
   ```

2. Change the password for user `jessica`:

   ```
   SQL> password jessica;
   ```

3. Enter a new password (for example, `oracle_2`) on a command line (note that typing will not be visible in the command line):

   ```
   New password:
   ```

4. Retype the new password (for example, `oracle_2`) on the command line (note that typing will not be visible in the command line):

   ```
   Retype new password:
   ```

5. Connect to the database as any user (for example, `tom`, to change their own password):

   ```
   $ sqlplus tom/"Qax7UnP!123*"
   ```

6. Change the password using the following code:

   ```
   SQL> password
   ```

7. Enter the old password (for example, `Qax7UnP!123*`) on the command line (note that typing will not be visible on the command line):

   ```
   Old password:
   ```

8. Enter the new password (for example, `oracle_123`) on the command line (note that typing will not be visible on the command line):

   ```
   New password:
   ```

9. Retype the new password (for example, `oracle_123`) on the command line (note that typing will not be visible on the command line):

   ```
   Retype new password:
   ```

How it works…

In step 1, you used OS authentication to connect to the database.

In steps 2 through 4, a privileged user changed jessica's password, where in steps 6 through 9, the user `tom` changed his own password.

There's more…

There is another way to change the user's password using the `alter user` statement as follows:

```
SQL> alter user jessica identified by oracle_2;
```

This approach is not recommended because password remains in the command-line history.

See also

- *Creating and using OS-authenticated users*

Creating a user with the same credentials on another database

This recipe explains a way to create a user with the same credentials on another database.

Getting ready

To complete this recipe, you'll need:

- An existing user who has dba role in the first database (you can use an OS-authenticated user)
- An existing user in the first database (for example, `jessica`)
- An existing (for example, password-authenticated) user, who has `create user` privilege, in the second database (for example, `zoran`)

How to do it…

1. Connect to the first database as a user who has a DBA role:

   ```
   $ sqlplus /
   ```

2. Find a **Data Definition Language** (**DDL**) statement (`ddl`) that is used for user creation (for example, user `jessica`):

   ```
   SQL> select dbms_metadata.get_ddl('USER', 'JESSICA') from
   dual;
   ```

3. Connect to the second database as a user who has `create user` privilege:

   ```
   $ sqlplus zoran@orcl2
   ```

4. Create a user using the value you found in step 2:

   ```
   SQL> create user "JESSICA" identified by values
   'S:D82E6EF961F2EA7A878BCDDBC7E5C542BC148C4759D19A7
   20A96BBF65658;H:F297A50FD538EF4AB119EB0278C9E72D;
   C50B1E9C9AA52EC2';
   ```

How it works…

In step 1, you used OS authentication to connect to the database.

In step 2, you found a DDL statement that has been used for user creation. This DDL statement may contain `default` and `temporary` tablespace assignments (note that even if you haven't explicitly assigned these tablespaces during user creation, the system will assign them implicitly using default values for the database). For instance, output in step 2 may look like this:

```
SQL> select dbms_metadata.get_ddl('USER', 'JESSICA') from dual;
DBMS_METADATA.GET_DDL('USER','JESSICA')
------------------------------------------------------------------
CREATE USER "JESSICA" IDENTIFIED BY VALUES
'S:D82E6EF961F2EA7A878BCDDBC7E5C542BC148C4759D19A720A96BBF65658;H:F297A50FD
538EF4AB1 19EB0278C9E72D;C50B1E9C9AA52EC2'
DEFAULT TABLESPACE "USERS"            TEMPORARY TABLESPACE "TEMP"
```

However, we used only the first part of this DDL in step 4 to create a user on the second database (and let the database decide about default tablespaces).

There's more…

There is another way to accomplish the task.

You can only reveal the *hash* value of user's password (you cannot reveal the actual password).

This way requires `select` on the `sys.user$` table:

1. Connect to the first database as a user who has the `select` privilege on the `sys.user$` table (for example, user who has the `sysdba` privilege):

   ```
   $ sqlplus / as sysdba
   ```

2. Find the hash value of a user's password (for example, user `jessica`):

   ```
   SQL> select spare4
   from user$
   where name='JESSICA';
   ```

3. Connect to the second database as a user who has `create user` privilege:

   ```
   $ sqlplus zoran@orcl2
   ```

4. Create a user with the same username (for example, `jessica`) using the hash value of the password that you have found in step 2:

   ```
   SQL> create user jessica identified by values
   'S:2724193130FC67E7E23E3E44E33AF143F7A6C36489792B
   5856133DCB331D;H:184895E50EA2FBCC2311ED76A3E5CF35;
   T:BECCD5FC6F6E62BC34DF1C826AEE899EC6A6025FA0D5071659DA
   7DD1ABB37763483B5C821E5A34C1184A56BE4B1C92CED79639D11101D
   61B86ACBE60A30F19CC277D5753F7D3756DC1B7705C0ACE81F3';
   ```

See also

- *Creating and using OS-authenticated users*

Locking a user account

In this recipe, you'll learn to lock and unlock user accounts.

Getting ready

To complete this recipe, you'll need an existing (for example, OS-authenticated) user who has `alter user` privilege (you may use user who has a DBA role) and another existing user (for example, `mike`).

How to do it…

1. Connect to the database as a user who has `alter user` privilege:

   ```
   $ sqlplus /
   ```

2. Lock the account of user `mike`:

   ```
   SQL> alter user mike account lock;
   ```

3. Unlock the account of user `mike`:

   ```
   SQL> alter user mike account unlock;
   ```

How it works…

In step 1, you used OS authentication to connect to the database.

In step 2, you locked the account of user `mike`. This means that user `mike` cannot connect to the database:

```
SQL> alter user mike account lock;

User altered

SQL> connect mike/welcome1

ERROR: ORA-28000: the account is locked
```

However, objects in mike's schema are available, so users can access them (considering that they have necessary privileges):

```
SQL> select a, b from mike.table1;
         A         B
 ---------- ---------
         1         3
         2         4
         4         9
```

It is recommended that you lock the accounts of users that own your application objects (application schemas).

In step 3, you unlocked the account of user `mike`. Now user `mike` can successfully connect to the database:

```
SQL> alter user mike account unlock;

User altered.

SQL> conn mike/welcome1

Connected.
```

See also

- *Creating and using OS-authenticated users*

Expiring a user's password

The expiration of user's password is a very easy task.

Getting ready

To complete this recipe, you'll need an existing (for example, OS-authenticated) user who has the `alter user` privilege (you may use user who has a DBA role) and another existing user (for example, `mike`).

How to do it…

1. Connect to the database as a user who has the `alter user` privilege:

   ```
   $ sqlplus /
   ```

2. Mike's password expires with the following command:

   ```
   SQL> alter user mike password expire;
   ```

How it works…

In step 1, you used OS authentication to connect to the database.

In step 2, you expired password for the user `mike`. This means that the password is no longer valid and user `mike` must change his password after the next login:

```
SQL> alter user mike password expire;

User altered.

SQL> conn mike/welcome1
ERROR: ORA-28001: the password has expired
Changing password for mike
New password:
Retype new password:
Password changed
Connected.
```

See also

- *Creating and using OS-authenticated users*

Creating and using OS-authenticated users

In this recipe, you'll learn about OS-authenticated users.

Getting ready

To complete this recipe, you'll need an existing user who has a dba role, for example, `johndba`. It is assumed that you are working on Linux.

How to do it…

1. Connect to the database as a user who has a DBA role:

   ```
   $ sqlplus johndba
   ```

2. Find the prefix for operating system authentication:

   ```
   SQL> show parameter os_authent_prefix
   NAME                 TYPE          VALUE
   -----------------    --------      -----------
   os_authent_prefix    string        ops$
   ```

3. Create an OS-authenticated user:

   ```
   SQL> create user ops$zoran identified externally;
   ```

4. Grant this user the `create session` privilege:

   ```
   SQL> grant create session to ops$zoran;
   ```

5. Log in to the operating system as the user `zoran`:

   ```
   $ su - zoran
   ```

6. Connect to the database without entering a user name or password:

   ```
   $ sqlplus /
   ```

How it works…

In OS authentication, database delegates user authentication to the operating system. This means that in order for OS authentication to work, user must exist as the user of the operating system. In database, these users are created with a prefix that is defined in the `os_authent_prefix` parameter (default is `ops$`). If an OS-authenticated user has the `create session` privilege, he or she can connect to the database using the following syntax:

```
SQL> connect /
Connected.
SQL> show user
USER is "OPS$ZORAN"
```

Note that you cannot grant a `sysdba`, `sysoper`, `sysbackup`, `sysdg`, or `syskm` privilege to users that are identified externally, using a `grant` statement:

```
  SQL> grant sysdba to ops$zoran;
    grant sysdba to ops$zoran
ERROR at line 1: ORA-01997: GRANT failed: user
     'OPS$ZORAN' identified externally
```

If you want to connect as `sysdba` using OS authentication, you have to add OS user `zoran` to OS group DBA:

```
[root@db121 ~]# usermod -a -G dba zoran
[root@db121 ~]# su - zoran
[zoran@db121 ~]$ sqlplus / as sysdba
SQL*Plus: Release 12.1.0.1.0 Production on Fri Sep 03 20:14:03 2013
Copyright (c) 1982, 2013, Oracle. All rights reserved.
Connected to:
Oracle Database 12c Enterprise Edition Release 12.1.0.1.0 - 64 bit
Production With the Partitioning, OLAP, Advanced Analytics and Real
Application Testing options
```

There's more…

You can change the `os_authent_prefix` parameter with custom value (or you can leave it blank if you want OS-authenticated database users to have the same name as OS users).

Creating and using proxy users

In this recipe, you'll learn about proxy users.

Getting ready

To complete this recipe, you'll need an existing (for example, OS-authenticated) user who has a DBA role and another existing user (for example, `mike`).

How to do it...

1. Connect to the database as a user who has a DBA role:

   ```
   $ sqlplus /
   ```

2. Create a proxy user named `appserver`:

   ```
   SQL> create user appserver identified by oracle_1;
   ```

3. Grant `create session` to the user `appserver`:

   ```
   SQL> grant create session to appserver;
   ```

4. Alter the user to connect through the proxy user:

   ```
   SQL> alter user mike grant connect through appserver;
   ```

5. Connect to the database through proxy user:

   ```
   SQL> connect appserver[mike]
   ```

6. Enter a password for the appserver user (for example, `oracle_1`):

   ```
   Enter password:
   ```

7. To revoke connection through the proxy user, first connect to the database as a user who has altered user privilege:

   ```
   $ sqlplus /
   ```

8. Revoke connection through the proxy user appserver from user `mike`:

   ```
   SQL> alter user mike revoke connect through appserver;
   ```

How it works...

Proxy authentication is best-suited type of authentication for three-tiered environments. The middle tier is represented as a proxy user in the database and this user can authenticate end-users in such a way that these end users can be audited by the database.
In the second step, you created a user `appserver` (to be the proxy user).
In the third step, you granted this user only the `create session` privilege.

It is recommended that you grant only the `create session` privilege to proxy users.

In step 4, you authorized user `mike` to connect through proxy user `appserver`. This means that the user `appserver` can connect to the database on behalf of user `mike`:

```
SQL> connect appserver[mike]

Enter password:
Connected.

SQL> show user
USER is "MIKE"

SQL> select sys_context('USERENV','PROXY_USER') from dual;
SYS_CONTEXT('USERENV','PROXY_USER')
-----------------------------------
APPSERVER
```

To see proxy users, you can query the `proxy_users` view:

```
SQL> select * from proxy_users;

PROXY      CLIENT  AUT   FLAGS
---------- ------- ---- -----------------------------------
APPSERVER   MIKE    NO   PROXY MAY ACTIVATE ALL CLIENT ROLES
```

In the last step, you revoked authorization from user `mike` to connect through proxy user `appserver`. This means that the user `appserver` can no longer connect to the database on behalf of user `mike`.

There's more…

You can control which roles the proxy user can activate for user. By default, all user roles are activated. If you want the proxy user to activate only particular roles (or no roles) for a user, you can do that by adding the `WITH ROLES <role1, role2, .., roleN>` (or `WITH NO ROLES`) clause at the end of the `alter user` statement.
For instance, if the user `mike` has many roles (including `usr_role`), and you want him to have only `usr_role` when he is connected through proxy user `appserver`, statement will look like this:

```
SQL> alter user mike grant connect through appserver with roles usr_role;

User altered.

SQL> connect appserver[mike]

Enter password:
Connected.

SQL> select * from session_roles;

ROLE
------------
USR_ROLE

SQL> connect mike

Enter password:
Connected.

SQL> select count(*) from session_roles;

COUNT(*)
--------
25
```

You can request reauthentication of a user to the database. This means that during proxy authentication, a user's password must be provided. This is done by using the `authentication required` clause at the end of `alter user` statement:

```
SQL> alter user mike grant connect through appserver authentication
required;
User altered.
```

Creating and using database roles

In this recipe, you'll learn the basics about database roles.
Roles group together related system and/or object privileges and they can be granted to users and other roles. They simplify privilege management (for example, rather than granting the same set of privileges to many users, you can grant those privileges to a role and then grant that role to users that need those privileges).

Getting ready

For this recipe, you will need an existing (for example, OS-authenticated) user that has a dba role and another three existing users (for example, `mike`, `tom`, and `jessica`). It is assumed that sample schemas are installed.

How to do it…

1. Connect to the database as a user who has a dba role:

   ```
   $ sqlplus /
   ```

2. Create the role `usr_role`:

   ```
   SQL> create role usr_role;
   ```

3. Grant system privilege to `usr_role`:

   ```
   SQL> grant create session to usr_role;
   ```

4. Grant object privileges to `usr_role`:

   ```
   SQL> grant select, insert on hr.employees to usr_role;
   ```

5. Create another role as follows:

   ```
   SQL> create role mgr_role;
   ```

6. Grant `usr_role` to `mgr_role`:

   ```
   SQL> grant usr_role to mgr_role;
   ```

7. Grant system privileges to `mgr_role`:

   ```
   SQL> grant create table to mgr_role;
   ```

8. Grant object privileges to `mgr_role`:

   ```
   SQL> grant update, delete on hr.employees to mgr_role;
   ```

9. Grant `usr_role` to user (`mike`):

   ```
   SQL> grant usr_role to mike;
   ```

10. Grant `mgr_role` to user (`tom`):

    ```
    SQL> grant mgr_role to tom;
    ```

How it works…

In the first step, you used OS authentication to connect to the database. In steps 2 and 3, you granted system privileges and object privileges, respectively, to the role `usr_role`. In the next steps, you practiced using database roles; you granted the following:

- A role to another role
- System and object privileges to role
- Roles to users

You revoke privileges and roles by using a `revoke` statement. For example:

```
SQL> revoke usr_role from mike;
```

Circular granting of roles is not allowed.

```
SQL> grant role1 to role2;
Grant succeeded.

SQL> grant role2 to role1;
grant role2 to role1
*
ERROR at line 1: ORA-01934: circular role grant detected
```

There's more…

You should be careful about granting privileges to the PUBLIC role because then every database user can use these privileges.

Suppose that user mike grants object privilege to user jessica with a grant option and user jessica grants that privilege to user tom. If user mike revokes that privilege from jessica, it will be automatically revoked from tom.

Revoking a system privilege will not cascade.

```
SQL> grant select on hr.employees to jessica with grant option;
Grant succeeded.

SQL> connect jessica
Enter password:
Connected.

SQL> grant select on hr.employees to tom;
Grant succeeded.

SQL> connect tom/oracle_123
Connected.

SQL> select count(*) from hr.employees;
COUNT(*)
----------
 107

SQL> connect mike/welcome1
Connected.

SQL> revoke select on hr.employees from jessica;
Revoke succeeded.

SQL> connect tom/oracle_123
Connected.

SQL> select count(*) from hr.employees;
select count(*) from hr.employees
*
```

```
ERROR at line 1:
ORA-00942: table or view does not exist
```

You cannot revoke object privileges you didn't grant.

See also

- If you want to learn more about roles, see the official Oracle documentation—*Oracle Database Security Guide 12c Release 1* (refer *Chapter 4, Configuring Privilege and Role Authorization*, of this documentation).

The sysbackup privilege – how, when, and why should you use it?

It is recommended that you use the `sysbackup` administrative privilege instead of the `sysdba` administrative privilege to perform operations related to backup and recovery tasks.

Getting ready

For this recipe, you'll need:

- An existing database user (for example, `tom`) and a password file in 12c format, if you want to complete it using a password-authenticated user
- An existing OS user (for example, `john`), who belongs to the `backupdba` OS group, in order to connect to the database using OS authentication

How to do it…

Instructions are given in the *Database authentication* and *OS authentication* sections.

Database authentication

The instructions for database authentication are as follows:

1. Connect to the database as `sysdba` (or another user that can grant the `sysbackup` privilege):

   ```
   sqlplus / as sysdba
   ```

2. Grant the `sysbackup` privilege to user `tom`:

   ```
   grant sysbackup to tom;
   ```

3. Verify that there is an entry in the password file that grants user `tom` the `sysbackup` administrative privilege. Select data from the `v$pwfile_users` view:

   ```
   select * from v$pwfile_users;
   ```

   The following table is the result of the preceding command:

Username	**sysdb**	**sysop**	**sysas**	**sysba**	**sysdg**	**syskm**	**con_id**
sys	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	0
sysdg	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	0
sysbackup	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	0
syskm	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	0
tom	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	0

4. Test the connection using `RMAN`:

   ```
   rman target '"tom/oracle_123 as sysbackup"'
   ```

OS authentication

The instructions for OS authentication are as follows:

1. Verify that the OS user (for example, `john`) is a member of the `backupdba` OS group:

   ```
   $ id john
   ```

2. Connect to the database using the `sysbackup` privilege (SQL*Plus or RMAN):

   ```
   $> sqlplus / as sysbackup
   $> rman target '"/ as sysbackup"'
   ```

How it works…

You can use either Oracle **Recovery Manager** (**RMAN**) or SQL*Plus to perform the operations. When you connect to the database as `sysbackup`, you are connected as a predefined user `sysbackup`. If you want to check this, run the following statement:

```
SQL> select user from dual;
```

Otherwise, the following statement:

```
SQL> show user
```

Using the `sysbackup` privilege, you can connect to the database even when it is not open. This privilege enables better *separation of duties* and the implementation of the *least privilege principle*.

From a security perspective, it is recommended that you implement the least privilege principle. The least privilege principle is an important security concept that requires that users are given only those privileges they need to perform their job.

To view the list of privileges a user can exercise when connected to the database using `sysbackup` privilege, you can create a user (for example, `tom`) and grant the user only `sysbackup` privileges. The next step is to connect to the database as user `tom`, using the `sysbackup` privilege and the `execute` statement:

```
select * from session_privs;
```

These privileges are shown in the following table:

Privileges (output from the previous statement)			
`sysbackup`	`select any transaction`	`select any dictionary`	`resumable`
`create any directory`	`alter database`	`audit any`	`create any cluster`
`create any table`	`unlimited tablespace`	`drop tablespace`	`alter tablespace`
`alter session`	`alter system`		

This is how you can check *enabled* roles:

```
SQL> select * from session_roles;

ROLE
-------------------
 SELECT_CATALOG_ROLE
 HS_ADMIN_SELECT_ROLE
```

`HS_ADMIN_SELECT_ROLE` is granted to `SELECT_CATALOG_ROLE`.

If you want to view the roles and privileges granted to `sysbackup`, you can query `DBA_ROLE_PRIVS` and `DBA_SYS_PRIVS`:

```
SQL> select * from dba_role_privs where grantee='SYSBACKUP';
SQL> select * from dba_sys_privs where grantee='SYSBACKUP';
```

Also, this new administrative privilege enables you to select, insert, delete, execute, and perform operations:

SELECT	**PERFORM operations**
`X$` tables	`STARTUP`, `SHUTDOWN`
`V$` and `GV$` views	`CREATE PFILE`, `CREATE SPFILE`
`APPQOSSYS.WLM_CLASSIFIER_PLAN`	`CREATE CONTROLFILE`
`SYSTEM.LOGSTDBY$PARAMETERS`	`FLASHBACK DATABASE`
INSERT/DELETE	`DROP DATABASE`
`SYS.APPLY$_SOURCE_SCHEMA`	`CREATE/DROP RESTORE POINT` (including `GUARANTEED` restore points)
`SYSTEM.LOGSTDBY$PARAMETERS`	
EXECUTE	
`SYS.DBMS_BACKUP_RESTORE`	`SYS.DBMS_DATAPUMP`
`SYS.DBMS_RCVMAN`	`SYS.DBMS_IR`
`SYS.DBMS_PIPE`	`SYS.SYS_ERROR`
`SYS.DBMS_TTS`	`SYS.DBMS_TDB`
`SYS.DBMS_PLUGTS`	`SYS.DBMS_PLUGTSP`

TIP

It is important for you to remember that:
When using the `sysbackup` privilege, you can't view application data.

There's more…

You can't drop user `sysbackup`.
In a multitenant environment, you can restrict a user to be able to perform backups only for the PDB it can connect to. You can accomplish that by creating a local user in the PDB and granting the `sysbackup` privilege to the user.
When you are connected to the database as the `sysbackup`, you are connected as `sysbackup` user to `SYS` schema:

```
SQL> connect / as sysbackup
Connected.

SQL> show user
USER is "SYSBACKUP"

SQL> select sys_context( 'userenv', 'current_schema' ) from dual;
SYS_CONTEXT('USERENV','CURRENT_SCHEMA')
---------------------------------------
SYS
```

See also

- *Creating password-authenticated users*
- *Creating and using OS-authenticated users*

The syskm privilege – how, when, and why should you use it?

It is recommended that you use the `syskm` administrative privilege instead of the `sysdba` administrative privilege to perform operations related to managing the **transparent data encryption** (**TDE**) keystore.

Getting ready

For this recipe, you'll need:

- An existing database user (for example, `jessica`) and a password file in the 12c format, if you want to complete it using a password-authenticated user
- An existing OS user (for example, `bob`), who belongs to the `kmdba` OS group, in order to connect to the database using OS authentication

How to do it...

Instructions are split into sections for database authentication and OS authentication.

Database authentication

The instructions for database authentication are as follows:

1. Connect to the database as `sysdba` (or another user that can grant the `syskm` privilege):

```
sqlplus / as sysdba
```

2. Grant the `syskm` privilege to user `jessica`:

```
grant syskm to jessica;
```

3. Connect user `jessica` to the database as `syskm`:

```
SQL> connect jessica/oracle_1 as syskm
```

4. View privileges:

```
SQL> select * from user_tab_privs;
SQL> select * from session_privs;
```

OS authentication

The instructions for OS authentication are as follows:

1. Verify that an OS user (for example, `bob`) is a member of the `kmdba` OS group.

   ```
   $ id bob
   ```

2. Connect to the database using `syskm` privilege:

   ```
   $ sqlplus / as syskm
   ```

How it works…

When you connect to the database as `syskm`, you are connected as a predefined user, `syskm`. Using the `syskm` privilege, you can connect to the database even when it is not open.

In most circumstances when using TDE, you don't have to have `syskm` administrative privilege. For a more detailed discussion about TDE operations and which privileges users need, see recipes in `Chapter 8`, *Transparent Data Encryption*.

In the *Database authentication* section after completing step 3, you can perform operations related to managing the TDE keystore. Step 4 is not necessary and its sole purpose is to show you which privileges you can use when connected as `syskm`. These privileges are:

- `ADMINISTER KEY MANAGEMENT`
- `CREATE SESSION`
- `SELECT` on `V$` (and `GV$`) views:
    - `SYS.V$ENCRYPTED_TABLESPACES`
    - `SYS.V$ENCRYPTION_WALLET`
    - `SYS.V$WALLET`
    - `SYS.V$ENCRYPTION_KEYS`
    - `SYS.V$CLIENT_SECRETS`
    - `SYS.DBA_ENCRYPTION_KEY_USAGE`
    - `SYS.DATABASE_KEY_INFO`

It is important for you to remember that:
When using `syskm` privilege, you can't view the application data.

There's more…

You can't drop user `syskm`.
When you are connected to the database as `syskm`, you are connected as the `syskm` user to `SYS` schema:

```
SQL> connect / as syskm
Connected.

SQL> show user
USER is "SYSKM"

SQL> select sys_context( 'userenv', 'current_schema' ) from dual;
SYS_CONTEXT('USERENV','CURRENT_SCHEMA')
---------------------------------------
SYS
```

See also

- *Creating password-authenticated users*
- *Creating and using OS-authenticated users*
- `Chapter 8`, *Transparent Data Encryption*

The sysdg privilege – how, when, and why should you use it?

It is recommended that you use the `sysdg` administrative privilege instead of `sysdba` administrative privilege to perform operations related to data guard tasks.

Getting ready

For this recipe, you'll need:

- An existing database user (for example, `mike`) and a password file in the 12c format if you want to complete it using a password-authenticated user
- An existing OS user (for example, `kelly`), who belongs to the `dgdba` OS group in order to connect to the database using OS authentication

How to do it…

Instructions are split into sections for database authentication and OS authentication.

Database authentication

The instructions for database authentication are as follows:

1. Connect to the database as `sysdba` (or another user who can grant the `sysdg` privilege):

   ```
   sqlplus / as sysdba
   ```

2. Grant `SYSDG` privilege to user `mike`:

   ```
   SQL> grant sysdg to mike;
   ```

3. Exit SQL*Plus, connect `mike` using the `dgmgrl` command-line interface:

   ```
   SQL> exit

   $ dgmgrl

   DGMRRL> connect mike/test_1
   ```

OS authentication

The instructions for OS authentication are as follows:

1. Verify that the OS user (for example, `kelly`) is a member of the `dgdba` OS group:

   ```
   $ id kelly
   ```

2. Connect using the `dgmgrl` utility and OS authentication:

   ```
   $ dgmgrl

   DGMGRL> connect /
   ```

How it works…

When you connect to the database as `sysdg`, you are connected as a predefined user, `sysdg`. Using the `sysdg` privilege, you can connect to the database even when it is not open.

After completing step 2 successfully in the *Database authentication* section, user `mike`, as expected, can grant/revoke `sysdg` privilege to/from another existing user. If you want to try it out, type the statements given here.

After you connect to the database using the `sysdg` administrative privilege, you can perform the following operations:

Operations	
`STARTUP, SHUTDOWN`	`CREATE SESSION`
`ALTER SESSION`	`SELECT ANY DICTIONARY`
`ALTER DATABASE`	`FLASHBACK DATABASE`
`ALTER SYSTEM`	`EXECUTE SYS.DBMS_DRS`
`CREATE/DROP RESTORE POINT` (including `GUARANTEED` restore points)	`SELECT X$ tables, V$` and `GV$` views
`DELETE APPQOSSYS.WLM_CLASSIFIER_PLAN`	`SELECT APPQOSSYS.WLM_CLASSIFIER_PLAN`

It is important for you to remember that:
When using the `sysdg` administrative privilege, you can't view application data.

There's more…

You can't drop user sysdg.
When you are connected to the database as sysdg, you are connected as sysdg user to the SYS schema:

```
SQL> connect / as sysdg
Connected.

SQL> show user
USER is "SYSDG"

SQL> select sys_context( 'userenv', 'current_schema' ) from dual;
SYS_CONTEXT('USERENV','CURRENT_SCHEMA')
-------------------------------------------------------------------
SYS
```

See also

- *Creating password-authenticated users*
- *Creating and using OS-authenticated users*

2
Security Considerations in Multitenant Environment

In this chapter, we will cover the following tasks:

- Creating a common user
- Creating a local user
- Creating a common role
- Creating a local role
- Granting privileges commonly
- Granting privileges locally
- Granting common and local roles
- The effects of plugging/unplugging operations on users, roles, and privileges

Introduction

The **Oracle multitenant environment** is a new architecture of Oracle Database, introduced in version 12c (12.1.0.1). It brings major changes to the way Oracle Database administrators think about the concept of databases and how they work (in a multitenant environment). One of the most significant changes is that many databases (up to 252) can share one database instance.

This chapter is focused on some of the security considerations concerning common and local users, roles, and privileges. The prerequisite for understanding recipes in this chapter is to have at least basic knowledge of fundamental multitenant concepts, such as what is a **container database** (**CDB**), **pluggable database** (**PDB**), **root container**, and **seed**.

Figure 1 shows the traditional architecture of Oracle Database.

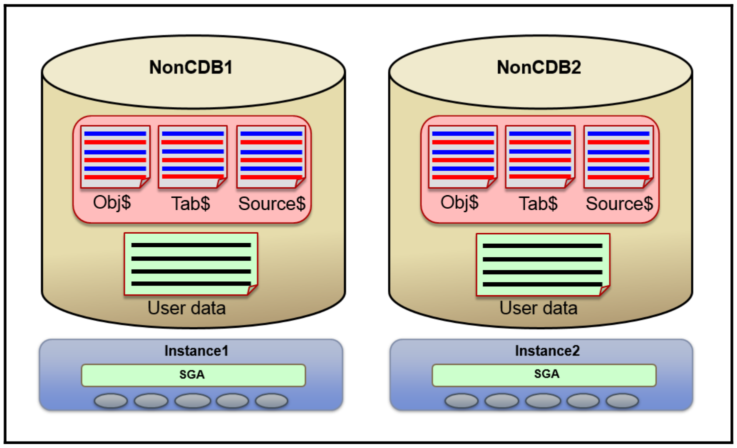


Figure 1 – A traditional architecture

Figure 2 shows the separation of the data dictionary in a multitenant architecture:

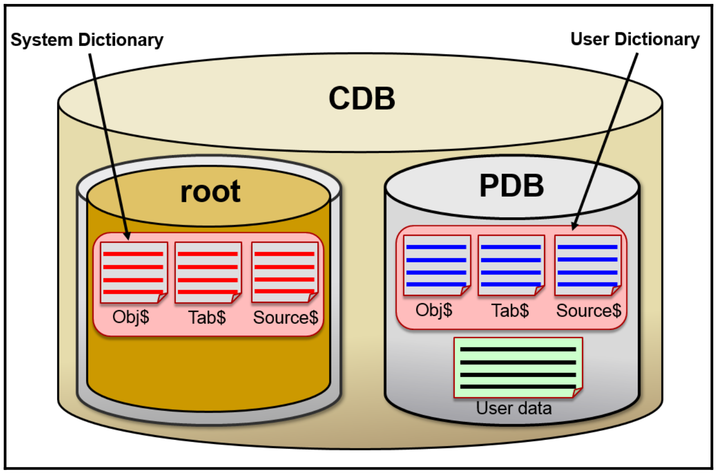


Figure 2 – Data Dictionary separation

Figure 3 shows a multitenant architecture. To learn more about it, see the Oracle official guide, *Oracle Database Concepts, 12c Release 1 (12.1), Part VI Multitenant Architecture*.

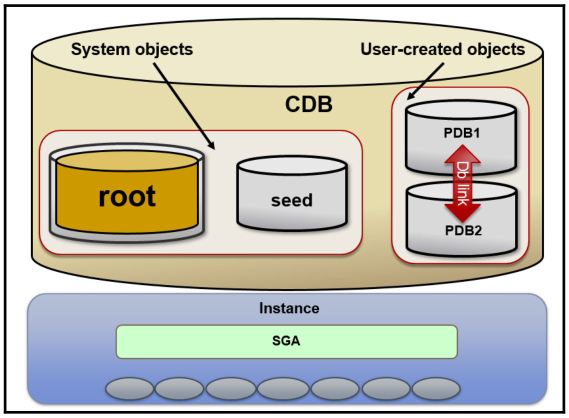


Figure 3 – A multitenant architecture

For all recipes in this chapter, you can use Oracle Database 12c Enterprise Edition with the multitenant option. All of the concepts presented in this chapter also apply to the single-tenant architecture (one CDB and one PDB), which exists in all editions of Oracle Database 12c. Also, for all recipes in this chapter, it is assumed that a container database (`cdb1`) is up and running. Also, the EM Cloud Control version should be 12.1.0.3+. The default prompt in SQL*Plus is `SQL>`. In this chapter, the `glogin.sql` script (located under `$ORACLE_HOME/sqlplus/admin`) is changed so that the prompt reflects the connected user and the current container. The only purpose is to make it easier to follow who is doing what and where. You don't have to change the prompt.

Creating a common user

A common user is a user created in the root container, which has the same identity across all containers. The main purpose of a common user is to perform "infrastructure" administrative tasks, such as starting up a CDB, plugging and unplugging PDBs, and opening PDBs. There are two types of common users: Oracle-supplied (for example, `SYS` and `SYSTEM`) and user-created common users.

Getting ready

To complete this recipe, you'll need an existing common user who has `create user` privilege granted commonly.

How to do it…

1. Connect to the root container as a common user who has `create user` privilege granted commonly (for example, `c##zoran` or system user):

```
SQL> connect c##zoran@cdb1
```

2. Create a common user (for example, `c##maja`):

```
c##zoran@CDB1> create user c##maja identified by oracle1
container=all;
```

How it works…

`c##maja` is actually not a single user, but each container has a user named `c##maja` and the passwords must be the same.

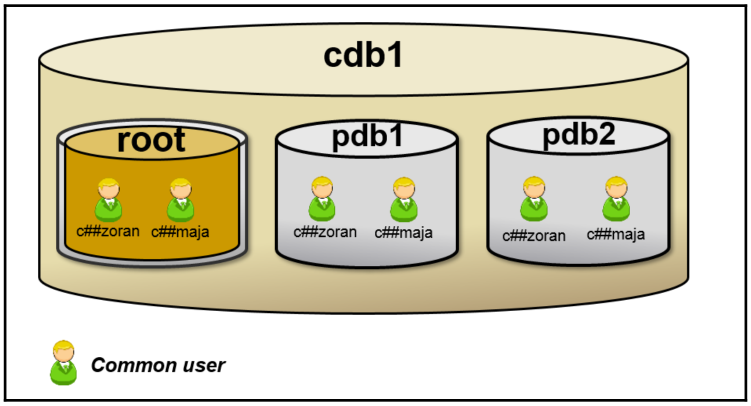


Figure 4

Rules/guidelines for creating and managing common users

There are a few rules you should be aware of:

- The name of a common user must be unique across all containers. In version 12.1.0.1, it must begin with `c##` or `C##` unless you change the internal parameter `common_user_prefix` (which you shouldn't do on a production system without approval from Oracle Support) and, in version 12.1.0.2, it is best practice to use a prefix (default value `c##` or `C##`). However, you can choose it by changing the value of the `common_user_prefix` parameter (this naming convention doesn't apply to Oracle-supplied users in either version).
- A common user can have different privileges in different containers.
- The schemas for a common user may contain different objects in different containers.

The column `oracle_maintained` (in `DBA_USERS`) provides information as to whether a user is created and maintained by Oracle-supplied scripts:

```
c##zoran@CDB1> select username, oracle_maintained from dba_users where
username='SYSTEM' or username='C##ZORAN';

USERNAME           O
---------------    -
SYSTEM             Y
C##ZORAN           N
```

There's more…

You can also create common users by using *Oracle Enterprise Manager Cloud Control (OEM) 12c*.

How to create a common user using OEM 12c

1. Start OEM 12c and log in using user `SYSMAN` or `SYSTEM`.

2. From the **Databases** page, select the root database in which you want to create a common user. The database home page appears.

3. From the **Administration** menu, select **Security** (a drop-down menu) and then **Users** (see Figure 5):

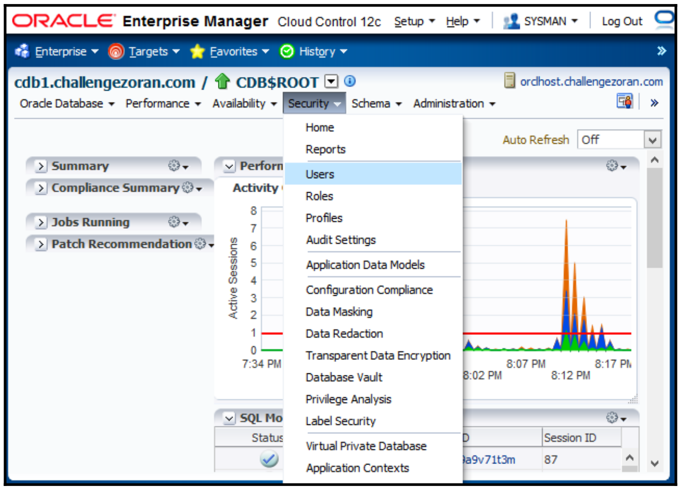
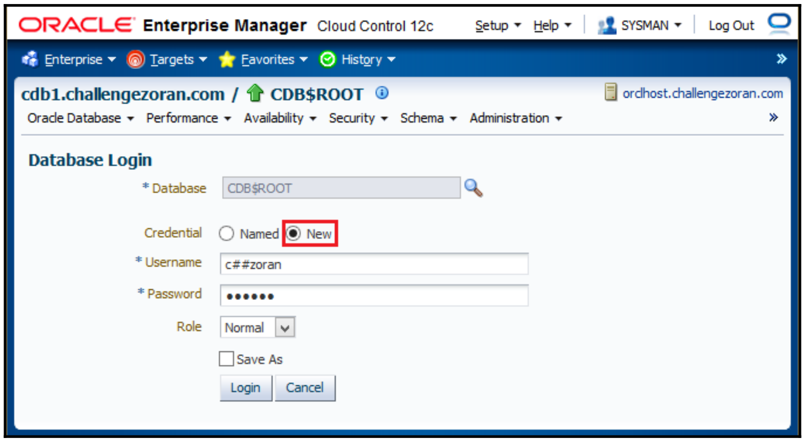


Figure 5

4. If prompted, log in to the root as a common user who has a `create user` privilege (for example, `c##zoran`; see Figure 6):

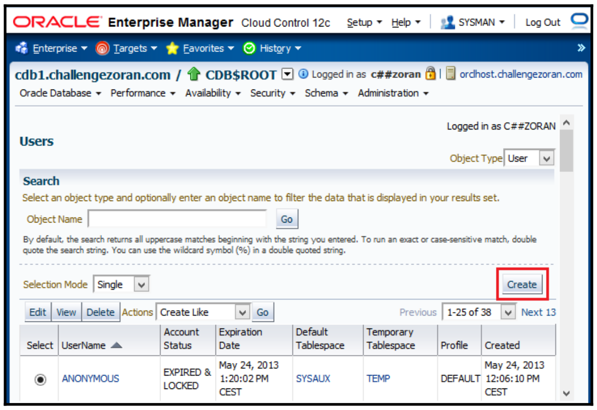


Database Login

* Database	CDB$ROOT
Credential	Named [✓ New]
* Username	c##zoran
* Password	••••••
Role	Normal
	☐ Save As

Figure 6

5. Click on the **Create** button (see Figure 7):



Users

Logged in as C##ZORAN

Object Type: User

Search

Select an object type and optionally enter an object name to filter the data that is displayed in your results set.

Object Name:

By default, the search returns all uppercase matches beginning with the string you entered. To run an exact or case-sensitive match, double quote the search string. You can use the wildcard symbol (%) in a double quoted string.

Selection Mode: Single

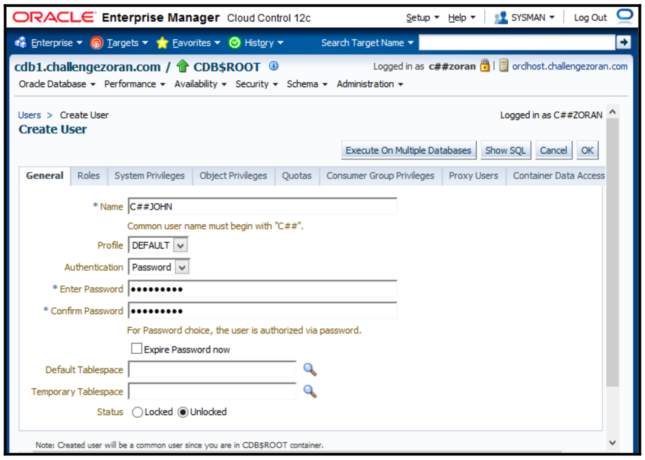
Actions: Create Like

1-25 of 38

Select	UserName	Account Status	Expiration Date	Default Tablespace	Temporary Tablespace	Profile	Created
●	ANONYMOUS	EXPIRED & LOCKED	May 24, 2013 1:20:02 PM CEST	SYSAUX	TEMP	DEFAULT	May 24, 2013 12:06:10 PM CEST

Figure 7

6. To create a common user, it is enough to fill out the following fields on the **General** tab: **Name** (for example, `c##john`), **Enter Password**, and **Confirm Password** (see Figure 8) and then click on the **OK** button:



Logged in as C##ZORAN

Create User

* Name: C##JOHN

Common user name must begin with "C##".

Profile: DEFAULT

Authentication: Password

* Enter Password: •••••••••

* Confirm Password: •••••••••

For Password choice, the user is authorized via password.

☐ Expire Password now

Default Tablespace:

Temporary Tablespace:

Status: Locked [✓ Unlocked]

Note: Created user will be a common user since you are in CDB$ROOT container.

Figure 8

Creating a local user

A **local user** is a user that is created and that exists in only one PDB. A local user can't be created in the root container.

Getting ready

A pluggable database (in our case, `pdb1`) should be open. You'll need an existing user (either common or local) who has `create user` privilege in that pluggable database.

How to do it…

1. Connect to PDB (for example, `pdb1`) as a common user or local user who has `create user` privilege in that PDB (for example, `c##zoran` or system user):

   ```
   SQL> connect c##zoran@pdb1
   ```

2. Create a local user (for example, `mike`):

   ```
   c##zoran@PDB1> create user mike identified by pa3t5brii
   container=current;
   ```

How it works…

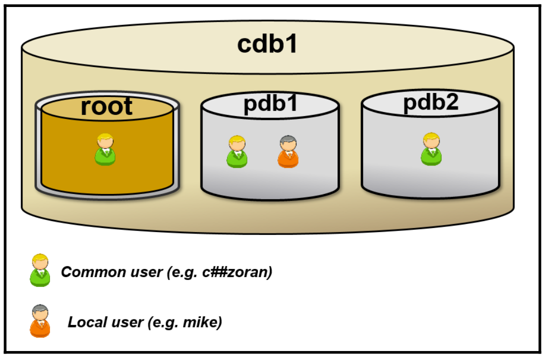


Figure 9

Rules/guidelines for creating and managing local users

There are a few rules you should be aware of:

- The name of a local user must be unique within its pluggable database and it *must not* begin with `c##` or `C##`
- A local user cannot be created in the root
- A local user exists in one and only one PDB and owns a schema in that PDB

There's more…

You can also create local users by using *Oracle Enterprise Manager Cloud Control (OEM) 12c*.

How to create a local user using OEM 12c

You can follow the steps given in the *How to create a common user using OEM 12c* section, except that, in Step 2, you should connect to the pluggable database (for example, `pdb1`) instead of the root. Also, you can connect to PDB as a local user who has a local `create user` privilege. If you want to switch container, you should click on **Container Switcher** and a drop-down menu will open (see Figure 10):

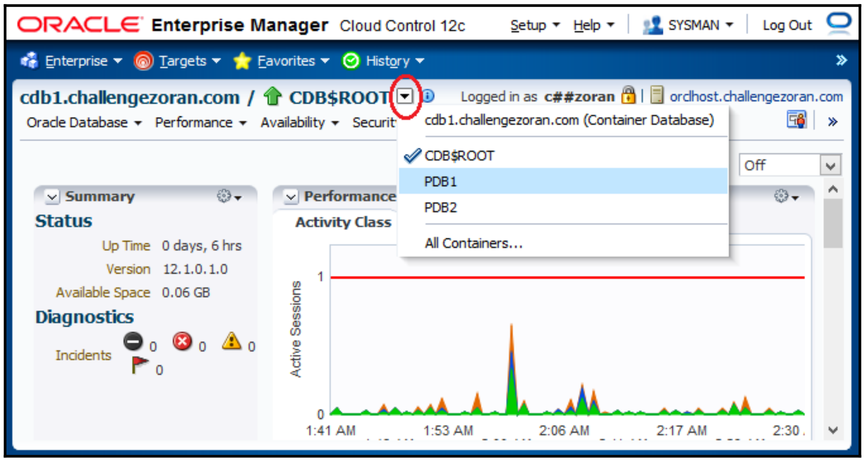
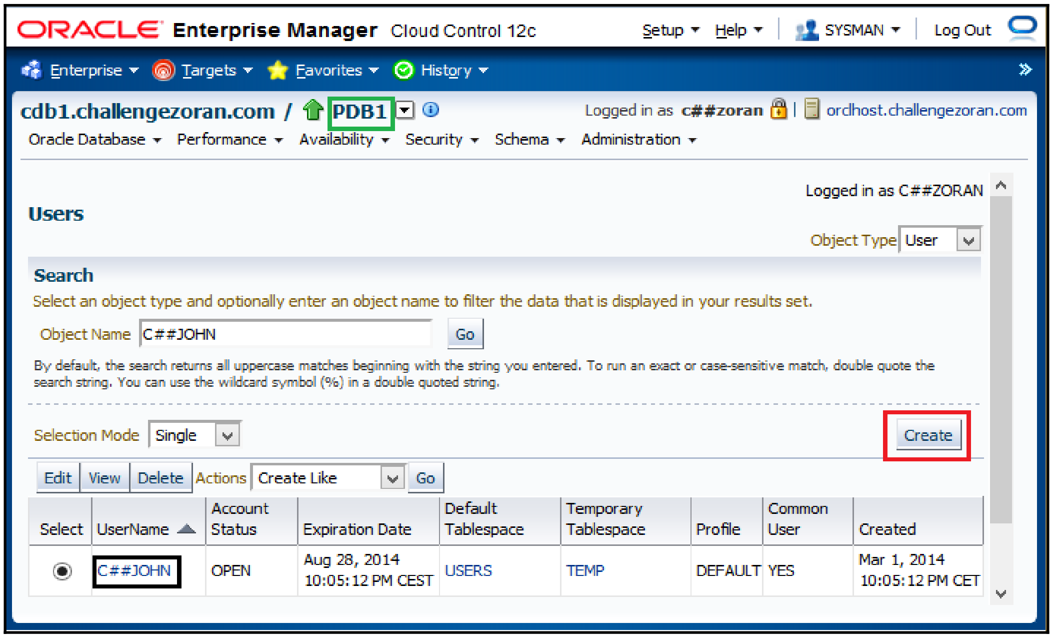


Figure 10

In Figure 11, it is shown that the common user you created in the previous recipe is created in the pluggable database (for example, `c##john` is created in `pdb1`; the common user is created in all pluggable databases that reside in the CDB and will be created in all future PDBs). By clicking on the **Create** button shown in Figure 11, you can create (only) a local user:



Logged in as C##ZORAN

Users

Object Type: User

Search

Select an object type and optionally enter an object name to filter the data that is displayed in your results set.

Object Name: C##JOHN Go

By default, the search returns all uppercase matches beginning with the string you entered. To run an exact or case-sensitive match, double quote the search string. You can use the wildcard symbol (%) in a double quoted string.

Selection Mode: Single Create

Edit | View | Delete | Actions: Create Like | Go

Select	UserName	Account Status	Expiration Date	Default Tablespace	Temporary Tablespace	Profile	Common User	Created
●	C##JOHN	OPEN	Aug 28, 2014 10:05:12 PM CEST	USERS	TEMP	DEFAULT	YES	Mar 1, 2014 10:05:12 PM CET

Figure 11

Creating a common role

Common roles are roles created in the root container and they exist in all containers. These roles can have a different set of privileges in different containers and they can be granted to either common or local users or roles.

Getting ready

To complete this recipe, you'll need an existing common user who has `create role` privilege granted commonly.

How to do it…

1. Connect to the root container as a common user who has `create role` privilege granted commonly (for example, `c##zoran` or system user):

```
SQL> connect c##zoran@cdb1
```

2. Create a common role (for example, `c##role1`):

```
SQL> create role c##role1 container=all;
```

How it works…

When you create a common role, that role exists in all containers in that database (including a root container and existing and future pluggable databases).

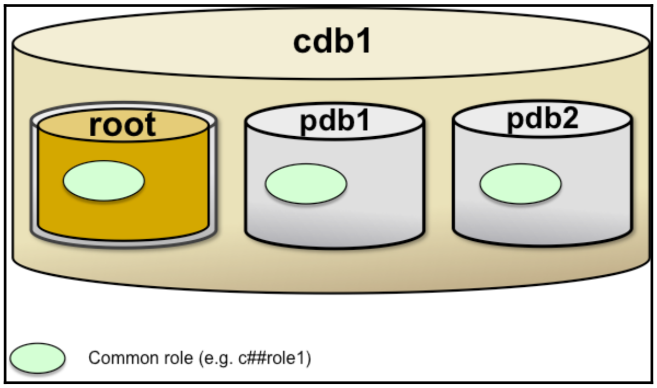


Figure 12

```
c##zoran@CDB1> select * from dba_roles where role='C##ROLE1';


ROLE                  PASSWORD AUTHENTICAT   COM  O
----------------      --------  -----------  ---  -
C##ROLE1              NO        NONE         YES  N

c##zoran@CDB1> connect c##zoran/oracle@pdb1

Connected.

c##zoran@PDB1> select * from dba_roles where role='C##ROLE1';

ROLE                  PASSWORD  AUTHENTICAT  COM  O
----------------      --------  -----------  ---  -
C##ROLE1              NO        NONE         YES  N


c##zoran@PDB1> connect c##zoran/oracle@pdb2

Connected.


c##zoran@PDB2> select * from dba_roles where role='C##ROLE1';

ROLE                  PASSWORD  AUTHENTICAT  COM  O
----------------      --------  -----------  ---  -
C##ROLE1              NO        NONE         YES  N
```

There's more…

You can also create common roles by using *Oracle Enterprise Manager Cloud Control (OEM) 12c*.

How to create a common role using OEM 12c

You should connect to the root (`CDB$ROOT`) as a common user who has `create role` privilege granted commonly (for example, `c##zoran` or system user). From the **Administration** menu, select **Security** (drop-down menu) and then **Roles** (see Figure 13):

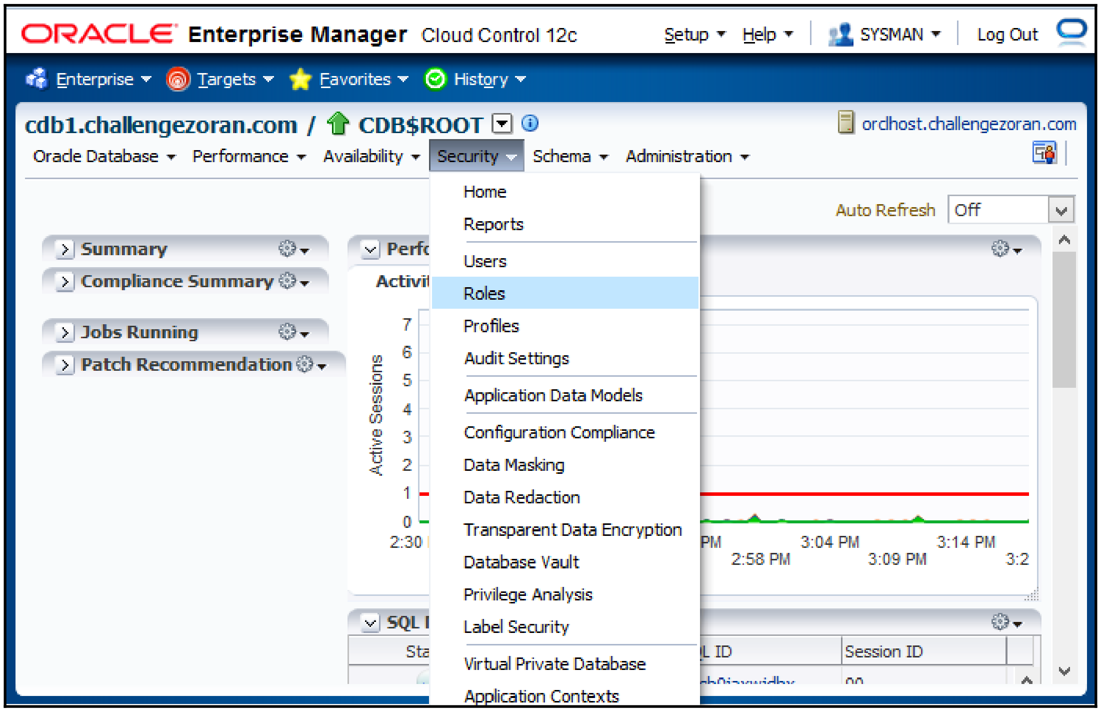
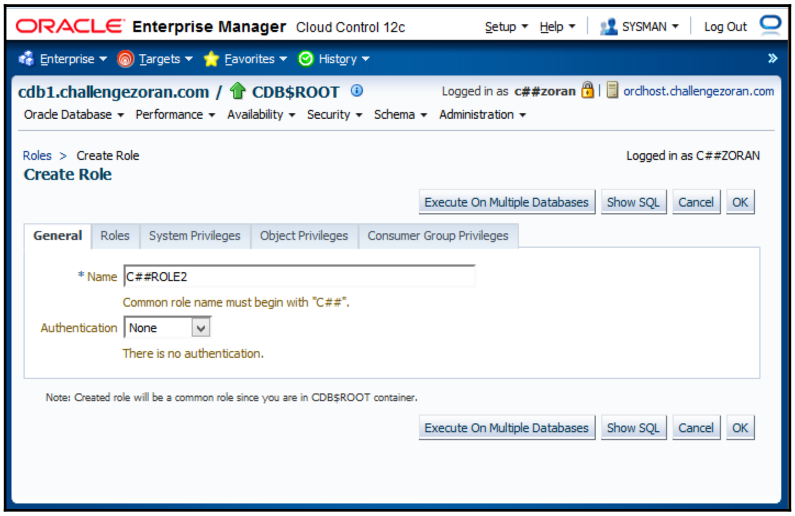


Figure 13

On the **Roles** page, click on the **Create** button and the **Create Role** page appears (Figure 14):



cdb1.challengezoran.com / CDB$ROOT

Logged in as c##zoran | orclhost.challengezoran.com

Create Role

Logged in as C##ZORAN

* Name: C##ROLE2

Common role name must begin with "C##".

Authentication: None

There is no authentication.

Note: Created role will be a common role since you are in CDB$ROOT container.

Figure 14

On the **Create Role** page, you name the role on the **General** tab (for example, `c##role2`). Also, you may grant other roles and privileges to `c##role2` (using the tabs **Roles**, **System Privileges**, and **Object Privileges**). After choosing the options and granting privileges to the role, click on the **OK** button to create it.

Creating a local role

Local roles are roles created in PDB and they exist only in that PDB. These roles can be granted *only locally* to either common or local users or roles.

Getting ready

For this recipe, a pluggable database (in our case, `pdb1`) should be open. You'll need an existing user (either common or local) who has `create role` privilege in that pluggable database.

How to do it...

1. Connect to PDB (for example, `pdb1`) as a common or local user who has `create role` privilege in that PDB (for example, `c##maja`):

   ```
   SQL> connect c##maja@pdb1
   ```

2. Create a local role (for example, `local_role1`):

   ```
   c##maja@PDB1> create role local_role1 container=current;
   ```

How it works...

When you create a local role, that role exists only in the pluggable database in which it is created. Local roles cannot be created in the root container. These roles are traditional roles.

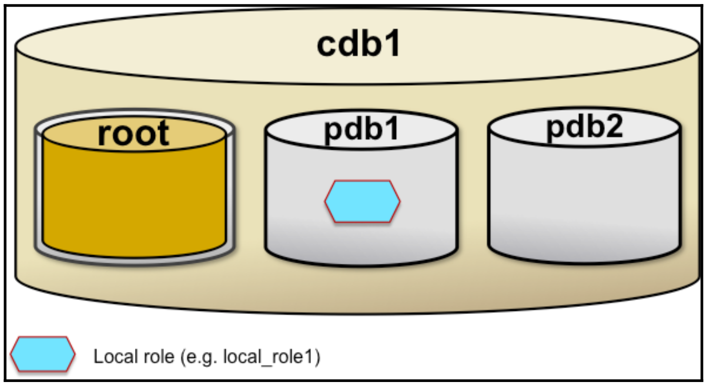


Figure 15

```
c##maja@CDB1> select * from dba_roles where role='LOCAL_ROLE1';

no rows selected


c##maja@CDB1> connect c##maja/oracle@pdb1

Connected.


c##maja@PDB1> select * from dba_roles where role='LOCAL_ROLE1';
```

```
ROLE                    PASSWORD   AUTHENTICAT   COM   O
-------------------      --------   -----------   ---   -
LOCAL_ROLE1              NO         NONE          NO    N


c##maja@PDB1> connect c##maja/oracle@pdb2

Connected.


c##maja@PDB2> select * from dba_roles where role='LOCAL_ROLE1';

no rows selected
```

There's more…

You can also create local roles by using *Oracle Enterprise Manager Cloud Control (OEM) 12c*.

How to create a local role using OEM 12c

You should connect to PDB (for example, `pdb1`) as a common or local user who has `create role` privilege in that PDB (for example, `c##maja`). All the remaining steps are done in the same way as in the *How to create a common role using OEM 12c* section.

Granting privileges and roles commonly

The common privilege is a privilege that can be exercised across all containers in a container database. Depending only on the way it is granted, a privilege becomes common or local. When you grant a privilege commonly (across all containers) it becomes a common privilege. Only common users or roles can have common privileges. Only common role can be granted commonly.

Getting ready

For this recipe, you will need to connect to the root container as an existing common user who is able to grant a specific privilege or existing role (in our case, `create session`, `select any table`, `c##role1`, `c##role2`) to another existing common user (`c##john`). If you want to try out examples in the *How it works* section, you should open `pdb1` and `pdb2`.

You will use the following:

- Common users `c##maja` and `c##zoran` with the dba role granted commonly
- Common user `c##john`
- Common roles `c##role1` and `c##role2`

How to do it…

1. You should connect to the root container as a common user who can grant these privileges and roles (for example, `c##maja` or system user):

   ```
   SQL> connect c##maja@cdb1
   ```

2. Grant a privilege (for example, `create session`) to a common user (for example, `c##john`) commonly:

   ```
   c##maja@CDB1> grant create session to c##john container=all;
   ```

3. Grant a privilege (for example, `select any table`) to a common role (for example, `c##role1`) commonly:

   ```
   c##maja@CDB1> grant select any table to c##role1 container=all;
   ```

4. Grant a common role (for example, `c##role1`) to a common role (for example, `c##role2`) commonly:

   ```
   c##maja@CDB1> grant c##role1 to c##role2 container=all;
   ```

5. Grant a common role (for example, `c##role2`) to a common user (for example, `c##john`) commonly:

   ```
   c##maja@CDB1> grant c##role2 to c##john container=all;
   ```

How it works…

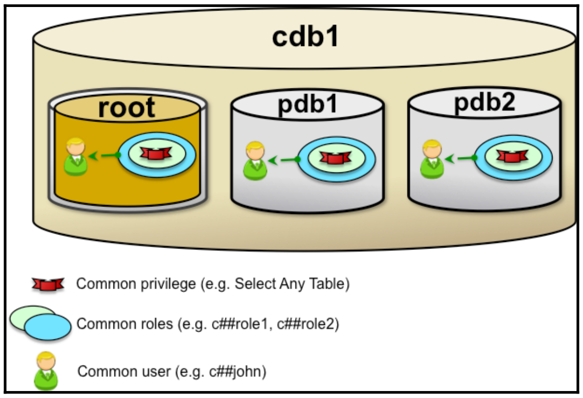

cdb1
root
pdb1
pdb2
Common privilege (e.g. Select Any Table)
Common roles (e.g. c##role1, c##role2)
Common user (e.g. c##john)

Figure 16

You can grant privileges or common roles commonly only to a common user. You need to connect to the root container as a common user who is able to grant a specific privilege or role.

In Step 2, system privilege, `create session` is granted to the common user `c##john` *commonly* by adding a `container=all` clause to the `grant` statement. This means that the user `c##john` can connect (`create session`) to the root or any pluggable database in this container database (including all pluggable databases that will be plugged in in the future).

Note that the `container = all` clause is NOT optional even though you are connected to the root. Unlike during the creation of common users and roles (if you omit `container=all`, the user or role will be created in all containers commonly), if you omit this clause during the privilege or role grant, the privilege or role will be granted locally and it can be exercised only in root container.

```
SQL> connect c##john/oracle@cdb1

Connected.


c##john@CDB1> connect c##john/oracle@pdb1
```

```
Connected.


c##john@PDB1> connect c##john/oracle@pdb2

Connected.


c##john@PDB2>
```

In step 3, system privilege `select any table` is granted to the common role `c##role1` commonly. This means that the role `c##role1` contains the `select any table` privilege in all containers (root and pluggable databases):

```
c##zoran@CDB1> select * from role_sys_privs where role='C##ROLE1';

ROLE                     PRIVILEGE                     ADM  COM
-----------------         ------------------            ---  ---
C##ROLE1                 SELECT ANY TABLE               NO  YES


c##zoran@CDB1> connect c##zoran/oracle@pdb1

Connected.


c##zoran@PDB1> select * from role_sys_privs where role='C##ROLE1';

ROLE                     PRIVILEGE                     ADM  COM
-----------------         ------------------            ---  ---
C##ROLE1                 SELECT ANY TABLE               NO  YES


c##zoran@PDB1> connect c##zoran/oracle@pdb2

Connected.


c##zoran@PDB2> select * from role_sys_privs where role='C##ROLE1';

ROLE                     PRIVILEGE                     ADM  COM
-----------------        ------------------            ---  ---
C##ROLE1                 SELECT ANY TABLE               NO  YES
```

In Step 4, the common role `c##role1` is granted to another common role `c##role2` commonly. This means that the role `c##role2` has granted the role `c##role1` in all containers:

```
c##zoran@CDB1> select * from role_role_privs where role='C##ROLE2';

ROLE                     GRANTED_ROLE                  ADM  COM
-----------------        ----------------------        ---- ---
C##ROLE2                 C##ROLE1                      NO   YES


c##zoran@CDB1> connect c##zoran/oracle@pdb1

Connected.


c##zoran@PDB1> select * from role_role_privs where role='C##ROLE2';

ROLE                     GRANTED_ROLE                  ADM  COM
-----------------       ----------------------         ---- ---
C##ROLE2                 C##ROLE1                      NO   YES


c##zoran@PDB1> connect c##zoran/oracle@pdb2

Connected.


c##zoran@PDB2> select * from role_role_privs where role='C##ROLE2';

ROLE                     GRANTED_ROLE                  ADM  COM
-----------------       ----------------------         ---- ---
C##ROLE2                 C##ROLE1                      NO   YES
```

In step 5, the common role `c##role2` is granted to the common user `c##john` commonly. This means that the user `c##john` has `c##role2` in all containers.

Consequently, the user `c##john` can use the `select any table` privilege in all containers in this container database:

```
c##john@CDB1> select count(*) from c##zoran.t1;

  COUNT(*)
----------
         4


c##john@CDB1> connect c##john/oracle@pdb1

Connected.


c##john@PDB1> select count(*) from hr.employees;

  COUNT(*)
----------
       107


c##john@PDB1> connect c##john/oracle@pdb2

Connected.


c##john@PDB2> select count(*) from sh.sales;

 COUNT(*)
----------
  918843
```

Granting privileges and roles locally

A local privilege is a privilege than can be exercised only in a container in which it is granted. Depending only on the way it is granted, a privilege becomes common or local. When you grant privilege locally (in the current container), it becomes a local privilege. Both common and local users or roles can have local privileges.

Getting ready

For this recipe, you'll need an existing user (`c##maja`) who can grant some privileges (for example, `create procedure`, `create table`, `create view`, and `create synonym`) and roles (`c##role1`, `c##role2`, `c##role3`, `c##role4`, and `local_role1`) in a specific container (root or PDB; in our case, `pdb1`) to existing users and roles (`c##john`, `mike`, `local_role1`, `c##role1`, `c##role3`, and `c##role4`).

How to do it…

1. You should connect to the container (root or pluggable database) in which you want to grant the privilege as a common or local user who can grant that privilege (for example, `c##maja`):

   ```
   SQL> connect c##maja@pdb1
   ```

2. Grant a privilege (for example, `create synonym`) to a common user (for example, `c##john`) locally:

   ```
   c##maja@PDB1> grant create synonym to c##john container=current;
   ```

3. Grant a privilege (for example, `create view`) to a local user (for example, `mike`) locally:

   ```
   c##maja@PDB1> grant create view to mike container=current;
   ```

4. Grant a privilege (for example, `create table`) to a common role (for example, `c##role1`) locally:

   ```
   c##maja@PDB1> grant create table to c##role1 container=current;
   ```

5. Grant a privilege (for example, `create procedure`) to a local role (for example, `local_role1`) locally:

   ```
   c##maja@PDB1> grant create procedure to local_role1
   container=current;
   ```

6. Grant a common role (for example, `c##role2`) to another common role (for example, `c##role3`) locally:

   ```
   c##maja@PDB1> grant c##role2 to c##role3 container=current;
   ```

7. Grant a common role (for example, `c##role3`) to a local role (for example, `local_role1`) locally:

   ```
   c##maja@PDB1> grant c##role3 to local_role1 container=current;
   ```

8. Grant a local role (for example, `local_role1`) to a common role (for example, `c##role4`) locally:

   ```
   c##maja@PDB1> grant local_role1 to c##role4 container=current;
   ```

9. Grant a common role (for example, `c##role4`) to a common user (for example, `c##john`) locally:

   ```
   c##maja@PDB1> grant c##role4 to c##john container=current;
   ```

How it works…

In the previous section, we have seen different types of local grants. Local grants are valid only in the current container even though the granted user (or role) is common. Consequently, common users and common roles can have a different set of privileges in different containers. Steps 3, 5, 7, and 8 can't be done in the root container because there are no local users and local roles in the root container.

Effects of plugging/unplugging operations on users, roles, and privileges

The purpose of this recipe is to show what is going to happen to users, roles, and privileges when you unplug a pluggable database from one container database (`cdb1`) and plug it into some other container database (`cdb2`).

Getting ready

To complete this recipe, you will need the following:

- Two container databases (`cdb1` and `cdb2`)
- One pluggable database (`pdb1`) in the container database `cdb1`
- Local user `mike` in the pluggable database `pdb1` with the local `create session` privilege
- The common user `c##john` with the `create session` common privilege and `create synonym` local privilege on the pluggable database `pdb1`

How to do it…

1. Connect to the root container of `cdb1` as user `sys`:

   ```
   SQL> connect sys@cdb1 as sysdba
   ```

2. Unplug `pdb1` by creating an XML metadata file:

   ```
   SQL> alter pluggable database pdb1 unplug into
   '/u02/oradata/pdb1.xml';
   ```

3. Drop `pdb1` and keep the datafiles:

   ```
   SQL> drop pluggable database pdb1 keep datafiles;
   ```

4. Connect to the root container of `cdb2` as user `sys`:

   ```
   SQL> connect sys@cdb2 as sysdba
   ```

5. Create (plug) `pdb1` to `cdb2` by using the previously created metadata file:

   ```
   SQL> create pluggable database pdb1 using '/u02/oradata/pdb1.xml'
   nocopy;
   ```

How it works…

By completing the previous steps, you unplugged `pdb1` from `cdb1` and plugged it into `cdb2`. After this operation, all local users and roles (in `pdb1`) are migrated with the `pdb1` database.

The following is how you try to connect to `pdb1` as a local user:

```
SQL> connect mike@pdb1
```

All local privileges are migrated even if they are granted to common users/roles. However, if you try to connect to `pdb1` as a previously created common user, `c##john`, you'll get an error, as follows:

```
SQL> connect c##john@pdb1

ERROR:
ORA-28000: the account is locked
Warning: You are no longer connected to ORACLE.
```

This happened because, after migration, common users are migrated in a pluggable database as locked accounts. You can continue to use objects in these users' schemas, or you can create these users in a root container of a new CDB. To do this, we first need to close `pdb1`:

```
sys@CDB2> alter pluggable database pdb1 close;
Pluggable database altered.

sys@CDB2> create user c##john identified by oracle container=all;
User created.

sys@CDB2> alter pluggable database pdb1 open;
Pluggable database altered.
```

If we try to connect to pdb1 as the user c##john, we will get the following error:

```
SQL> conn c##john/oracle@pdb1

ERROR:
ORA-01045: user C##JOHN lacks CREATE SESSION privilege; logon denied
Warning: You are no longer connected to ORACLE.
```

Even though c##john had the create session common privilege in cdb1, he cannot connect to the migrated PDB. This is because common privileges are *not migrated*! So, we need to give the create session privilege (either common or local) to the user c##john, as follows:

```
sys@CDB2> grant create session to c##john container=all;

Grant succeeded.
```

In the earlier recipe (*Granting privileges and roles locally*), we granted a create synonym local privilege to a user, c##john. Let's try this privilege on the migrated pdb2:

```
c##john@PDB1> create synonym emp for hr.employees;

Synonym created.
```

This proves that local privileges are always migrated.

3
PL/SQL Security

In this chapter, we will cover the following tasks:

- Creating and using definer's rights procedures
- Creating and using invoker's rights procedures
- Using code-based access control
- Restricting access to program units by using `accessible by`

Introduction

In this section, you will learn the definitions of concepts that will be used in the rest of the chapter.

Definer is the owner of a procedure.

Invoker is a user who uses (invokes) a procedure, but is not the definer of the procedure.

Definer's rights procedure is a procedure (or a program unit) that executes with the privileges of its definer.

Invoker's rights procedure is a procedure (or a program unit) that executes with the privileges of the invoker.

Another difference between definer's and invoker's rights procedures is that invoker's rights procedures are not bound to the schema in which they are located.

Code base access control is a new feature, introduced in Oracle Database 12c. It enables you to grant database roles to PL/SQL functions, procedures, or packages. You can use it with definer's and invoker's rights procedures.

The purpose of the `accessible by` clause is to limit the calling set of program units to be those in the `accessible by` clause and the unit itself.

For all the recipes in this chapter, you will use non-CDB 12c. We assume that the database is up and running.

Creating and using definer's rights procedures

In this recipe, you'll learn to create and use definer's rights procedures.

Getting ready

To complete this recipe, you'll use a user who has a DBA role.

How to do it…

1. Connect to the database as a user with the DBA role (for example, `zoran`)

```
SQL> connect zoran
```

2. Create two users (`procowner` and `procuser`) and grant them appropriate privileges:

```
SQL> create user procowner identified by oracle1;
SQL> create user procuser identified by oracle2;
SQL> grant create session, create procedure to procowner;
SQL> grant create session to procuser;
```

3. Create a table called `zoran.tbl` and grant users privileges on this table:

```
SQL> create table zoran.tbl(a number, b varchar2(40));
SQL> insert into zoran.tbl values(1, 'old_value');
SQL> commit;
SQL> grant select on zoran.tbl to procuser;
SQL> grant update on zoran.tbl to procowner;
```

4. Connect as a user, `procowner`, create a procedure to update table `zoran.tbl`, and grant `execute` on this procedure to user `procuser`:

```
SQL> connect procowner/oracle1
CREATE OR REPLACE PROCEDURE UpdateTbl (x IN number,
y IN varchar2)
  AUTHID DEFINER
    AS
      BEGIN
       UPDATE ZORAN.TBL
       SET b = y
        WHERE a = x;
    END;
  /
SQL> grant execute on UpdateTbl to procuser;
```

5. Connect as user `procuser` and try to directly update table `zoran.tbl`:

```
SQL> connect procuser/oracle2
SQL> UPDATE ZORAN.TBL SET B = 'value1' WHERE A = 1;
UPDATE ZORAN.TBL SET B = 'value1' WHERE A = 1
         *
ERROR at line 1:
ORA-01031: insufficient privileges
```

6. When the previous step fails, update table by using the `UpdateTbl` procedure:

```
SQL> EXEC procowner.UpdateTbl(1, 'new_value');
PL/SQL procedure successfully completed.
```

7. Check whether the table is updated:

```
SQL> select * from zoran.tbl;
   A          B
---------- ----------------------------------------
   1          new_value
```

How it works…

Definer's rights procedures are executed by using privileges that are granted to the owner of the procedure. In our example, we have two users: `procowner` - a user who is the owner of the procedure and has privilege to update table `zoran.tbl` and `procuser` - a user who just executes the procedure. In step 4, `procuser` creates procedure by using the `AUTHID DEFINER` clause, which means that this procedure will be definer's rights procedure. This is a default behavior (we can omit the `AUTHID DEFINER` clause). In step 5, `procuser` tries to update table `zoran.tbl` directly, but it gets an error:

```
SQL> UPDATE ZORAN.TBL SET B = 'value1' WHERE A = 1;
UPDATE ZORAN.TBL SET B = 'value1' WHERE A = 1
             *
ERROR at line 1:
ORA-01031: insufficient privileges
```

This is the expected behavior, considering that `procuser` doesn't have an update privilege on `zoran.tbl`. When `procuser` executes the procedure in step 6, the table is updated because the privilege of the definer is applied.

Creating and using invoker's right procedures

In this recipe, you'll learn to create and use invoker's rights procedures. They can be useful when creating PL/SQL procedures in a highly privileged schema (because in this case, it is more secure to grant specific privileges to the invoker). Also, when there is no SQL code in the PL/SQL procedure and the procedure is available to other users, invoker's rights procedure will be executed more efficiently. There are no changes in the values of current schema and currently enabled roles during the execution (these changes are not necessary because without SQL in PL/SQL code, privilege checking is not performed).

Getting ready

To complete this recipe, you'll use a user who has the DBA role.

How to do it…

1. Connect to the database as a user with the DBA role (for example, `zoran`):

   ```
   SQL> connect zoran
   ```

2. Create two users (`procuser1`, `procuser2`) and grant them privileges:

   ```
   SQL> create user procuser1 identified by oracle1;
   SQL> create user procuser2 identified by oracle2;
   SQL> grant create session to procuser1;
   SQL> grant create session to procuser2;
   ```

3. Create the table `table1` and grant `select` and `update` privileges on that table to `procuser1` and only `select` privilege to `procuser2`:

   ```
   SQL> create table table1(a number, b varchar2(30));
   SQL> insert into zoran.table1 values(1, 'old_value');
   SQL> commit;
   SQL> grant select on zoran.table1 to procuser1;
   SQL> grant update on zoran.table1 to procuser1;
   SQL> grant select on zoran.table1 to procuser2;
   ```

4. Create an invoker's rights procedure to update `table1`:

   ```
   CREATE OR REPLACE PROCEDURE UpdateTable1 (x IN number,
   y IN varchar2)
     AUTHID CURRENT_USER
       AS
         BEGIN
          UPDATE ZORAN.TABLE1
          SET b = y
           WHERE a = x;
       END;
     /
   ```

5. Grant `execute` on that procedure to `procuser1` and `procuser2`:

   ```
   SQL> grant execute on zoran.UpdateTable1 to procuser1;
   SQL> grant execute on zoran.UpdateTable1 to procuser2;
   ```

6. Connect as user `procuser1` and execute the procedure `UpdateTable1`:

```
SQL> connect procuser1
SQL> EXEC zoran.UpdateTable1(1, 'new_value');
PL/SQL procedure successfully completed.
SQL> commit;
```

7. Check whether the table is updated:

```
SQL> select * from zoran.table1;
   A         B
---------- ----------------------------------------
   1         new_value
```

8. Connect as the user `procuser2` and try to execute the procedure `UpdateTable1`:

```
SQL> connect procuser2
SQL> EXEC zoran.UpdateTable1(1, 'newer_value');
BEGIN zoran.UpdateTable1(1, 'new_value'); END;
*
ERROR at line 1:
ORA-01031: insufficient privileges
ORA-06512: at "ZORAN.UPDATETABLE1", line 5
ORA-06512: at line 1
```

How it works…

Invoker's rights procedures are executed by using privileges that are granted to the user that executes the procedure. In step 4, the user `zoran` creates an invoker's rights procedure by specifying the `AUTHID CURRENT_USER` clause. When `procuser1` executes that procedure in step 6, he or she succeeds because `update` privilege is granted to `procuser1`, but when `procuser2` tries to execute it in step 8, he or she gets an error because `procuser2` lacks the `update` privilege on `table1`.

There's more…

Let's consider this security problem.

1. Connect as a user who has a DBA role (for example, `zoran`). Create a new user `maluser` and grant him the privileges `create session` and `create procedure`.

   ```
   SQL> create user maluser identified by oracle1;
   SQL> grant create session, create procedure to maluser;
   ```

2. Connect as the user `maluser` and create the following “malicious” procedure with the purpose of granting him the DBA role:

   ```
   SQL> connect maluser/oracle1
   create or replace procedure mal_proc
       authid current_user
       as
       begin
          execute immediate 'grant dba to maluser';
      end;
      /
   ```

3. Connect as a user who has a DBA role (for example, `zoran`) and execute the procedure you created in the previous step:

   ```
   SQL> connect zoran
   SQL> EXEC maluser.mal_proc;
   PL/SQL procedure successfully completed.
   ```

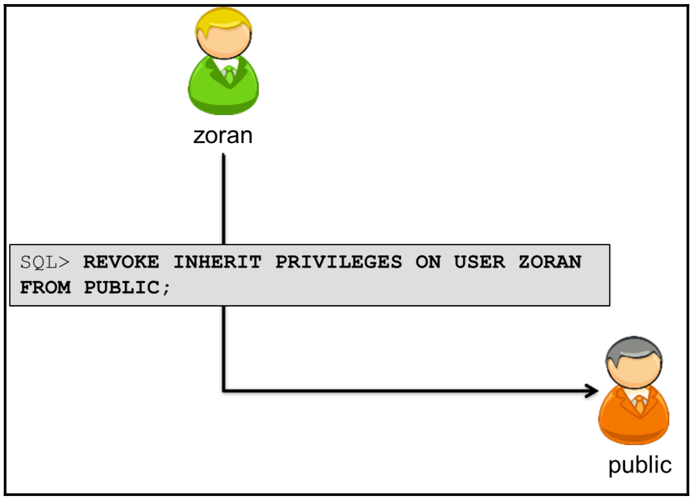
4. Connect as `maluser` and check whether the DBA role is granted:

   ```
   SQL> connect maluser
   SQL> select * from session_roles where role= 'DBA';
   ```

In this example, we've seen that a low-privileged user can trick the DBA user to grant him the DBA role, by tricking the DBA user (in this case, `zoran`) to execute an invoker's rights procedure that was created by low-privileged user (in this case, `maluser`). The user `zoran` can avoid this scenario by examining code that he is executing using his own privileges and specifying users whose procedures he wants to execute using his own privileges. The latter can be done by granting the `INHERIT PRIVILEGE` privilege to these users. Remember that this privilege is granted by default to public user, meaning that `zoran` can execute procedures from all users in the database. The first thing `zoran` can do is to revoke this privilege from the public user and then grant it only to users whose invoker's rights procedures he wants to execute. Let's try this:

1. Connect as a user `zoran` and revoke `inherit` privileges from public user:

```
SQL> connect zoran
SQL> revoke inherit privileges on user zoran from public;
```

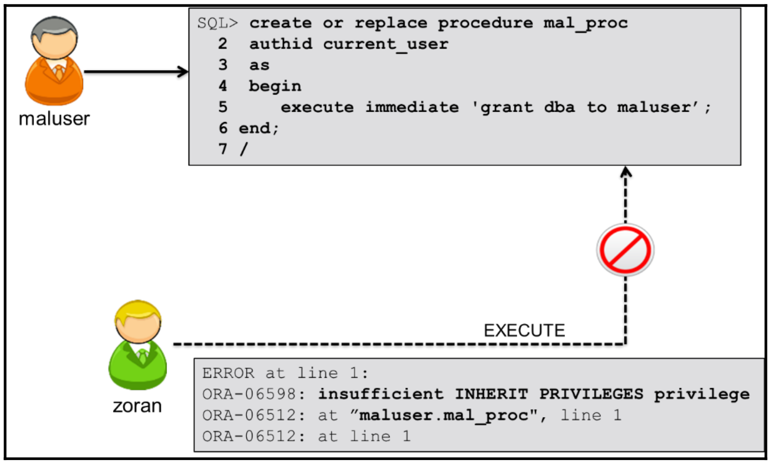


```
SQL> REVOKE INHERIT PRIVILEGES ON USER ZORAN
FROM PUBLIC;
```

Figure 1

2. Try to execute `mal_proc`:

```
SQL> EXEC maluser.mal_proc;
BEGIN maluser.mal_proc; END;
*
ERROR at line 1:
ORA-06598: insufficient INHERIT PRIVILEGES privilege
ORA-06512: at "MALUSER.MAL_PROC", line 1
ORA-06512: at line 1
```



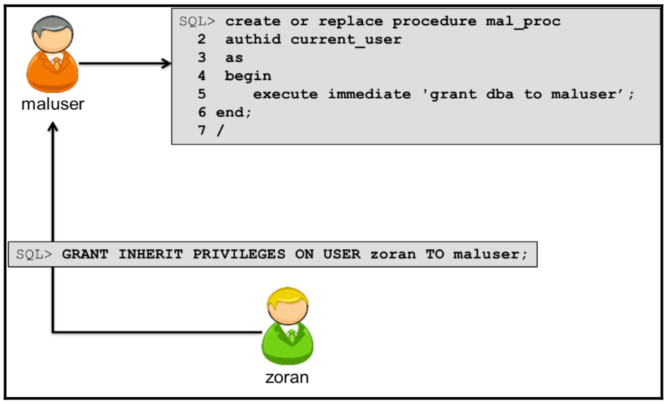
```
SQL> create or replace procedure mal_proc
  2  authid current_user
  3  as
  4  begin
  5      execute immediate 'grant dba to maluser';
  6 end;
  7 /
```

```
ERROR at line 1:
ORA-06598: insufficient INHERIT PRIVILEGES privilege
ORA-06512: at "maluser.mal_proc", line 1
ORA-06512: at line 1
```

Figure 2

3. Grant `inherit rights` privileges to `maluser`:

```
SQL> grant inherit privileges on user zoran to maluser;
```



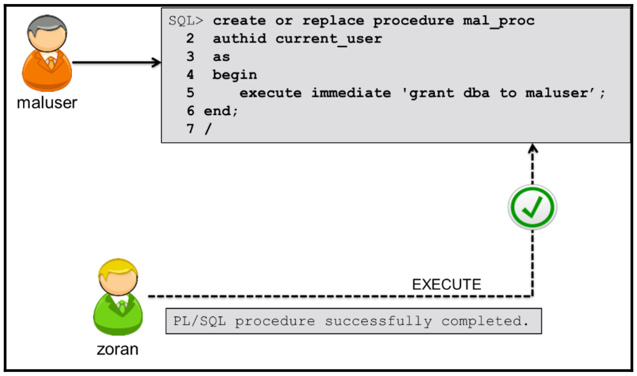
```
SQL> create or replace procedure mal_proc
authid current_user
as
begin
    execute immediate 'grant dba to maluser';
end;
/
```

```
SQL> GRANT INHERIT PRIVILEGES ON USER zoran TO maluser;
```

Figure 3

4. Try again to execute `mal_proc`:

```
SQL> EXEC maluser.mal_proc;
PL/SQL procedure successfully completed.
```



```
SQL> create or replace procedure mal_proc
authid current_user
as
begin
    execute immediate 'grant dba to maluser';
end;
/
```

```
PL/SQL procedure successfully completed.
```

Figure 4

Users who have the `inherit any privileges` system privilege are exempted from this rule, meaning that procedures from these users can be executed by all the users in the database. For example, we have the following steps:

1. Connect as a user who has a DBA role (for example, `zoran`), create two users, and grant them the following privileges:

```
SQL> connect zoran
SQL> create user super_user identified by oracle1;
SQL> create user regular_user identified by oracle2;
SQL> grant create session, create procedure to super_user;
SQL> grant create session, create procedure to
regular_user;
```

2. Grant `inherit any privileges` only to `super_user`:

```
SQL> grant inherit any privileges to super_user;
```

3. Connect as `regular_user` and create the following procedure:

```
SQL> connect regular_user
create or replace procedure reg_proc
    authid current_user
    as
    begin
       execute immediate 'grant dba to regular_user';
   end;
      /
```

4. Connect as `super_user` and create the following procedure:

```
SQL> connect super_user
create or replace procedure sup_proc
    authid current_user
    as
    begin
       execute immediate 'grant dba to super_user';
   end;
      /
```

5. Connect as user `zoran` and try to execute `reg_proc` from `regular _user` (observe an error because `regular_user` doesn't have the `inherit privileges` privilege on user `zoran`):

```
SQL> connect zoran/oracle_4U
Connected.
SQL> EXEC regular_user.reg_proc;
BEGIN regular_user.reg_proc; END;
*
ERROR at line 1:
ORA-06598: insufficient INHERIT PRIVILEGES privilege
ORA-06512: at "REGULAR_USER.REG_PROC", line 1
ORA-06512: at line 1
```

6. Try to execute `sup_proc` from `super_user` (this succeeds because, even though `super_user` doesn't have `inherit privileges` privilege on the user `zoran`, he has `inherited any privileges` system privilege, which can be interpreted as `inherit privileges` on all users of the database):

```
SQL> EXEC super_user.sup_proc;
PL/SQL procedure successfully completed.
```

Using code-based access control

In this recipe, you'll use code base access control with invoker's rights procedure.

Getting ready

To complete this recipe, you'll use a user who has a DBA role.

How to do it…

1. Connect to the database as a user with a DBA role (for example, `zoran`), create `proc_user`, and grant him the `create session` privilege:

```
SQL> create user proc_user identified by oracle1;
SQL> grant create session to proc_user;
```

2. Create table `tbl1` and insert test data:

   ```
   SQL> create table tbl1(a number, b varchar2(30));
   SQL> insert into tbl1 values (1, 'old_value');
   SQL> commit;
   ```

3. Create the invoker's rights procedure `UpdateTbl1` and grant `execute` on that procedure to `proc_user`:

   ```
   CREATE OR REPLACE PROCEDURE UpdateTbl1 (x IN number,
   y IN varchar2)
     AUTHID CURRENT_USER
       AS
         BEGIN
          UPDATE ZORAN.TBL1
          SET b = y
           WHERE a = x;
       END;
       /
   SQL> grant execute on zoran.UpdateTbl1 to proc_user;
   ```

4. Create the role `proc_role` and grant `update` on `tbl1` to `proc_role`:

   ```
   SQL> create role proc_role;
   SQL> grant update on zoran.tbl1 to proc_role;
   ```

5. Grant `proc_role` to the procedure `UpdateTbl1`:

   ```
   SQL> grant proc_role to procedure zoran.UpdateTbl1;
   ```

6. Connect as a user `proc_user`:

   ```
   SQL> connect proc_user
   ```

7. Try to directly update the table:

   ```
   SQL> update zoran.tbl1 set b = 'value1' where a = 1;
   update zoran.tbl1 set b = 'value1' where a = 1
                *
   ERROR at line 1:
   ORA-00942: table or view does not exist
   ```

8. Execute the procedure `UpdateTbl1`:

   ```
   SQL> execute zoran.UpdateTbl1(1, 'new_value');
   PL/SQL procedure successfully completed.
   ```

9. Connect as the user zoran and verify whether the table is updated:

```
SQL> connect zoran
SQL> select * from tbl1;
   A         B
---------- ----------------------------------------
   1         new_value
```

How it works…

Code-based access control allows us to grant a role to a PL/SQL procedure, function, or package. It works with both definer's rights and invoker's rights procedures. The scenario in this example shows one use of this feature. The invoker's rights procedure in step 3 created by zoran (UpdateTbl1), is used to update the table tbl1. Execute on this procedure is granted to the user proc_user. This is an invoker's rights procedure, meaning that it is executed by using privileges granted to invoker (in our case, proc_user). However, proc_user doesn't have update privilege on this table, but he can still execute it successfully because procedure itself contains update privilege on tbl1 table, granted through the role proc_role in step 5.

There's more…

Remember that, in some cases, privileges granted to users via roles are not active during the PL/SQL calls. Let's try this:

1. Connect as a user who has a DBA role (for example, zoran), create the user plsusr, and grant him the create session and create procedure privileges:

```
SQL> create user plsusr identified by oracle1;
SQL> grant create session, create procedure to plsusr;
```

2. Create the role plsrole1 and grant the create table privilege to it:

```
SQL> create role plsrole1;
SQL> grant create table to plsrole1;
```

3. Grant plsrole1 to the user plsusr:

```
SQL> grant plsrole1 to plsusr;
```

4. Connect as `plsusr` and create the procedure `cr_table`:

   ```
   SQL> connect plsusr
   create or replace procedure cr_table
       authid definer
       as
       begin
          execute immediate 'create table test2(a int)';
      end;
      /
   ```

5. Create the table `test1` to check whether the `plsusr` user has a `create table` privilege:

   ```
   SQL> create table test1(a int);
   Table created.
   ```

6. Execute the `cr_table` procedure and observe the `insufficient privileges` error. Even though the user `plsusr` has a `create table` privilege, that privilege is granted via role and roles are not active during this PL/SQL call resulting in the `insufficient privileges` error.

   ```
   SQL> exec cr_table;
   BEGIN cr_table; END;
   *
   ERROR at line 1:
   ORA-01031: insufficient privileges
   ORA-06512: at "PLSUSR.CR_TABLE", line 5
   ORA-06512: at line 1
   ```

7. Connect as a user who has the DBA role and grant the `create table` privilege directly to the user `plsusr`:

   ```
   SQL> connect zoran
   SQL> grant create table to plsusr;
   ```

8. Connect as the user `plsusr` and try to execute the procedure `cr_table` again. This time, the `create table` privilege is granted directly; thus, it is active during the PL/SQL call, resulting in successful completion:

   ```
   SQL> connect plsusr/oracle1
   SQL> exec cr_table;
   PL/SQL procedure successfully completed.
   ```

Restricting access to program units by using accessible by

In this recipe, you'll learn about the effects of using the `accessible by` clause.

Getting ready

To complete this recipe, you'll use a user who has the `create procedure` privilege.

How to do it…

1. Connect as a user who has the `create procedure` privilege (for example, `zoran`):

```
SQL> connect zoran
```

2. Create the `protected_pkg` package that is only accessible by `public_pkg`:

```
CREATE OR REPLACE PACKAGE protected_pkg
   ACCESSIBLE BY (public_pkg)
IS
   PROCEDURE protected_proc;
END;
/
CREATE OR REPLACE PACKAGE BODY protected_pkg
IS
   PROCEDURE protected_proc
   IS
   BEGIN
      DBMS_OUTPUT.PUT_LINE ('This is a Protected Procedure
      that can only be accessed from Public Package');
   END;
END;
/
```

3. Create the `public_pkg` package:

```
CREATE OR REPLACE PACKAGE public_pkg
IS
   PROCEDURE public_proc;
END;
/
CREATE OR REPLACE PACKAGE BODY public_pkg
IS
   PROCEDURE public_proc
   IS
   BEGIN
      DBMS_OUTPUT.PUT_LINE ('This is Public Procedure from
      Public Package!');
      protected_pkg.protected_proc;
   END;
END;
/
```

4. Execute the `public_proc` procedure from `public_pkg`:

```
SQL> set serveroutput on
SQL> EXEC public_pkg.public_proc;
This is Public Procedure from Public Package!
This is a Protected Procedure that can only be accessed from
Public Package
PL/SQL procedure successfully completed.
```

5. Try to directly execute `protected_proc` from `protected_pkg` and observe the error:

```
SQL> EXEC protected_pkg.protected_proc;
BEGIN protected_pkg.protected_proc; END;
      *
ERROR at line 1:
ORA-06550: line 1, column 7:
PLS-00904: insufficient privilege to access object
PROTECTED_PKG
ORA-06550: line 1, column 7:
PL/SQL: Statement ignored
```

6. Try to create another package that accesses `protected_proc` from `protected_pkg`:

```
CREATE OR REPLACE PACKAGE other_pkg
IS
   PROCEDURE other_proc;
END;
/
CREATE OR REPLACE PACKAGE BODY other_pkg
IS
   PROCEDURE other_proc
   IS
   BEGIN
        DBMS_OUTPUT.PUT_LINE ('This is Other Procedure from
        Other Package!');
      protected_pkg.protected_proc;
   END;
END;
/
Warning: Package Body created with compilation errors.
```

7. Find the compilation errors, as follows:

```
SQL> show errors
Errors for PACKAGE BODY OTHER_PKG:
LINE/COL ERROR
-------- --------------------------------------------------
7/7         PL/SQL: Statement ignored
7/7         PLS-00904: insufficient privilege to access object
            PROTECTED_PKG
```

How it works…

An `accessible by` clause enables us to specify which packages can access procedures and functions of another package. This process is called **white listing**. In step 2, we created the `protected_pkg` package and we specified that procedures and functions of this package can be accessed only by procedures and functions of `public_pkg` package. In step 4, we executed the `public_proc` procedure from the `public_pkg` package and, in output, we can observe that the `protected_proc` procedure has been successfully executed. However, if we try to execute `protected_proc` directly, we get an `insufficient privileges` error because the `accessible by` clause restricts execution of this procedure (step 5). Even if we try to create a new package with the procedure that calls the `protected_proc` procedure, we get an `insufficient privileges` error (steps 6 and 7).

4
Virtual Private Database

In this chapter, we will cover the following tasks:

- Creating different policy functions
- Creating Oracle Virtual Private Database row-level policies
- Creating column-level policies
- Creating a driving context
- Creating policy groups
- Setting context as a driving context
- Adding a policy to a group
- Exempting users from VPD policies

Introduction

Oracle **Virtual Private Database** (**VPD**) is a security feature, introduced in Oracle Database 8i. It is available only in Enterprise Edition of Oracle Database. **Discretionary access control** (**DAC**) grants/restricts access to data at an object level (for example, table level). This means that a user can access either the entire data in a table or no data. VPD enables you more granular control over security of your data. Using VPD, you can restrict access to data at row level or column level.

VPD doesn't replace DAC, but it is complimentary to DAC. VPD can further restrict access to users who have been given access to data by DAC.

There are five types of policies based on how often a **policy function** is evaluated:

- `DBMS_RLS.DYNAMIC`
- `DMBS_RLS.STATIC`
- `DBMS_RLS.SHARED_STATIC`
- `DBMS_RLS.CONTEXT_SENSITIVE`
- `DBMS_RLS.SHARED_CONTEXT_SENSITIVE`

`DBMS_RLS.DYNAMIC` is default.

Although it is not necessary to use application contexts when implementing VPD policies, it is a common practice. Figure 1 shows usual steps that you will need to complete to implement the VPD policy on protected objects, such as table or view:

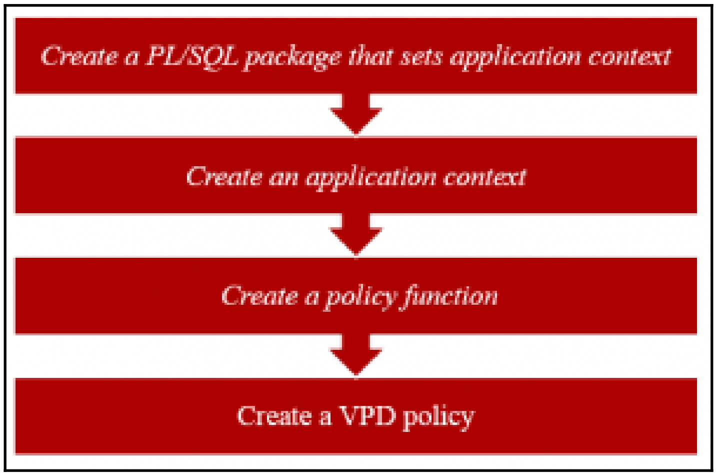

Create a PL/SQL package that sets application context
Create an application context
Create a policy function
Create a VPD policy

Figure 1 – Steps to implement the VPD policy

A **driving context** is an application context that has at least one attribute and its purpose is to determine which group of policies will be applied. The driving context is set by an application that is trying to access the data.

The default VPD behavior is that all policies defined on a table or a view are enforced for all SQL statements regardless of the application that executes them. If multiple applications share a table or a view, it is highly likely that you will either need to establish more complex logic to handle security requirements (to determine in which case, which predicate should be returned) or change the default VPD behavior by creating and using policy groups. If policies are already defined, you should identify which policies should be in effect when each application accesses the table or view. Each object has a predefined default policy group (`SYS_DEFAULT`), and the policies defined in this group are always applied for that particular object. A driving context determines which other policy group will also be applied at that time.

Suppose that there are two applications (*A* and *B*) that access data in table `HR.EMP_VPD_TEST`. Their specific policies are defined in two policy groups (`HR_GRP_A` and `HR_GRP_B`), and policies that should be enforced in any case are defined in the default group (`SYS_DEFAULT`). When application *A* accesses the data, policies that belong to `HR_GRP_A` and `SYS_DEFAULT` groups are applied, and when application *B* accesses the data, polices that belong to `HR_GRP_B` and `SYS_DEFAULT` groups are applied (it is assumed that the driving context is properly set).

Steps to implement policy groups are shown in Figure 2:

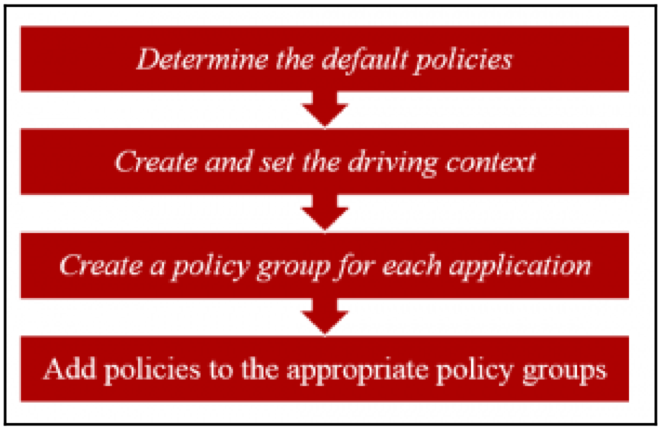

Determine the default policies
Create and set the driving context
Create a policy group for each application
Add policies to the appropriate policy groups

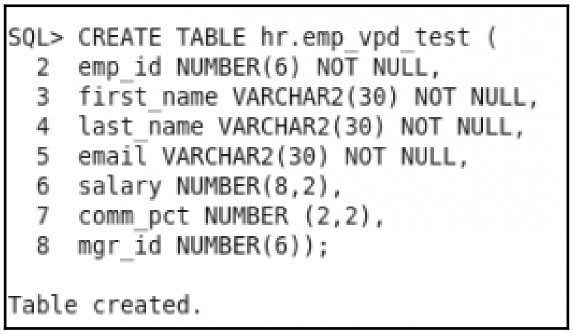
Figure 2 – Steps to implement policy groups

Creating different policy functions

The purpose of a policy function is to return a predicate that will be applied in `WHERE` clause of the statement (except for `INSERT` operation). In this recipe, you'll create several simple policy functions, based on different business and security requirements.

Getting ready

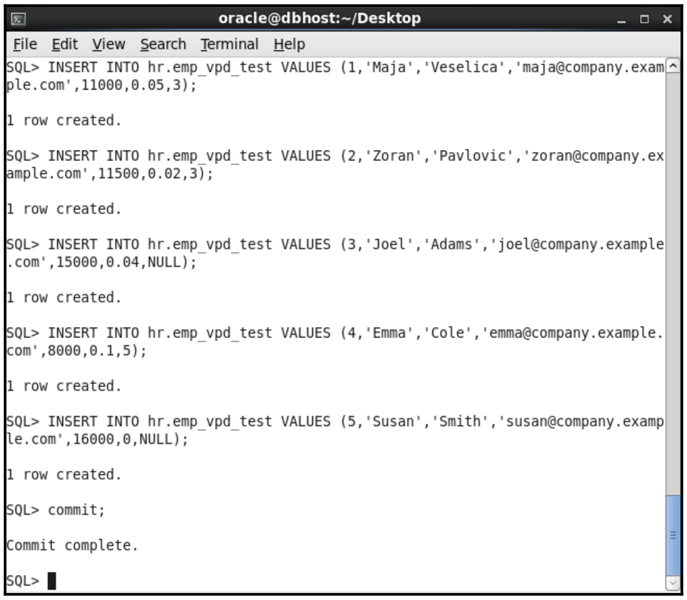
To complete this recipe, you'll need to create the table `hr.emp_vpd_test`, insert several values into that table, and create several users (in our case, `susan`, `joel`, `emma`, `maja`, and `zoran` already exist).



```
SQL> CREATE TABLE hr.emp_vpd_test (
  2  emp_id NUMBER(6) NOT NULL,
  3  first_name VARCHAR2(30) NOT NULL,
  4  last_name VARCHAR2(30) NOT NULL,
  5  email VARCHAR2(30) NOT NULL,
  6  salary NUMBER(8,2),
  7  comm_pct NUMBER (2,2),
  8  mgr_id NUMBER(6));

Table created.
```

Figure 3 – A test table

If you won't use the same data as shown in Figure 4, then keep in mind to accordingly make changes in the *How to do it* section and the rest of the recipes in this chapter.



```
SQL> INSERT INTO hr.emp_vpd_test VALUES (1,'Maja','Veselica','maja@company.exam
ple.com',11000,0.05,3);

1 row created.

SQL> INSERT INTO hr.emp_vpd_test VALUES (2,'Zoran','Pavlovic','zoran@company.ex
ample.com',11500,0.02,3);

1 row created.

SQL> INSERT INTO hr.emp_vpd_test VALUES (3,'Joel','Adams','joel@company.example
.com',15000,0.04,NULL);

1 row created.

SQL> INSERT INTO hr.emp_vpd_test VALUES (4,'Emma','Cole','emma@company.example.
com',8000,0.1,5);

1 row created.

SQL> INSERT INTO hr.emp_vpd_test VALUES (5,'Susan','Smith','susan@company.examp
le.com',16000,0,NULL);

1 row created.

SQL> commit;

Commit complete.

SQL> 
```

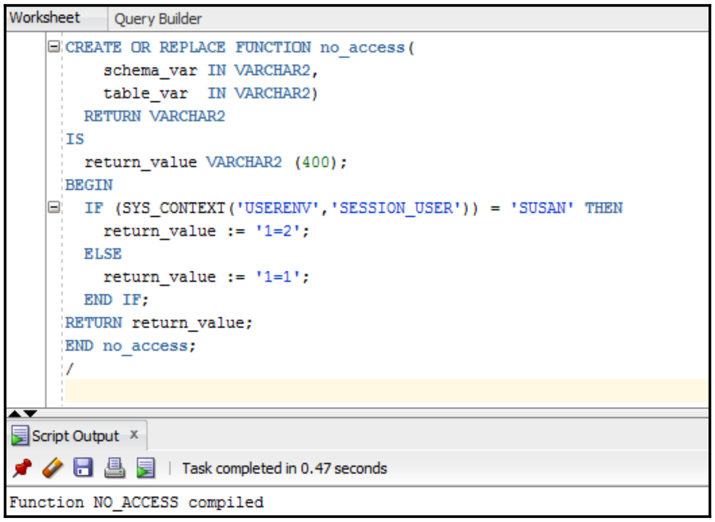
Figure 4 – Test data in the table hr.emp_vpd_test

How to do it…

1. Connect to the database as a user who has appropriate privileges (for example, user `maja`):

    ```
    $ sqlplus maja
    ```

2. Create a policy function that satisfies this condition: The user `susan` can't access data in a table (for example, `hr.emp_vpd_test`) and other users can access entire data in the table.



```
CREATE OR REPLACE FUNCTION no_access(
    schema_var IN VARCHAR2,
    table_var  IN VARCHAR2)
  RETURN VARCHAR2
IS
  return_value VARCHAR2 (400);
BEGIN
  IF (SYS_CONTEXT('USERENV','SESSION_USER')) = 'SUSAN' THEN
    return_value := '1=2';
  ELSE
    return_value := '1=1';
  END IF;
RETURN return_value;
END no_access;
/
```

```
Function NO_ACCESS compiled
```

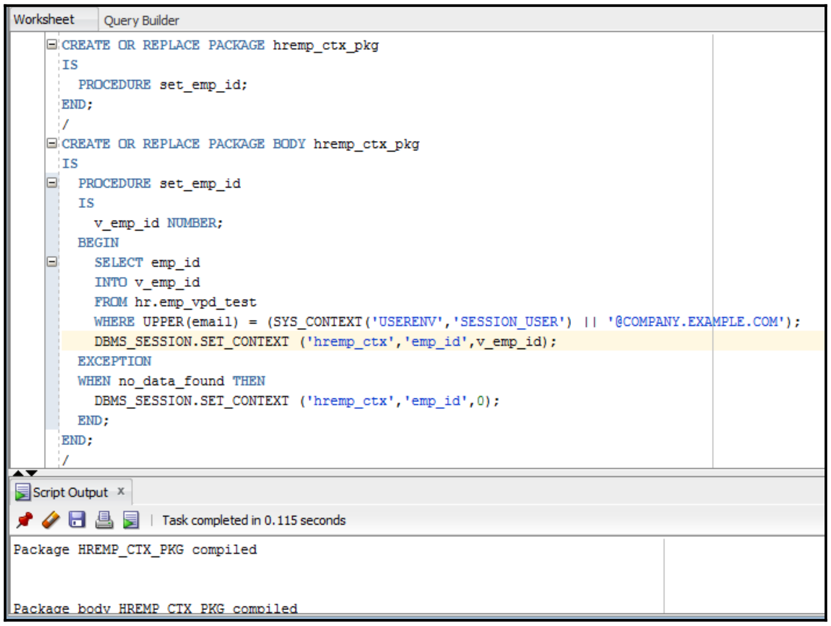
Figure 5

3. Create an application context that has the `emp_id` attribute and the value is `emp_id` (from the `hr.emp_vpd_test`) of the connected user or if the connected user is not employee. See `Chapter 12`, *Appendix – Application Contexts* for detailed explanation (recipes: *Creating an application context* and *Setting application context attributes*) and make appropriate changes.

    - Create an application context

```
SQL> connect maja
Enter password:
Connected.
SQL> create context hremp_ctx using hremp_ctx_pkg;

Context created.
```

- Create a PL/SQL package



Worksheet | Query Builder

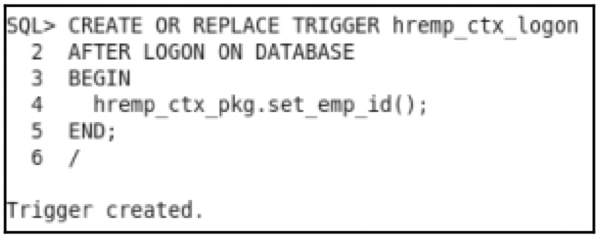
```
CREATE OR REPLACE PACKAGE hremp_ctx_pkg
IS
  PROCEDURE set_emp_id;
END;
/
CREATE OR REPLACE PACKAGE BODY hremp_ctx_pkg
IS
  PROCEDURE set_emp_id
  IS
    v_emp_id NUMBER;
  BEGIN
    SELECT emp_id
    INTO v_emp_id
    FROM hr.emp_vpd_test
    WHERE UPPER(email) = (SYS_CONTEXT('USERENV','SESSION_USER') || '@COMPANY.EXAMPLE.COM');
    DBMS_SESSION.SET_CONTEXT ('hremp_ctx','emp_id',v_emp_id);
  EXCEPTION
  WHEN no_data_found THEN
    DBMS_SESSION.SET_CONTEXT ('hremp_ctx','emp_id',0);
  END;
END;
/
```

Script Output ×

Task completed in 0.115 seconds

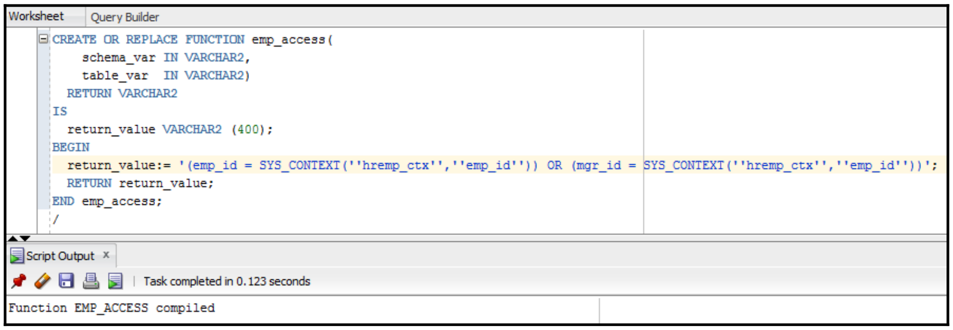
```
Package HREMP_CTX_PKG compiled


Package body HREMP_CTX_PKG compiled
```

- Create a logon trigger



```
SQL> CREATE OR REPLACE TRIGGER hremp_ctx_logon
  2  AFTER LOGON ON DATABASE
  3  BEGIN
  4    hremp_ctx_pkg.set_emp_id();
  5  END;
  6  /

Trigger created.
```

4. Create a policy function (for example, `emp_access`) that satisfies this condition: a "regular" employee can access only his or her data in a table (for example, `hr.emp_vpd_test`) and manager users can access his or her data in the table and data for employees he or she directly manages.



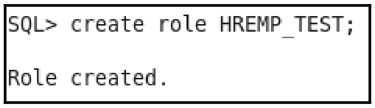
```
CREATE OR REPLACE FUNCTION emp_access(
    schema_var IN VARCHAR2,
    table_var  IN VARCHAR2)
  RETURN VARCHAR2
IS
  return_value VARCHAR2 (400);
BEGIN
  return_value:= '(emp_id = SYS_CONTEXT(''hremp_ctx'',''emp_id'')) OR (mgr_id = SYS_CONTEXT(''hremp_ctx'',''emp_id''))';
  RETURN return_value;
END emp_access;
/
```

Task completed in 0.123 seconds

```
Function EMP_ACCESS compiled
```

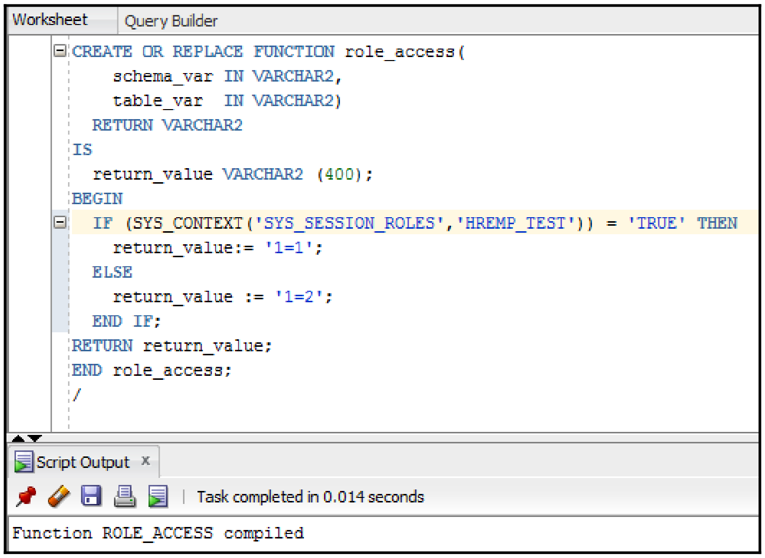
Figure 9 – The emp_access policy function

5. Create a role (for example, `HREMP_TEST`).



```
SQL> create role HREMP_TEST;

Role created.
```

6. Create a policy function that satisfies this condition: Only users who have the `HREMP_TEST` role can view data in a table (for example, `hr.emp_vpd_test`).



```
CREATE OR REPLACE FUNCTION role_access(
    schema_var IN VARCHAR2,
    table_var  IN VARCHAR2)
  RETURN VARCHAR2
IS
  return_value VARCHAR2 (400);
BEGIN
  IF (SYS_CONTEXT('SYS_SESSION_ROLES','HREMP_TEST')) = 'TRUE' THEN
    return_value:= '1=1';
  ELSE
    return_value := '1=2';
  END IF;
RETURN return_value;
END role_access;
/
```

```
Function ROLE_ACCESS compiled
```

Figure 11 – The role_access policy function

How it works…

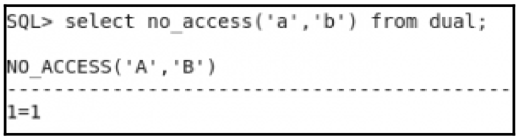
In step 4, you created a policy function that uses the application context you created, where as other policy functions you created use built-in application contexts.

A policy function can be part of a package or is standalone.

There's more…

To test whether the function defined in step 2 works properly, perform the following tasks:

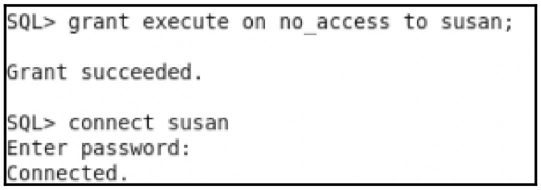
1. Connect to the database as the user `maja` and execute the following statement:



```
SQL> select no_access('a','b') from dual;

NO_ACCESS('A','B')
--------------------------------------------
1=1
```

Figure 12 – Maja can access data

2. Grant the user `susan` execute on `no_access` function and connect to the database as the user `susan`.

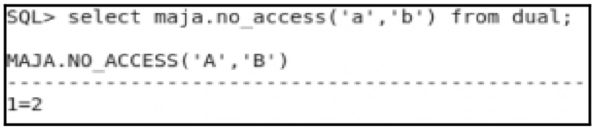


```
SQL> grant execute on no_access to susan;

Grant succeeded.

SQL> connect susan
Enter password:
Connected.
```

Figure 13 – Temporary grant the susan privilege

3. Execute the following statement:

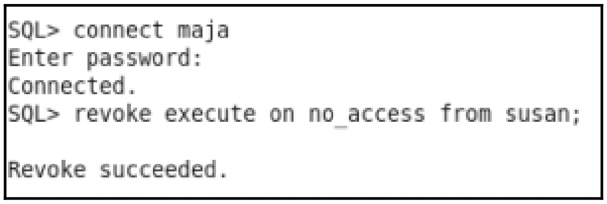
```
select maja.no_access('a','b') from dual;
```



```
SQL> select maja.no_access('a','b') from dual;

MAJA.NO_ACCESS('A','B')
--------------------------------------------
1=2
```

Figure 14 – Susan can't access data

4. Connect to the database as the user `maja` and revoke execute on `no_access` function from the user `susan`.



```
SQL> connect maja
Enter password:
Connected.
SQL> revoke execute on no_access from susan;

Revoke succeeded.
```

Figure 15 – Clean up environment (revoke privilege)

See also

- All recipes of `Chapter 12`, *Appendix – Application Contexts*

Creating Oracle Virtual Private Database row-level policies

Oracle VPD row-level policies restrict users' access per row for a protected object. This means that two users who execute the same query against, for example, a table may, as a result, receive different number of rows.

Getting ready

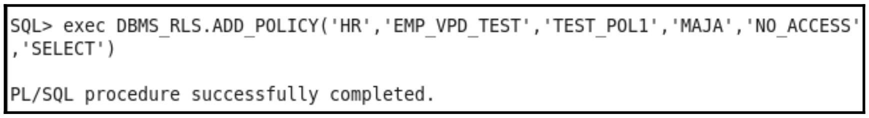
See the *Getting ready* section of the recipe *Creating different policy functions*.

How to do it…

1. Connect to the database as a user who has appropriate privileges (for example, the user `maja`):

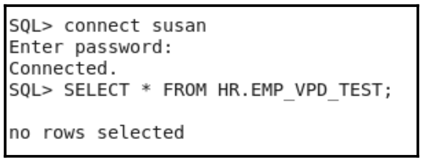
   ```
   $ sqlplus maja
   ```

2. Create a VPD policy (for example, `test_pol1`) that protects the `hr.emp_vpd_test` table in the following way: it restricts `SELECT` operation based on a policy function (for example, `no_access`).



```
SQL> exec DBMS_RLS.ADD_POLICY('HR','EMP_VPD_TEST','TEST_POL1','MAJA','NO_ACCESS'
,'SELECT')

PL/SQL procedure successfully completed.
```

3. To test VPD policy created in the previous step, connect as the user `susan` to the database (keep in mind that she has the `SELECT ANY TABLE` privilege) and try to access data in the table `hr.emp_vpd_test`.

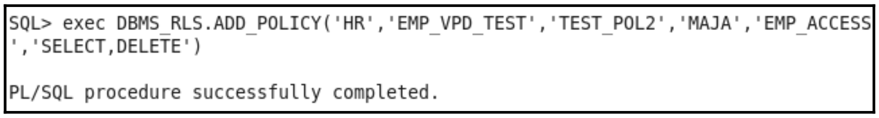


```
SQL> connect susan
Enter password:
Connected.
SQL> SELECT * FROM HR.EMP_VPD_TEST;

no rows selected
```

Figure 17 – Susan can't access data

4. Connect to the database as a user who can create a VPD policy (for example, user `maja`). Create a VPD policy (for example, `test_pol2`) that additionally protects the `hr.emp_vpd_test` table in the following way: it restricts the `SELECT` and `DELETE` operations based on a policy function (for example, `emp_access`).

```
SQL> connect maja
```



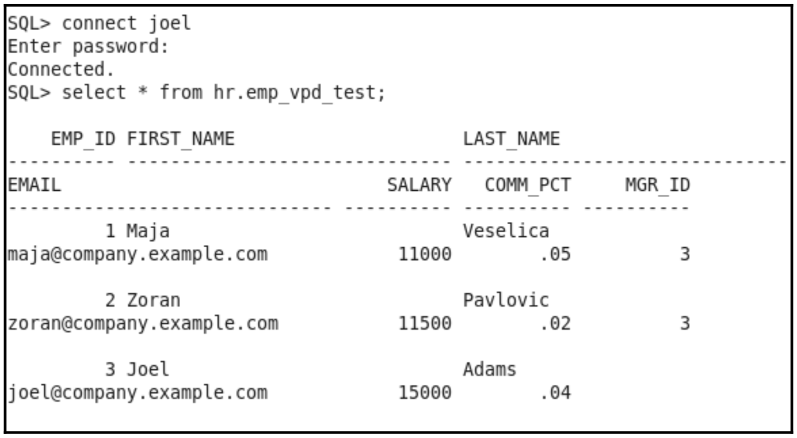
```
SQL> exec DBMS_RLS.ADD_POLICY('HR','EMP_VPD_TEST','TEST_POL2','MAJA','EMP_ACCESS
','SELECT,DELETE')

PL/SQL procedure successfully completed.
```

Figure 18 – The VPD policy TEST_POL2

5. Connect to the database as the user `joel` and execute the following query:

```
SELECT * FROM HR.EMP_VPD_TEST;
```

The result will show 3 rows, because `joel` can view his data and data for his direct employees (policy function `emp_access`).



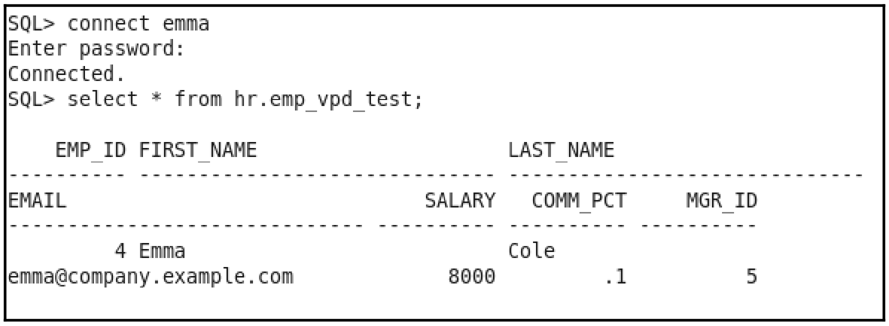
```
SQL> connect joel
Enter password:
Connected.
SQL> select * from hr.emp_vpd_test;

    EMP_ID FIRST_NAME                     LAST_NAME
---------- ------------------------------ ------------------------------
EMAIL                              SALARY   COMM_PCT     MGR_ID
------------------------------ ---------- ---------- ----------
         1 Maja                           Veselica
maja@company.example.com            11000        .05          3

         2 Zoran                          Pavlovic
zoran@company.example.com           11500        .02          3

         3 Joel                           Adams
joel@company.example.com            15000        .04
```

Figure 19 – Joel can view his data and data for his direct employees

6. Connect to the database as the user `emma` and execute the following query:

```
SELECT * FROM HR.EMP_VPD_TEST;
```

   The result will show only 1 row, because `emma` is a “regular” employee, so she can view only her own data (policy function `emp_access`).



```
SQL> connect emma
Enter password:
Connected.
SQL> select * from hr.emp_vpd_test;

    EMP_ID FIRST_NAME                     LAST_NAME
---------- ------------------------------ ------------------------------
EMAIL                              SALARY   COMM_PCT     MGR_ID
------------------------------ ---------- ---------- ----------
         4 Emma                           Cole
emma@company.example.com             8000         .1          5
```

Figure 20 – Emma can only view her own data

There's more…

You defined two VPD policies on the same table, and they are both enabled. The first one only restricts the user `susan` from accessing the table, whereas the other one affects all users connected to the database (with some exceptions, see the recipe *Exempting users from VPD policies*). If `susan` connects to the database, both policies will determine whether she can access the data and if `yes`, which data. The way the policies are defined, she won't be able to view data in the table.

See also

- The recipe *Exempting users from VPD policies*

Creating column-level policies

When you create a column-level VPD policy, you define sensitive columns, and if those columns are referenced in a query, statement will be rewritten. To create a column-level VPD policy, you also use the `DBMS_RLS.ADD_POLICY` procedure.

Getting ready

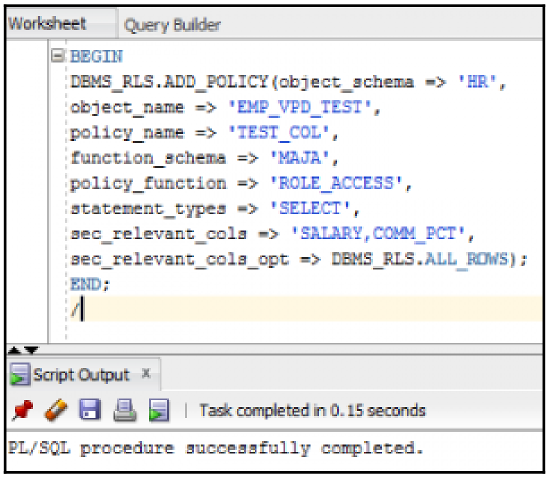
See the *Getting ready* section for the first recipe in this chapter. Results shown in this recipe assume that you completed previous recipes in this chapter.

How to do it…

1. Connect to the database as a user who has appropriate privileges (for example, the user `maja`):

   ```
   $ sqlplus maja
   ```

2. Create a VPD policy (for example, `test_col`) that protects the `hr.emp_vpd_test` table in the following way: it defines that `salary` and `comm_pct` are sensitive columns and a user can access them only if he or she has the `HREMP_TEST` role (the `role_access` policy function).



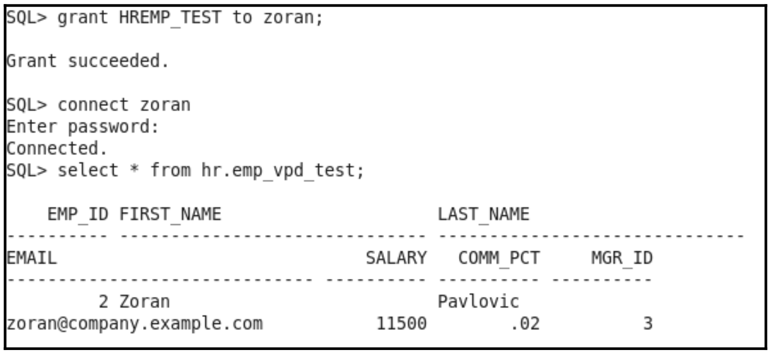
```
BEGIN
DBMS_RLS.ADD_POLICY(object_schema => 'HR',
object_name => 'EMP_VPD_TEST',
policy_name => 'TEST_COL',
function_schema => 'MAJA',
policy_function => 'ROLE_ACCESS',
statement_types => 'SELECT',
sec_relevant_cols => 'SALARY,COMM_PCT',
sec_relevant_cols_opt => DBMS_RLS.ALL_ROWS);
END;
/
```

```
PL/SQL procedure successfully completed.
```

3. Grant the role `HREMP_TEST` to user `zoran`:

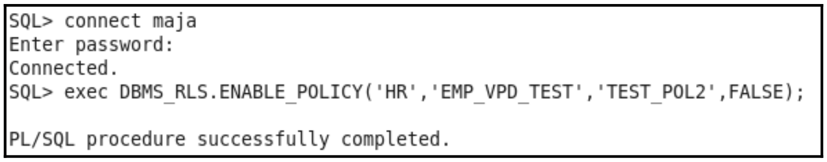
   ```
   SQL> grant HREMP_TEST to zoran;
   ```

4. Connect to the database as the user `zoran` and view data in the table `hr.emp_vpd_test`.



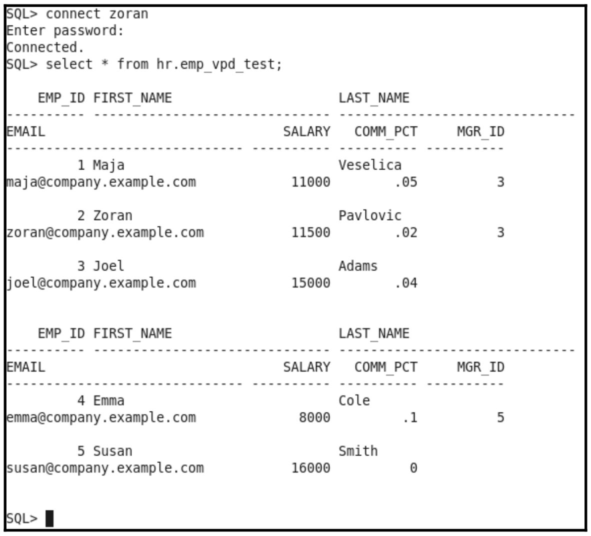
```
SQL> grant HREMP_TEST to zoran;

Grant succeeded.

SQL> connect zoran
Enter password:
Connected.
SQL> select * from hr.emp_vpd_test;

    EMP_ID FIRST_NAME                     LAST_NAME
---------- ------------------------------ ------------------------------
EMAIL                              SALARY   COMM_PCT     MGR_ID
------------------------------ ---------- ---------- ----------
         2 Zoran                          Pavlovic
zoran@company.example.com           11500        .02          3
```

5. Connect to the database as the user `maja` and disable the VPD policy `TEST_POL2`.



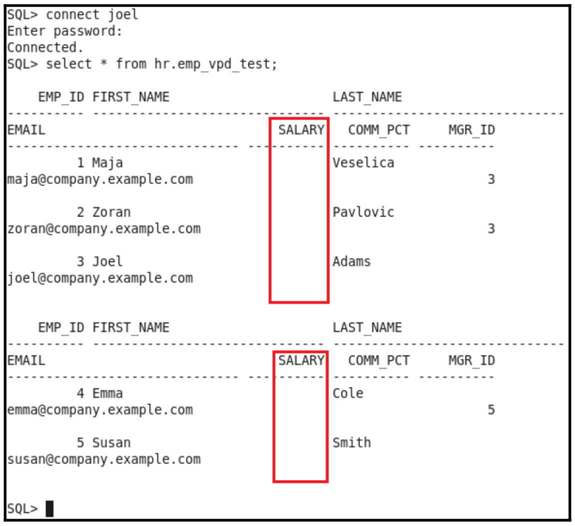
```
SQL> connect maja
Enter password:
Connected.
SQL> exec DBMS_RLS.ENABLE_POLICY('HR','EMP_VPD_TEST','TEST_POL2',FALSE);

PL/SQL procedure successfully completed.
```

6. Repeat step 4.



```
SQL> connect zoran
Enter password:
Connected.
SQL> select * from hr.emp_vpd_test;

    EMP_ID FIRST_NAME                     LAST_NAME
---------- ------------------------------ ------------------------------
EMAIL                              SALARY   COMM_PCT     MGR_ID
------------------------------ ---------- ---------- ----------
         1 Maja                           Veselica
maja@company.example.com            11000        .05          3

         2 Zoran                          Pavlovic
zoran@company.example.com           11500        .02          3

         3 Joel                           Adams
joel@company.example.com            15000        .04


    EMP_ID FIRST_NAME                     LAST_NAME
---------- ------------------------------ ------------------------------
EMAIL                              SALARY   COMM_PCT     MGR_ID
------------------------------ ---------- ---------- ----------
         4 Emma                           Cole
emma@company.example.com             8000         .1          5

         5 Susan                          Smith
susan@company.example.com           16000          0


SQL>
```

7. Connect to the database as the user `joel` and execute the same statement as in the previous step.



```
SQL> connect joel
Enter password:
Connected.
SQL> select * from hr.emp_vpd_test;

    EMP_ID FIRST_NAME                     LAST_NAME
---------- ------------------------------ ------------------------------
EMAIL                              SALARY   COMM_PCT     MGR_ID
------------------------------ ---------- ---------- ----------
         1 Maja                           Veselica
maja@company.example.com                                      3

         2 Zoran                          Pavlovic
zoran@company.example.com                                     3

         3 Joel                           Adams
joel@company.example.com


    EMP_ID FIRST_NAME                     LAST_NAME
---------- ------------------------------ ------------------------------
EMAIL                              SALARY   COMM_PCT     MGR_ID
------------------------------ ---------- ---------- ----------
         4 Emma                           Cole
emma@company.example.com                                      5

         5 Susan                          Smith
susan@company.example.com

SQL>
```

How it works…

In step 2, the test_col VPD policy is created. In step 3, the user zoran is granted the role (HREMP_TEST) that will allow him to view entire data in step 6 (after test_pol2 is disabled). In step 4, displayed rows are restricted by TEST_POL2, so user zoran can view only his data. In step 5, you disabled the TEST_POL2 policy using the DBMS_RLS.ENABLE_POLICY procedure (to disable the policy, you set enable parameter to false). The syntax is:

```
DBMS_RLS.ENABLE_POLICY (
    object_schema IN VARCHAR2 NULL,
    object_name   IN VARCHAR2,
    policy_name   IN VARCHAR2,
    enable        IN BOOLEAN TRUE)
```

In step 7, the user joel can view all rows, but cannot view salary and comm_pct, because he doesn't have the HREMP_TEST role.

Creating a driving context

In the previous recipe, you saw that having multiple VPD policies (most probably created because multiple application use that same table) is harder to manage, and it can lead to unexpected/unwanted results.

For example, you have two applications and want to create two policy groups. If the first application accesses the table, the test_pol1 and test_col policies should be enforced, and if second application accesses the table, the test_pol2 policies should be applied. There will be no default policies.

In this recipe, you'll create an application context and set it.

Getting ready

To complete this recipe, you'll need an existing user who can create an application context (for example, the user maja).

How to do it…

1. Connect to the database as a user who has appropriate privileges (for example, the user `maja`):

   ```
   $ sqlplus maja
   ```

2. Create a driving context (for example, `driver_ctx`):

   ```
   SQL> CREATE CONTEXT driver_ctx using driver_ctx_pkg;
   ```

3. Set the driving context:

   ```
   SQL> CREATE OR REPLACE PACKAGE driver_ctx_pkg IS
          PROCEDURE set_driver (p_group varchar2);
        END;
        /
   SQL> CREATE OR REPLACE PACKAGE BODY driver_ctx_pkg IS
          PROCEDURE set_driver (p_group varchar2)
          IS
          BEGIN
           DBMS_SESSION.SET_CONTEXT('driver_ctx','ACTIVE',p_group);
         END;
      END;
   /
   ```

Creating policy groups

In this recipe, you'll create two policy groups that will be applied to table `hr.emp_vpd_test`.

Getting ready

To complete this recipe, you'll need an existing user who has appropriate privileges (for example, the user `maja`).

How to do it…

1. Connect to the database as a user who has appropriate privileges (for example, the user `maja`):

   ```
   $ sqlplus maja
   ```

2. Create the first policy group (for example, `pol_grp_A`):

   ```
   SQL> BEGIN
   DBMS_RLS.CREATE_POLICY_GROUP(
   object_schema => 'HR',
   object_name => 'EMP_VPD_TEST',
   policy_group => 'pol_grp_A');
   END;
   /
   ```

3. Create the second policy group (for example, `pol_grp_B`):

   ```
   SQL> BEGIN
   DBMS_RLS.CREATE_POLICY_GROUP(
   object_schema => 'HR',
   object_name => 'EMP_VPD_TEST',
   policy_group => 'pol_grp_B');
   END;
   /
   ```

Setting context as a driving context

In this recipe, you'll make an existing application context a driving context (you'll associate it with the protected object).

Getting ready

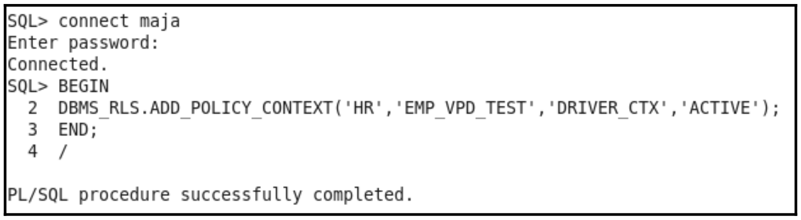
To complete this recipe, you'll need an existing application context (for example, `driver_ctx`) and an existing user who has appropriate privileges (for example, `maja`).

How to do it…

1. Connect to the database as a user who has appropriate privileges (for example, the user `maja`):

   ```
   $ sqlplus maja
   ```

2. Make an existing application context a driving context.



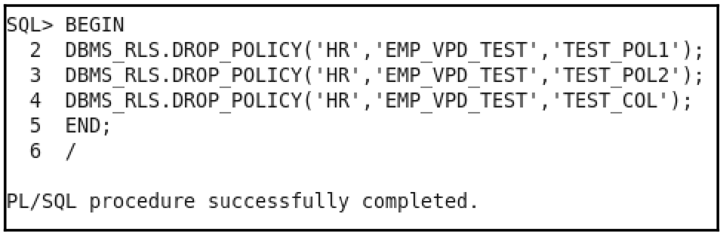
```
SQL> connect maja
Enter password:
Connected.
SQL> BEGIN
  2  DBMS_RLS.ADD_POLICY_CONTEXT('HR','EMP_VPD_TEST','DRIVER_CTX','ACTIVE');
  3  END;
  4  /

PL/SQL procedure successfully completed.
```

Adding policy to a group

In this recipe, create VPD policies as part of a policy group.

Getting ready

To complete this recipe, you'll need an existing user who has appropriate privileges (for example, `maja`). If you completed previous recipes, drop all VPD policies using the `DBMS_RLS.DROP_POLICY` procedure.



```
SQL> BEGIN
  2  DBMS_RLS.DROP_POLICY('HR','EMP_VPD_TEST','TEST_POL1');
  3  DBMS_RLS.DROP_POLICY('HR','EMP_VPD_TEST','TEST_POL2');
  4  DBMS_RLS.DROP_POLICY('HR','EMP_VPD_TEST','TEST_COL');
  5  END;
  6  /

PL/SQL procedure successfully completed.
```

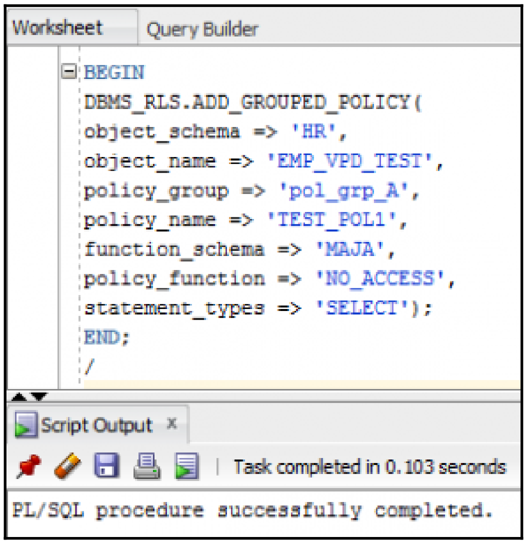
Figure 27 – Drop policies

How to do it…

1. Connect to the database as a user who has appropriate privileges (for example, the user `maja`):

   ```
   $ sqlplus maja
   ```

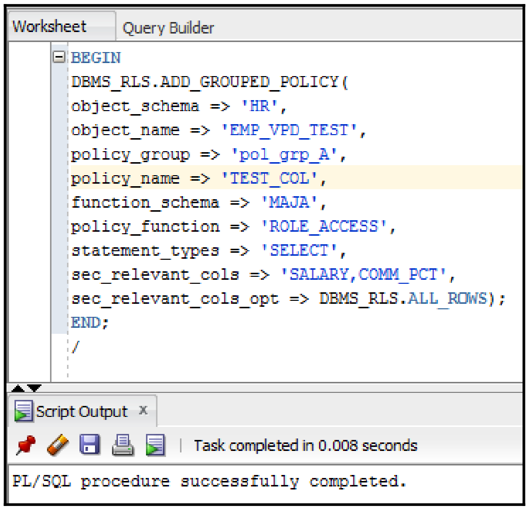
2. Add `TEST_POL1` to policy group `pol_grp_A`.



```
BEGIN
DBMS_RLS.ADD_GROUPED_POLICY(
object_schema => 'HR',
object_name => 'EMP_VPD_TEST',
policy_group => 'pol_grp_A',
policy_name => 'TEST_POL1',
function_schema => 'MAJA',
policy_function => 'NO_ACCESS',
statement_types => 'SELECT');
END;
/
```

```
PL/SQL procedure successfully completed.
```

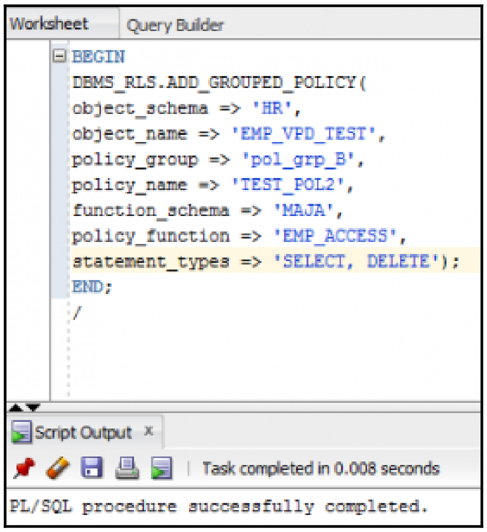
3. Add `TEST_COL` to policy group `pol_grp_A`.



```
BEGIN
DBMS_RLS.ADD_GROUPED_POLICY(
object_schema => 'HR',
object_name => 'EMP_VPD_TEST',
policy_group => 'pol_grp_A',
policy_name => 'TEST_COL',
function_schema => 'MAJA',
policy_function => 'ROLE_ACCESS',
statement_types => 'SELECT',
sec_relevant_cols => 'SALARY,COMM_PCT',
sec_relevant_cols_opt => DBMS_RLS.ALL_ROWS);
END;
/
```

```
PL/SQL procedure successfully completed.
```

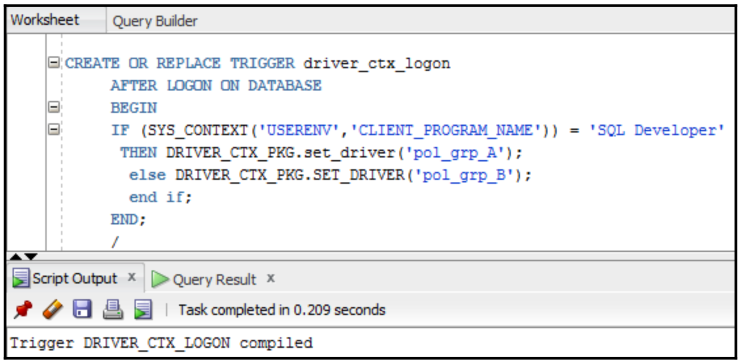
4. Add `TEST_POL2` to policy group `pol_grp_B`.



```
BEGIN
DBMS_RLS.ADD_GROUPED_POLICY(
object_schema => 'HR',
object_name => 'EMP_VPD_TEST',
policy_group => 'pol_grp_B',
policy_name => 'TEST_POL2',
function_schema => 'MAJA',
policy_function => 'EMP_ACCESS',
statement_types => 'SELECT, DELETE');
END;
/
```

```
PL/SQL procedure successfully completed.
```

5. Create a logon trigger.



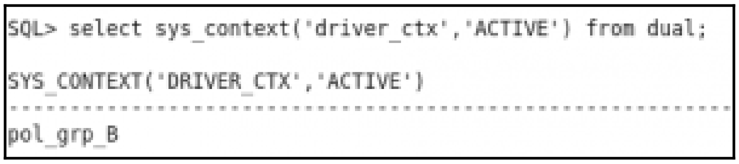
Worksheet Query Builder

```
CREATE OR REPLACE TRIGGER driver_ctx_logon
     AFTER LOGON ON DATABASE
     BEGIN
     IF (SYS_CONTEXT('USERENV','CLIENT_PROGRAM_NAME')) = 'SQL Developer'
      THEN DRIVER_CTX_PKG.set_driver('pol_grp_A');
       else DRIVER_CTX_PKG.SET_DRIVER('pol_grp_B');
       end if;
     END;
     /
```

Script Output × Query Result × | Task completed in 0.209 seconds

```
Trigger DRIVER_CTX_LOGON compiled
```

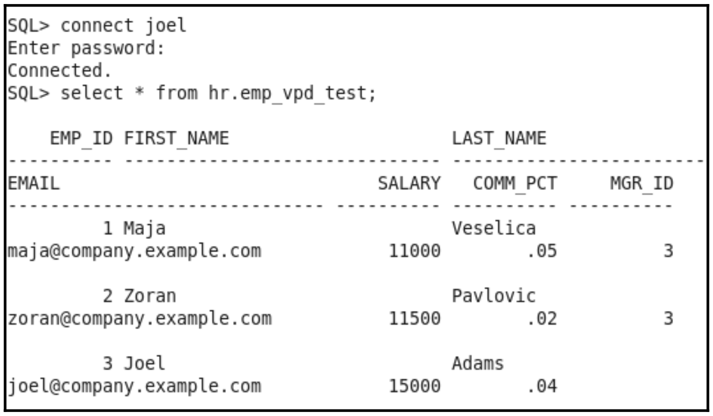
6. Connect to the database as the user `joel` using SQL*Plus and execute the `SELECT` statement, as shown in Figure 32.



```
SQL> select sys_context('driver_ctx','ACTIVE') from dual;

SYS_CONTEXT('DRIVER_CTX','ACTIVE')
------------------------------------------------------------
pol_grp_B
```

Figure 32

7. View data in the table `hr.emp_vpd_test`.

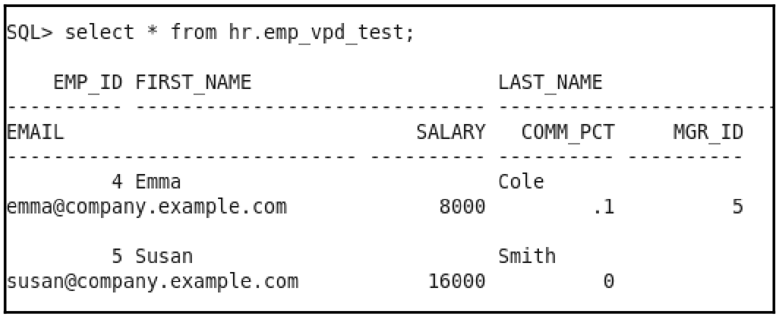


```
SQL> connect joel
Enter password:
Connected.
SQL> select * from hr.emp_vpd_test;

    EMP_ID FIRST_NAME                     LAST_NAME
---------- ------------------------------ -------------------------
EMAIL                              SALARY   COMM_PCT     MGR_ID
------------------------------ ---------- ---------- ----------
         1 Maja                           Veselica
maja@company.example.com            11000        .05          3

         2 Zoran                          Pavlovic
zoran@company.example.com           11500        .02          3

         3 Joel                           Adams
joel@company.example.com            15000        .04
```

Figure 33

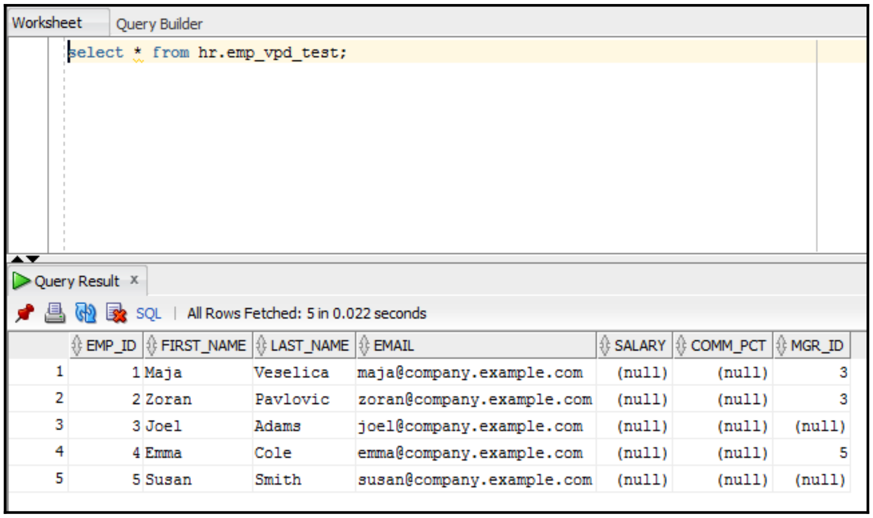
8. Connect to the database as the user `susan` using SQL*Plus and view data in the table `hr.emp_vpd_test`:

```
SQL> connect susan
```



```
SQL> select * from hr.emp_vpd_test;

    EMP_ID FIRST_NAME                     LAST_NAME
---------- ------------------------------ -------------------------
EMAIL                              SALARY   COMM_PCT     MGR_ID
------------------------------ ---------- ---------- ----------
         4 Emma                           Cole
emma@company.example.com             8000         .1          5

         5 Susan                          Smith
susan@company.example.com           16000          0
```

9. Connect as the user `emma` using SQL Developer and view data in the table `hr.emp_vpd_test`.



```
select * from hr.emp_vpd_test;
```

	EMP_ID	FIRST_NAME	LAST_NAME	EMAIL	SALARY	COMM_PCT	MGR_ID
1	1	Maja	Veselica	maja@company.example.com	(null)	(null)	3
2	2	Zoran	Pavlovic	zoran@company.example.com	(null)	(null)	3
3	3	Joel	Adams	joel@company.example.com	(null)	(null)	(null)
4	4	Emma	Cole	emma@company.example.com	(null)	(null)	5
5	5	Susan	Smith	susan@company.example.com	(null)	(null)	(null)

Exempting users from VPD policies

VPD policies are not enforced for users who connect as `sysdba`, during direct path export, and for users who have the `EXEMPT ACCESS POLICY` privilege.

Getting ready

To complete this recipe, you'll connect to the database as `SYS` user and grant `EXEMPT ACCESS POLICY` to an existing user.

How to do it…

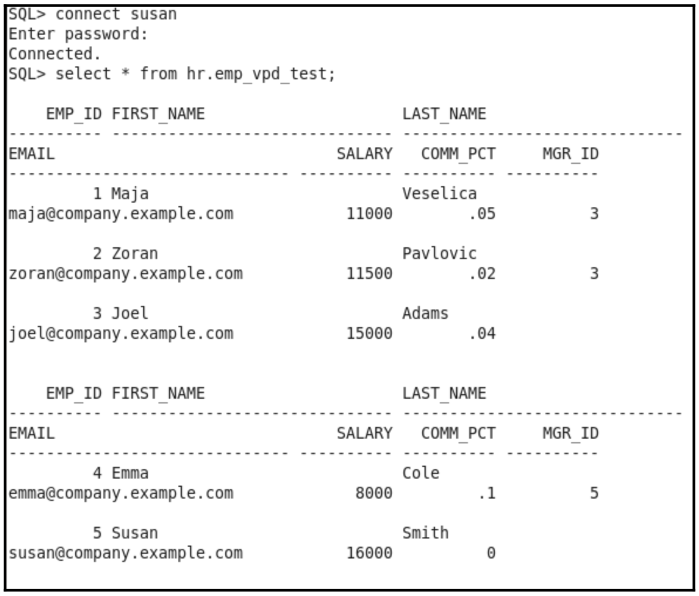
1. Connect to the database as `SYS` user:

   ```
   $ sqlplus / as sysdba
   ```

2. Grant the `EXEMPT ACCESS POLICY` privilege to an existing user (for example, `susan`):

   ```
   SQL> grant EXEMPT ACCESS POLICY to susan;
   ```

3. Connect to the database as the user `susan` and verify that now she can access data in the `hr.emp_vpd_test` table.



```
SQL> connect susan
Enter password:
Connected.
SQL> select * from hr.emp_vpd_test;

    EMP_ID FIRST_NAME                     LAST_NAME
---------- ------------------------------ ------------------------------
EMAIL                              SALARY   COMM_PCT     MGR_ID
------------------------------ ---------- ---------- ----------
         1 Maja                           Veselica
maja@company.example.com            11000        .05          3

         2 Zoran                          Pavlovic
zoran@company.example.com           11500        .02          3

         3 Joel                           Adams
joel@company.example.com            15000        .04


    EMP_ID FIRST_NAME                     LAST_NAME
---------- ------------------------------ ------------------------------
EMAIL                              SALARY   COMM_PCT     MGR_ID
------------------------------ ---------- ---------- ----------
         4 Emma                           Cole
emma@company.example.com             8000         .1          5

         5 Susan                          Smith
susan@company.example.com           16000          0
```

5
Data Redaction

In this chapter, we will cover the following tasks:

- Creating a redaction policy when using full redaction
- Creating a redaction policy when using partial redaction
- Creating a redaction policy when using random redaction
- Creating a redaction policy when using regular expression redaction
- Using Oracle Enterprise Manager Cloud Control 12c to manage redaction policies
- Changing the function parameters for a specified column
- Adding a column to the redaction policy
- Enabling, disabling, and dropping a redaction policy
- Exempting users from data redaction policies

Introduction

Oracle Data Redaction is a new security feature, introduced in Oracle Database 12*c*. From a licensing viewpoint, it is part of the **Advanced Security Option** (only available as an option for Oracle Database Enterprise Edition). However, afterwards, Oracle decided to make it available in Oracle Database 11*g* as well (only in version 11.2.0.4). The main idea behind this feature is to mask (hide/redact) some (sensitive) data from *end-users*. Having this in mind, it is logical that you will primarily use this security solution in a production environment.

Oracle Data Redaction and Oracle Data Masking are both used to mask sensitive data, but these solutions are completely different—from the way they are designed (how they work) to their target implementation use cases. **Oracle Data Masking** enables organizations to use production data in development and test environments by changing production data with realistic data (transformation is done by using masking rules).

Oracle Data Redaction masks sensitive data just before the results of the SQL query are returned to the application that issued the query. Data stored in the database is *NOT* changed in any way.

When you implement Oracle Data Redaction, you have to decide the following:

- What data should be redacted
- Which redaction method is most suitable for the identified data
- In which situations the redaction should take place

You define all these decisions by creating a redaction policy (Figure 1), and they are enforced as long as the policy is enabled.

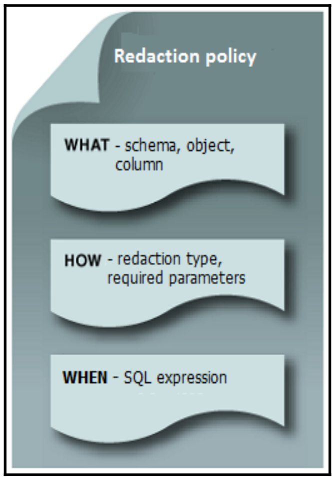

Redaction policy
WHAT - schema, object, column
HOW - redaction type, required parameters
WHEN - SQL expression

Figure 1 – The parts of a redaction policy

Different types of redaction are shown in Figure 2.

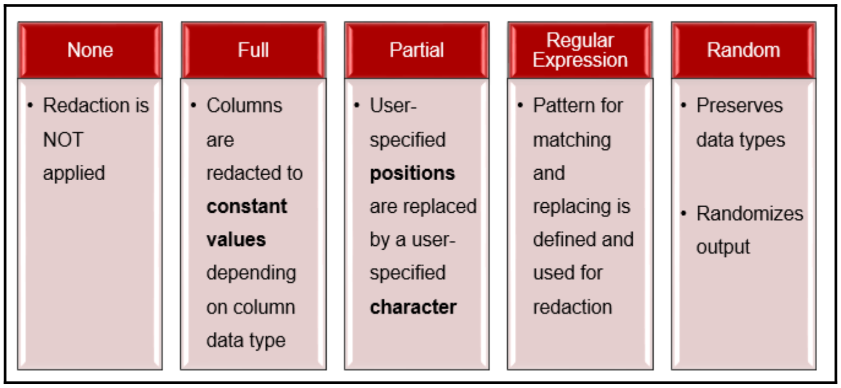

None
• Redaction is NOT applied
Full
• Columns are redacted to **constant values** depending on column data type
Partial
• User-specified **positions** are replaced by a user-specified **character**
Regular Expression
• Pattern for matching and replacing is defined and used for redaction
Random
• Preserves data types
• Randomizes output

Figure 2 – The types of redaction

You can define only one redaction policy on a table (or view).

To view which data redaction policies are defined and whether they are enabled, you can query the `redaction_policies` view. Also, it is very useful to query the `redaction_columns` view, which shows which columns will be masked and what type of redaction will be used. Note that the names of those two views *do not* have any prefix (such as `DBA_`, `USER_`, or `ALL_`).

Although Oracle Data Redaction as a concept is fantastic, you should keep in mind that there are some implementation limitations (for example, unsupported data types) and unexpected behavior (most likely bugs) observed in Oracle Database 12.1.0.2.

For all recipes in this chapter, we assume that database is up and running, and each user has at least a `create session` privilege. Recipes are tested on Oracle Database 12.1.0.2.

Creating a redaction policy when using full redaction

In this recipe, you will create a redaction policy on the `income_level` column (on the `income_level` column on the `CUSTOMERS` table in the sample schema `OE`), find the default values (for full redaction) for different data types, and change the default value for the `varchar2` data type.

You may consider data about customer address to be sensitive. Unfortunately, you can't create a redaction policy on the `CUST_ADDRESS` column (the table `CUSTOMERS` in the sample schema `OE`) because its data type is not supported (its data type is `TYPE`, which is not a literal value, so it can't be redacted). If you try to create a redaction policy, you will receive the following error: `ORA-28073`. The column `CUST_ADDRESS` has an unsupported data type.

Getting ready

To complete this recipe, you'll need the following:

- An existing user who can view data in `OE.CUSTOMERS` sample table but doesn't have exempt redaction policy privilege (for example, `oe`)
- To connect as a `SYS` user to the database
- To restart the database (*There's more…* section of the recipe)

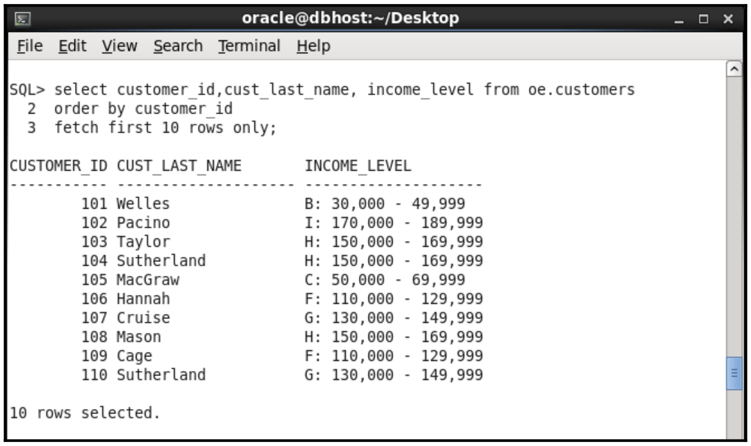
How to do it…

1. Connect to the database as a user who has the `SELECT` privilege on the `OE.CUSTOMERS` table or the `SELECT ANY TABLE` privilege (for example, the `oe` user):

```
$ sqlplus oe
```

2. Verify that the user (for example, the user `oe`) can view data by executing the following query:

```
select customer_id, cust_last_name, income_level from
oe.customers order by customer_id fetch first 10 rows
only;
```



```
SQL> select customer_id,cust_last_name, income_level from oe.customers
  2  order by customer_id
  3  fetch first 10 rows only;

CUSTOMER_ID CUST_LAST_NAME       INCOME_LEVEL
----------- -------------------- --------------------
        101 Welles               B: 30,000 - 49,999
        102 Pacino               I: 170,000 - 189,999
        103 Taylor               H: 150,000 - 169,999
        104 Sutherland           H: 150,000 - 169,999
        105 MacGraw              C: 50,000 - 69,999
        106 Hannah               F: 110,000 - 129,999
        107 Cruise               G: 130,000 - 149,999
        108 Mason                H: 150,000 - 169,999
        109 Cage                 F: 110,000 - 129,999
        110 Sutherland           G: 130,000 - 149,999

10 rows selected.
```

Figure 3 – Data in the clear text format (before redaction) in the OE.CUSTOMERS table

3. Connect to the database as a user who can create the user `secmgr` (who will be responsible for managing redaction policies) and grant him appropriate privileges (for example, `SYS`):

```
SQL> create user secmgr identified by oracle;

SQL> grant create session to secmgr;

SQL> grant execute on dbms_redact to secmgr;
```

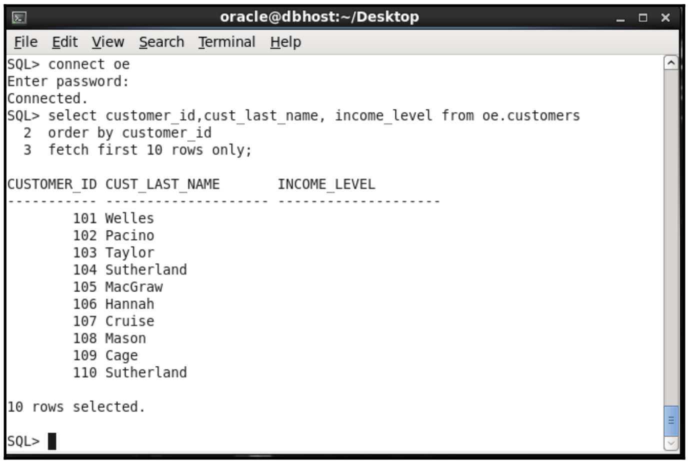
4. Connect to the database as the `secmgr` user:

```
SQL> connect secmgr/oracle
```

5. Create the redaction policy `CUST_POL` in such a manner that data in the column `income_level` (the table `oe.customers`) is redacted using full redaction:

```
SQL> begin
  2  dbms_redact.add_policy
  3  (object_schema => 'OE',
  4  object_name => 'CUSTOMERS',
  5  policy_name => 'CUST_POL',
  6  column_name => 'INCOME_LEVEL',
  7  function_type => DBMS_REDACT.FULL,
  8  expression => '1=1');
  9  end;
 10  /

PL/SQL procedure successfully completed.
```

6. Connect to the database as the same user as in step 1 (for example, `oe`) and execute the same query as in step 2.



```
SQL> connect oe
Enter password:
Connected.
SQL> select customer_id,cust_last_name, income_level from oe.customers
  2  order by customer_id
  3  fetch first 10 rows only;

CUSTOMER_ID CUST_LAST_NAME       INCOME_LEVEL
----------- -------------------- --------------------
        101 Welles
        102 Pacino
        103 Taylor
        104 Sutherland
        105 MacGraw
        106 Hannah
        107 Cruise
        108 Mason
        109 Cage
        110 Sutherland

10 rows selected.

SQL> 
```

Figure 4 – After applying the redaction policy

How it works…

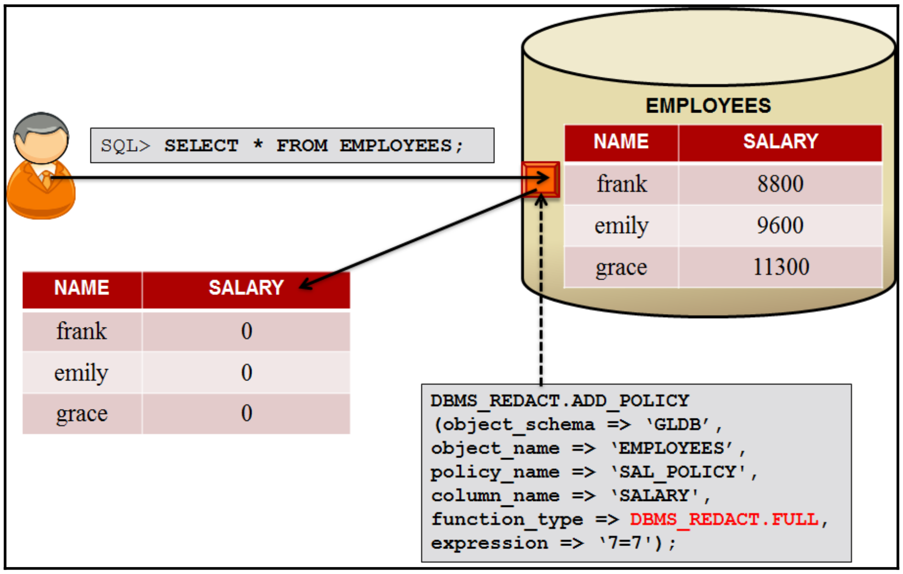
In order to manage redaction policies, you need to connect to a database as a user who has an execute privilege on the `dbms_redact` package (in this recipe, that user is created in step 3 – the `secmgr` user). In step 5, you defined redaction policy `CUST_POL`. Let's examine that step in more detail. Creating a new redaction policy is done by using the `ADD_POLICY` procedure in the `DBMS_REDACT` package (line 2). A policy consists of several distinct sections (see Figure 1). In step 5, lines 3-6 are part of the **WHAT** section in Figure 1. Lines 3, 4, and 6 define on which the column redaction policy (whose name is defined on line 5) should be applied. Line 7 is part of the **HOW** section in Figure 1. It defines the redaction type (in this case, full redaction). Line 8 is a part of the **WHEN** section in Figure 1. It defines the conditions when protected data will be masked (in situations when the expression is evaluated to `TRUE`, the data is masked). In this case, the expression is always `TRUE (1=1)`, meaning that data in column `INCOME_LEVEL` will always* be masked. Defining different, more complex expressions (using application contexts, and roles) will be done in the next few recipes in this chapter.

* Assume that the redaction policy `CUST_POL` is enabled and user doesn't have strong privileges. For more information about for which users/operations the data redaction policy doesn't have any effect, see the recipe *Exempting users from data redaction policies*.

In Figure 4, the result of applying the data redaction policy to the column `INCOME_LEVEL` (whose data type is `varchar2`) is shown, and as you can see, data in the column is masked. Every row is masked with the same value, in this case, whitespace (the default value when masking column whose data type is `varchar2`).

Keep in mind that whitespace is exactly one blank space and that it is different from `NULL`.

Figure 5 shows the example of creating a redaction policy (**SAL_POLICY**) using a full redaction method on a column (**SALARY** in table **EMPLOYEES** in schema **GLDB**) whose data type is a number. As you can see, the masked value is .



```
SQL> SELECT * FROM EMPLOYEES;
```

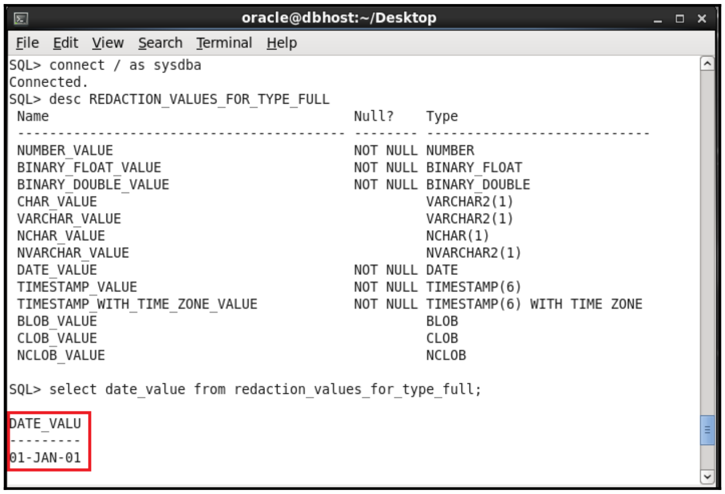
NAME	SALARY
frank	8800
emily	9600
grace	11300

NAME	SALARY
frank	0
emily	0
grace	0

```
DBMS_REDACT.ADD_POLICY
(object_schema => 'GLDB',
object_name => 'EMPLOYEES',
policy_name => 'SAL_POLICY',
column_name => 'SALARY',
function_type => DBMS_REDACT.FULL,
expression => '7=7');
```

Figure 5 – An example of the redaction policy applied on the column whose data type is a number

To find out default values (for full redaction) for other data types, query `REDACTION_VALUES_FOR_TYPE_FULL`. Finding the default value for `DATE` data type is depicted in Figure 6.



```
SQL> connect / as sysdba
Connected.
SQL> desc REDACTION_VALUES_FOR_TYPE_FULL
 Name                                      Null?    Type
 ----------------------------------------- -------- ----------------------------
 NUMBER_VALUE                              NOT NULL NUMBER
 BINARY_FLOAT_VALUE                        NOT NULL BINARY_FLOAT
 BINARY_DOUBLE_VALUE                       NOT NULL BINARY_DOUBLE
 CHAR_VALUE                                         VARCHAR2(1)
 VARCHAR_VALUE                                      VARCHAR2(1)
 NCHAR_VALUE                                        NCHAR(1)
 NVARCHAR_VALUE                                     NVARCHAR2(1)
 DATE_VALUE                                NOT NULL DATE
 TIMESTAMP_VALUE                           NOT NULL TIMESTAMP(6)
 TIMESTAMP_WITH_TIME_ZONE_VALUE            NOT NULL TIMESTAMP(6) WITH TIME ZONE
 BLOB_VALUE                                         BLOB
 CLOB_VALUE                                         CLOB
 NCLOB_VALUE                                        NCLOB

SQL> select date_value from redaction_values_for_type_full;

DATE_VALU
---------
01-JAN-01
```

Figure 6 – The default value for full redaction

At the time when you define data redaction policy, you can specify redaction for *only one column*. If you want to redact more than one column in a table, you can later modify the policy. For more information, see the recipe *Changing redaction policy*.

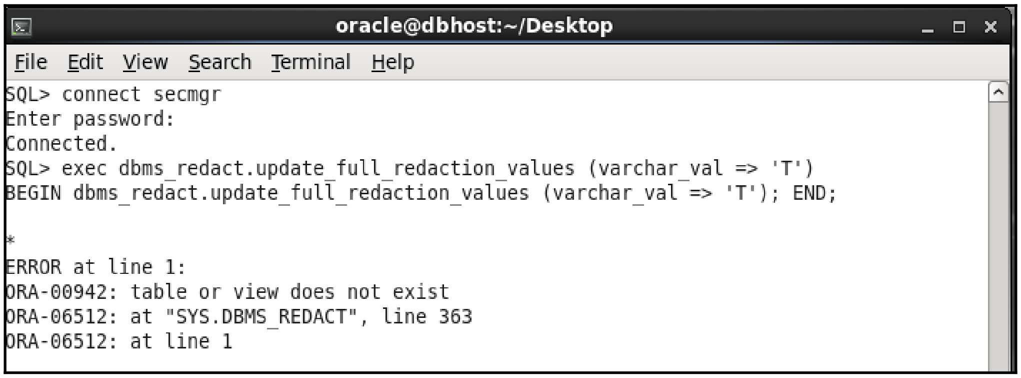
There's more…

In the following section, you will learn to change default value for full redaction type. Step-by-step instructions are given on how to change default value from whitespace to T for `varchar2` data type.

It is important to remember that changing default value for full redaction will affect *ALL* the defined redaction policies in a database (that use full redaction type).

How to change the default value

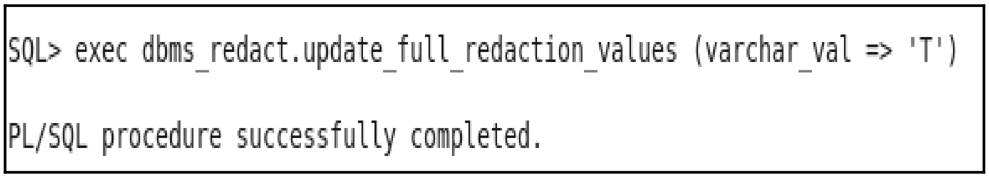
You will use the `update_full_redaction_values` procedure to change the default value from whitespace to `T` for the `varchar2` data type. Note that you can create a redaction policy (for example, as you have already done in step 5 in the beginning of the recipe), but you can't change the default value (Figure 7) even though the user `secmgr` has been granted `EXECUTE` on the `DBMS_REDACT` package.



```
SQL> connect secmgr
Enter password:
Connected.
SQL> exec dbms_redact.update_full_redaction_values (varchar_val => 'T')
BEGIN dbms_redact.update_full_redaction_values (varchar_val => 'T'); END;

*
ERROR at line 1:
ORA-00942: table or view does not exist
ORA-06512: at "SYS.DBMS_REDACT", line 363
ORA-06512: at line 1
```

Figure 7 – An unsuccessful change of default value

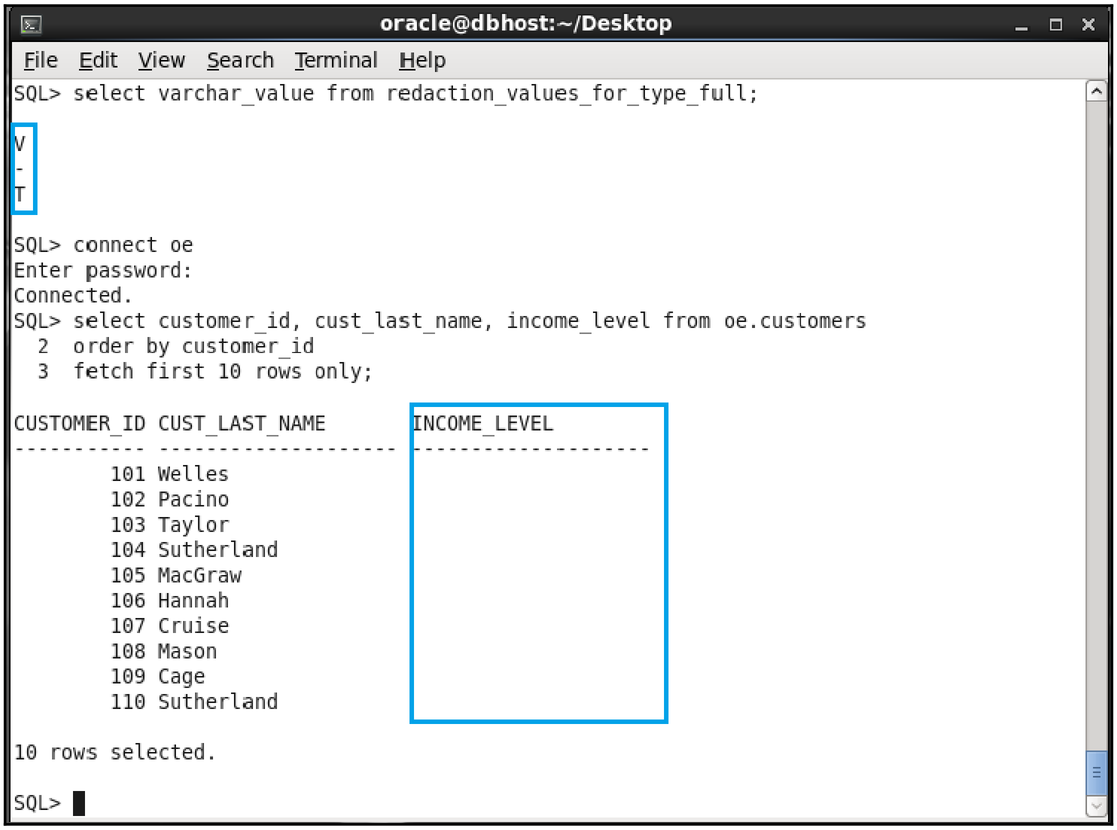
Connect to the database as the `SYS` user and change the default value.



```
SQL> exec dbms_redact.update_full_redaction_values (varchar_val => 'T')

PL/SQL procedure successfully completed.
```

Figure 8 – A successful change of the default value

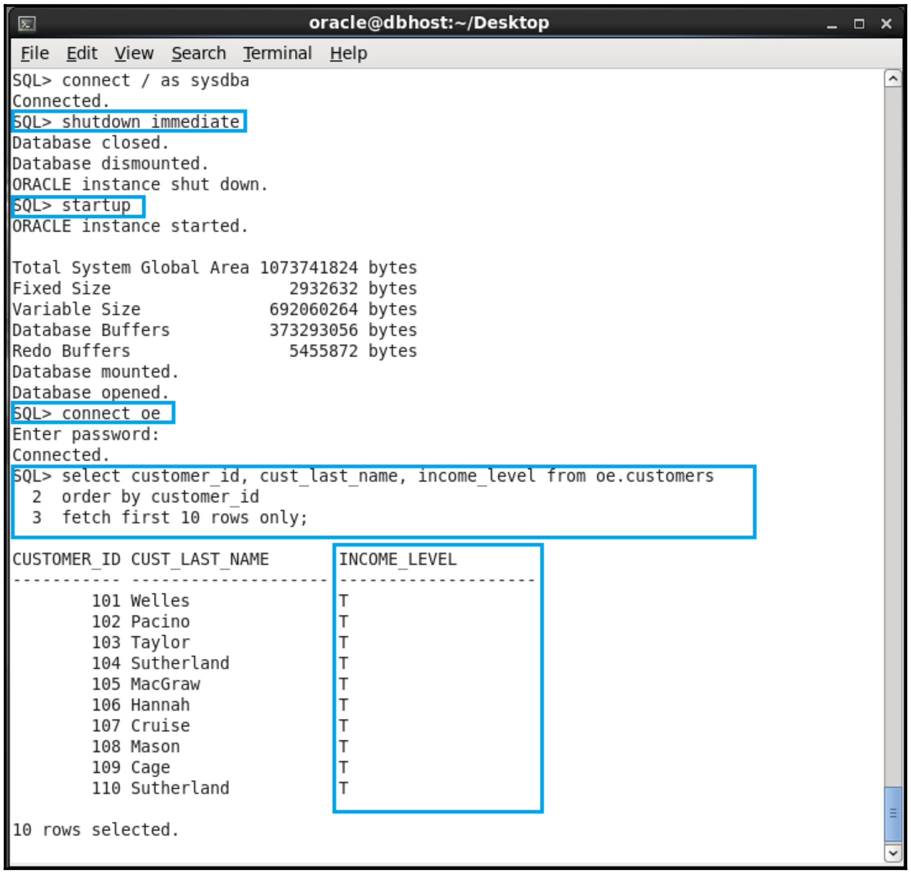
Optionally, verify that the default value is changed and that there is *no effect before you restart the database*. (Figure 9).



```
SQL> select varchar_value from redaction_values_for_type_full;

V
-
T

SQL> connect oe
Enter password:
Connected.
SQL> select customer_id, cust_last_name, income_level from oe.customers
  2  order by customer_id
  3  fetch first 10 rows only;

CUSTOMER_ID CUST_LAST_NAME       INCOME_LEVEL
----------- -------------------- --------------------
        101 Welles
        102 Pacino
        103 Taylor
        104 Sutherland
        105 MacGraw
        106 Hannah
        107 Cruise
        108 Mason
        109 Cage
        110 Sutherland

10 rows selected.

SQL>
```

Figure 9 – The changed default value still has no effect on the displayed value in the column income_level

Restart the database and verify that the modified default value is displayed (Figure 10).



```
SQL> connect / as sysdba
Connected.
SQL> shutdown immediate
Database closed.
Database dismounted.
ORACLE instance shut down.
SQL> startup
ORACLE instance started.

Total System Global Area 1073741824 bytes
Fixed Size                  2932632 bytes
Variable Size             692060264 bytes
Database Buffers          373293056 bytes
Redo Buffers                5455872 bytes
Database mounted.
Database opened.
SQL> connect oe
Enter password:
Connected.
SQL> select customer_id, cust_last_name, income_level from oe.customers
  2  order by customer_id
  3  fetch first 10 rows only;

CUSTOMER_ID CUST_LAST_NAME       INCOME_LEVEL
----------- -------------------- --------------------
        101 Welles               T
        102 Pacino               T
        103 Taylor               T
        104 Sutherland           T
        105 MacGraw              T
        106 Hannah               T
        107 Cruise               T
        108 Mason                T
        109 Cage                 T
        110 Sutherland           T

10 rows selected.
```

Figure 10 – A new default value is displayed

See also

- *Changing redaction policy*
- *Exempting users from data redaction policies*

Creating a redaction policy when using partial redaction

In this recipe, you will implement partial redaction on columns of two different types: `Number` and `Varchar2`. Partial redaction means that only part (hence the name partial) of the data in a specified column will be masked (redacted), whereas the other part of the data will be visible to the user – for instance, the first 12 digits of credit card number will be redacted, whereas other 4 digits will be visible.

How to do it…

1. Log in to database as a user who has a DBA role (for instance, `zoran`):

   ```
   $ sqlplus zoran/oracle
   ```

2. Create a test table and insert some data in it:

   ```
   SQL> create table tbl (a number);

   SQL> insert into tbl values (123456);

   SQL> insert into tbl values (234567);

   SQL> insert into tbl values (345678);

   SQL> commit;
   ```

3. Create role (that is going to be used in redaction policy) and user `usr1` as the first test user:

   ```
   SQL> create role myrole;

   SQL> create user usr1 identified by oracle1;

   SQL> grant create session to usr1;
   ```

4. Grant the select privilege and role to `usr1`:

   ```
   SQL> grant select on zoran.tbl to usr1;

   SQL> grant myrole to usr1;
   ```

5. Create the second test user and grant him `create session` and `select` privilege, but *don't* grant him the role `myrole`:

```
SQL> create user usr2 identified by oracle2;

SQL> grant create session to usr2;

SQL> grant select on zoran.tbl to usr2;
```

6. Create redaction policy to redact column `a` of the type `Number` using partial redaction (first four digits will be redacted and won't be seen at all). This redaction policy will be applied only to users that don't have role `myrole` and don't have the `EXEMPT REDACTION POLICY` privilege:

```
SQL> BEGIN
  2  DBMS_REDACT.ADD_POLICY(
  3  object_schema          => 'zoran',
  4  object_name            => 'tbl',
  5  column_name            => 'a',
  6  column_description     => 'Sensitive column A',
  7  policy_name            => 'a_tbl_partial',
  8  policy_description     => 'Redact column A of tbl',
  9  function_type          => DBMS_REDACT.PARTIAL,
 10  function_parameters    => '0,1,4',
 11  expression             => 'SYS_CONTEXT(
                               ''SYS_SESSION_ROLES'',
                               ''MYROLE'') =
                               ''FALSE''');
 12  END;
 13  /
```

7. Connect to database as the user `usr1` and select from the table `tbl` in the schema `zoran`:

```
SQL> connect usr1/oracle1

SQL> select a from zoran.tbl;

       A
 ----------
    123456
    234567
    345678
```

8. Now, connect to database as the user `usr2` and again select from the table `tbl` in the schema `zoran`:

   ```
   SQL> connect usr2/oracle2

   usr2@ORA12CR1> select a from zoran.tbl;

          A
    ----------
           56
           67
           78
   ```

9. Log in to database as a user who has a DBA role (for instance, `zoran`):

   ```
   $ sqlplus zoran/oracle
   ```

10. Create the test table to store credit cards data and insert some data in it:

    ```
    SQL> create table customers (name varchar2(20 CHAR),
    credit_card varchar2(20 CHAR));

    SQL> insert into customers values ('tom',
    '3455647456589132');

    SQL> insert into customers values ('mike',
    '3734982321225691');

    SQL> insert into customers values ('john',
    '3472586894975806');

    SQL> commit;
    ```

11. Grant select privilege on table customers in the schema `zoran` to `usr1`:

    ```
    SQL> grant select on zoran.customers to usr1;
    ```

12. Create a redaction policy to redact column `credit_card` of type `Varchar2` using partial redaction (first 12 values will be redacted with #sign). This redaction policy will be applied to all users, except those who have the `EXEMPT REDACTION POLICY` privilege (see the *Exempting users from data redaction policies* recipe):

```
SQL> BEGIN
  2  DBMS_REDACT.ADD_POLICY(
  3  object_schema          => 'zoran',
  4  object_name            => 'customers',
  5  column_name            => 'credit_card',
  6  column_description     => 'Credit Card numbers',
  7  policy_name            => 'CCN_POLICY',
  8  policy_description     => 'Redact column
                               credit_card of table
                               customers',
  9  function_type          => DBMS_REDACT.PARTIAL,
 10  function_parameters    => 'VVVVVVVVVVVVVVVV,
                               VVVVVVVVVVVVVVVV, #, 1,
                               12',
 11  expression             => '1=1');
 12  END;
 13  /
```

13. Connect to database as the user `usr1` and select from the table customers in the schema `zoran`:

```
SQL> connect usr1/oracle1

SQL> select * from zoran.customers;

NAME                 CREDIT_CARD
-------------------- --------------------
tom                  ############9132
mike                 ############5691
john                 ############5806
```

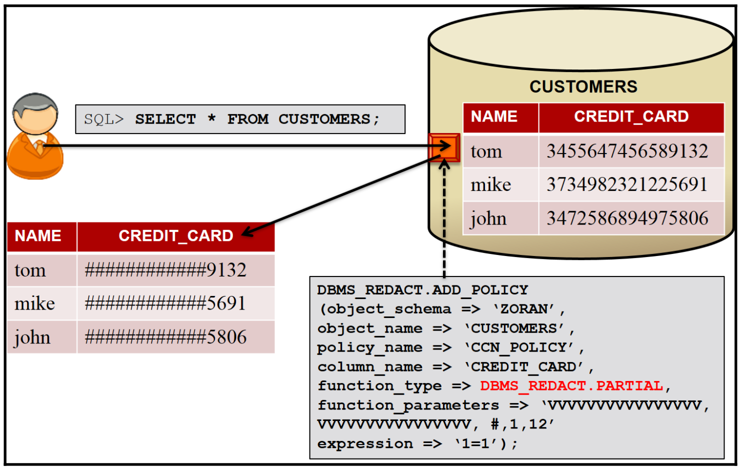
How it works…

In order to manage redaction policies and also to create some test tables, you can connect to a database as a user who has a dba role (for example, `zoran`). If you just need to manage redaction policies, you can connect with user who has the execute privilege on the `dbms_redact` package.

The previous section is divided into two parts. The first part shows the creation of redaction policy for number type column, in such a way that redaction should only be applied to users that don't have a particular role. The second part shows the creation of a redaction policy for `Varchar2` type column.

In step 6, you created a redaction policy named `a_tbl_partial`. Creating a new redaction policy is done by using the `ADD_POLICY` procedure in the `DBMS_REDACT` package (line 2). A policy consists of several distinct sections (see Figure 1). Lines 3, 4, and 5 define on which column our redaction policy should be applied. Line 9 defines redaction type (in this case, partial redaction). Line 10 is used for function parameters (in our case, it is defined that first four digits will be redacted to 0). In line 11, you defined condition when protected data will be masked (in our case, it is when user doesn't have role `myrole`), and it is evaluated using the following expression: `SYS_CONTEXT(''SYS_SESSION_ROLES'',''MYROLE'') = ''FALSE''`. In this case, expression is true only if user doesn't have role `myrole`, and in this case, data in column a will be redacted (which is a case with the user `usr2`, whereas the user `usr1`, who has the role `myrole`, can see the unmasked data).

Step 12 shows the creation of redaction policy for the `Varchar2` column type. The difference is on line 10- function parameters (in our case, the first 12 values will be redacted or changed with symbol `#`, so only last four digits will be visible) and on line 11-condition is always `TRUE`.



```
SQL> SELECT * FROM CUSTOMERS;
```

NAME	CREDIT_CARD
tom	3455647456589132
mike	3734982321225691
john	3472586894975806

NAME	CREDIT_CARD
tom	############9132
mike	############5691
john	############5806

```
DBMS_REDACT.ADD_POLICY
(object_schema => 'ZORAN',
object_name => 'CUSTOMERS',
policy_name => 'CCN_POLICY',
column_name => 'CREDIT_CARD',
function_type => DBMS_REDACT.PARTIAL,
function_parameters => 'VVVVVVVVVVVVVVVV,
VVVVVVVVVVVVVVVV, #,1,12'
expression => '1=1');
```

Figure 11 – Partial redaction

There's more…

Even though users can't see unmasked data, they can use redacted columns in `where` clause:

```
SQL> select * from zoran.customers;

NAME                 CREDIT_CARD
-------------------- ------------------------------
tom                  ############9132
mike                 ############5691
john                 ############5806

SQL> select * from zoran.customers where credit_card like
'34%';

NAME                 CREDIT_CARD
-------------------- ------------------------------
tom                  ############9132
john                 ############5806
```

Creating a redaction policy when using random redaction

Random redaction type is usually used for the number and date-time data types because for these data types, it is hard to make a distinction between the redacted (random) and real data. In this recipe, you will create redaction policy `EMP_POL` using random redaction type on `hr.employees` table, column salary, by using SQL*Plus. In the *Changing redaction policy* recipe, you will modify the `EMP_POL` redaction policy.

Getting ready

To complete this recipe, you'll need:

- An existing user who can view data in the `HR.EMPLOYEES` sample table but doesn't have an exempt redaction policy privilege (for example, `hr`)
- The `secmgr` user created in the *Creating a redaction policy using full redaction* recipe or another user who can create redaction policies (has execute on the `dbms_redact` package)

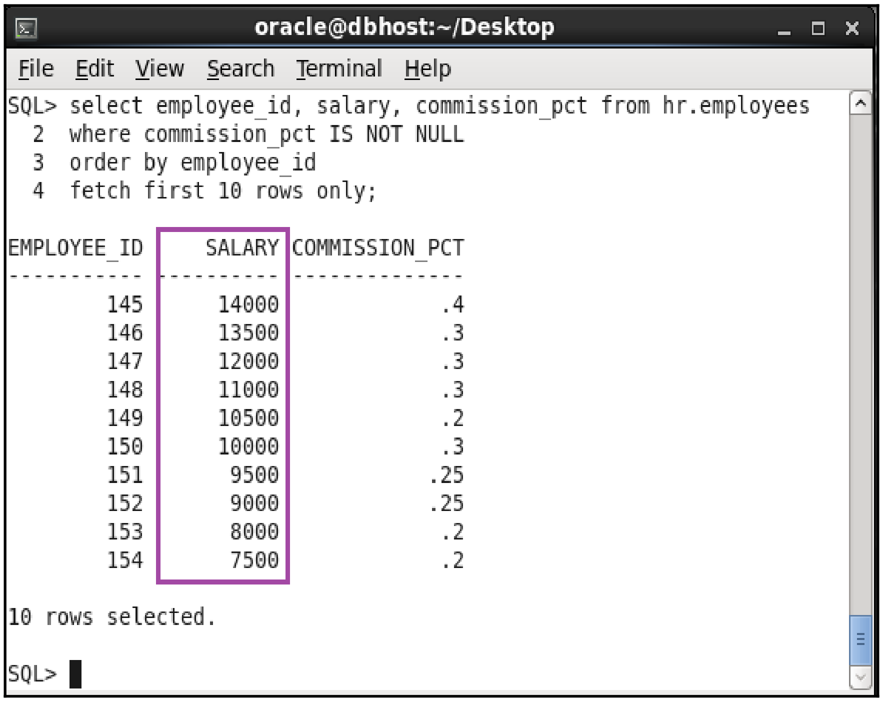
How to do it…

1. Connect to the database as a user who has the `SELECT` privilege on the `HR.EMPLOYEES` table or the `SELECT ANY TABLE` privilege (for example, `hr` user):

   ```
   $ sqlplus hr
   ```

2. Verify that the user (for example, `hr` user) can view data by executing the following query:

   ```
   select employee_id, salary, commission_pct from
   hr.employees where commission_pct IS NOT NULL order by
   employee_id fetch first 10 rows only;
   ```



```
SQL> select employee_id, salary, commission_pct from hr.employees
  2  where commission_pct IS NOT NULL
  3  order by employee_id
  4  fetch first 10 rows only;

EMPLOYEE_ID     SALARY COMMISSION_PCT
----------- ---------- --------------
        145      14000             .4
        146      13500             .3
        147      12000             .3
        148      11000             .3
        149      10500             .2
        150      10000             .3
        151       9500            .25
        152       9000            .25
        153       8000             .2
        154       7500             .2

10 rows selected.

SQL>
```

Figure 12 – Data in the clear text format in the HR.EMPOYEES table

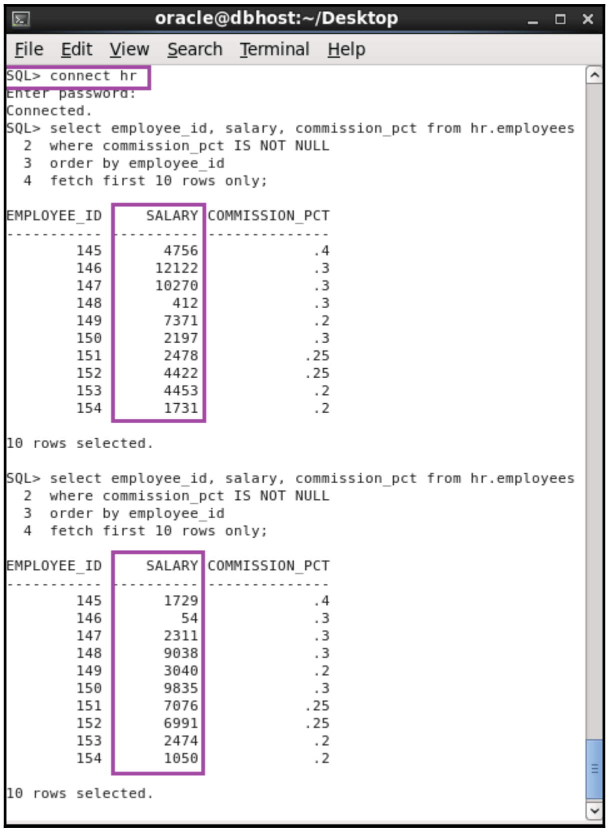
3. Connect to the database as the `secmgr` user:

```
SQL> connect secmgr/oracle
```

4. Create the redaction policy `EMP_POL` in such a way that data in column salary (the table `hr.employees`) is redacted using random redaction only when user in step 1 (for example, `hr`) tries to view it. If you don't use the hr user, modify line 8 to reflect that change:

```
SQL> begin
  2  dbms_redact.add_policy
  3  (object_schema => 'HR',
  4  object_name => 'EMPLOYEES',
  5  policy_name => 'EMP_POL',
  6  column_name => 'SALARY',
  7  function_type => DBMS_REDACT.RANDOM,
  8  expression => 'SYS_CONTEXT(''USERENV'',
                   ''SESSION_USER'') = ''HR''');
  9  end;
 10   /

PL/SQL procedure successfully completed.
```

5. Connect to the database as the same user as in step 1 (for example, `hr`) and execute the same query, as in step 2, twice.



```
SQL> connect hr
Enter password:
Connected.
SQL> select employee_id, salary, commission_pct from hr.employees
  2  where commission_pct IS NOT NULL
  3  order by employee_id
  4  fetch first 10 rows only;

EMPLOYEE_ID     SALARY COMMISSION_PCT
----------- ---------- --------------
        145       4756             .4
        146      12122             .3
        147      10270             .3
        148        412             .3
        149       7371             .2
        150       2197             .3
        151       2478            .25
        152       4422            .25
        153       4453             .2
        154       1731             .2

10 rows selected.

SQL> select employee_id, salary, commission_pct from hr.employees
  2  where commission_pct IS NOT NULL
  3  order by employee_id
  4  fetch first 10 rows only;

EMPLOYEE_ID     SALARY COMMISSION_PCT
----------- ---------- --------------
        145       1729             .4
        146         54             .3
        147       2311             .3
        148       9038             .3
        149       3040             .2
        150       9835             .3
        151       7076            .25
        152       6991            .25
        153       2474             .2
        154       1050             .2

10 rows selected.
```

Figure 13 – After applying redaction policy

How it works…

In step 4, you created the redaction policy `EMP_POL` by using the procedure `ADD_POLICY` in the `DBMS_REDACT` package. Line 7 defines that random redaction type will be used to redact data. Line 8 (policy expression) in this case specifies the blacklist (which contains only user HR). This means only the hr user is not allowed to view data in the column salary. To define a whitelist (for example, list only users who are allowed to view data, range of only those IP addresses from which access is allowed, and so on) change operator = to operator <> and define left and right operand according to your needs.

When defining security policies, it is a good practice to create whitelists.

When the number data type is redacted using random redaction type, the redacted value will belong to the interval [0, |*n*|], where |n| is the absolute value of the original data. According to the official Oracle documentation (*Database Advanced Security Guide*, Chapter 9), the only exception to this rule is when original data is an integer between *−1* and *9*, and in that case, the redacted value will belong to the interval [0, *9*].

Creating a redaction policy when using regular expression redaction

A regular expression redaction type enables you to create and implement flexible redaction rules. You define patterns that will be used in order to match and replace data, as well as some other parameters of the search. In this recipe, you will create the redaction policy `SHORT_POL`, which will be used to mask customers' phone numbers.

Getting ready

To complete this recipe, you'll need:

- An existing user who can view data in the `SH.CUSTOMERS` sample table but doesn't have an exempt redaction policy privilege (for example, `sh`)
- The `secmgr` user you created in the *Creating redaction policy using full redaction* recipe or another user who can create redaction policies (has execute on `dbms_redact` package)

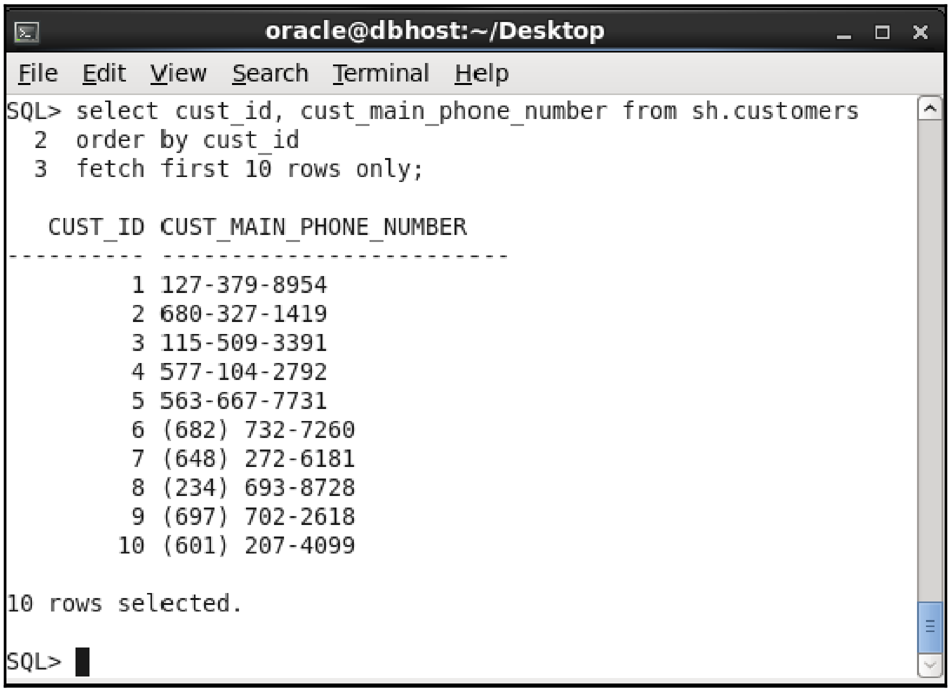
How to do it…

1. Connect to the database as a user who has the `SELECT` privilege on the `SH.CUSTOMERS` table or the `SELECT ANY TABLE` privilege (for example, the `sh` user):

```
$ sqlplus sh
```

2. Verify that the user (for example, the user `sh`) can view data by executing the following query:

```
select cust_id, cust_main_phone_number from sh.customers
order by cust_id fetch first 10 rows only;
```



```
SQL> select cust_id, cust_main_phone_number from sh.customers
  2  order by cust_id
  3  fetch first 10 rows only;

   CUST_ID CUST_MAIN_PHONE_NUMBER
---------- -------------------------
         1 127-379-8954
         2 680-327-1419
         3 115-509-3391
         4 577-104-2792
         5 563-667-7731
         6 (682) 732-7260
         7 (648) 272-6181
         8 (234) 693-8728
         9 (697) 702-2618
        10 (601) 207-4099

10 rows selected.

SQL>
```

Figure 14 – Data in the clear text format (before redaction) in the SH.CUSTOMERS table

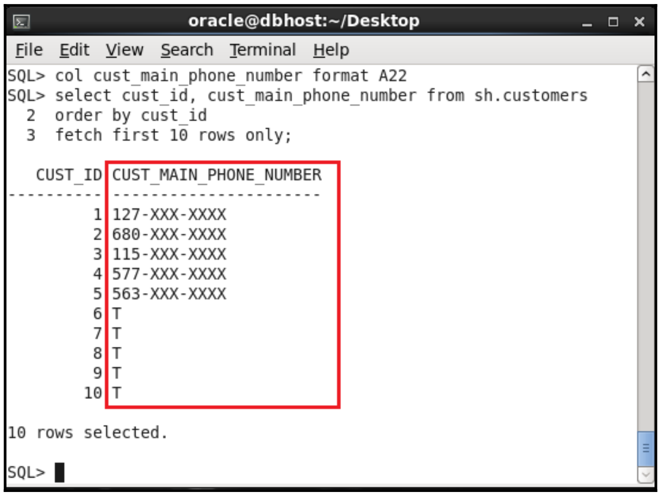
3. Connect to the database as the `secmgr` user:

```
SQL> connect secmgr/oracle
```

4. Create the redaction policy `SHORT_POL` in such a manner that data in the column `cust_main_phone_number` (the table `sh.customers`) is redacted using regular expression redaction:

```
SQL> begin
  2  dbms_redact.add_policy
  3  (object_schema => 'SH',
  4  object_name => 'CUSTOMERS',
  5  policy_name => 'SHORT_POL',
  6  column_name => 'CUST_MAIN_PHONE_NUMBER',
  7  function_type => DBMS_REDACT.REGEXP,
  8  expression => '1=1',
  9  regexp_pattern => DBMS_REDACT.RE_PATTERN_US_PHONE,
  10 regexp_replace_string => DBMS_REDACT.
                              RE_REDACT_US_PHONE_L7,
  11 regexp_position => DBMS_REDACT.RE_BEGINNING,
  12 regexp_occurrence => DBMS_REDACT.RE_FIRST);
  13 end;
  14 /

PL/SQL procedure successfully completed.
```

5. Connect to the database as the same user as in step 1 (for example, `sh`) and execute the same query as in step 2.



```
SQL> col cust_main_phone_number format A22
SQL> select cust_id, cust_main_phone_number from sh.customers
  2  order by cust_id
  3  fetch first 10 rows only;

   CUST_ID CUST_MAIN_PHONE_NUMBER
---------- ----------------------
         1 127-XXX-XXXX
         2 680-XXX-XXXX
         3 115-XXX-XXXX
         4 577-XXX-XXXX
         5 563-XXX-XXXX
         6 T
         7 T
         8 T
         9 T
        10 T

10 rows selected.

SQL> 
```

Figure 15 – After applying the redaction policy

How it works…

When creating redaction policies that use regular expression redaction type, you can choose between redaction shortcuts (they exist for commonly redacted data, such as e-mail address, social security number, and postal code) and the creation of custom regular expressions. In this recipe, in step 4, lines 9-12, you used redaction shortcuts.

In Figure 15, the value `T` is displayed in the places where regular expression didn't find a match and because of that full redaction was applied to them. With this kind of implementation, Oracle prevented accidental exposure of sensitive data.

Using Oracle Enterprise Manager Cloud Control 12c to manage redaction policies

In this recipe, you will perform several tasks with Data Redaction policies using Oracle Enterprise Manager Cloud Control 12*c*, including creation, modification, and deletion. Many tasks from other recipes, described in this chapter, can be done very easily using Enterprise Manager.

Getting ready

To complete this recipe, you need Enterprise Manager Cloud Control 12*c* and `HR` sample schema in the database.

How to do it…

1. Log in to **Oracle Enterprise Manager Cloud Control** at `https://hostname:port/em`.
2. Go to a **Database** home page (if it is a container database, you should go to a home page of PDB that contains sample schemas).

3. On menu, select **Security** | **Data Redaction** (see Figure 16).

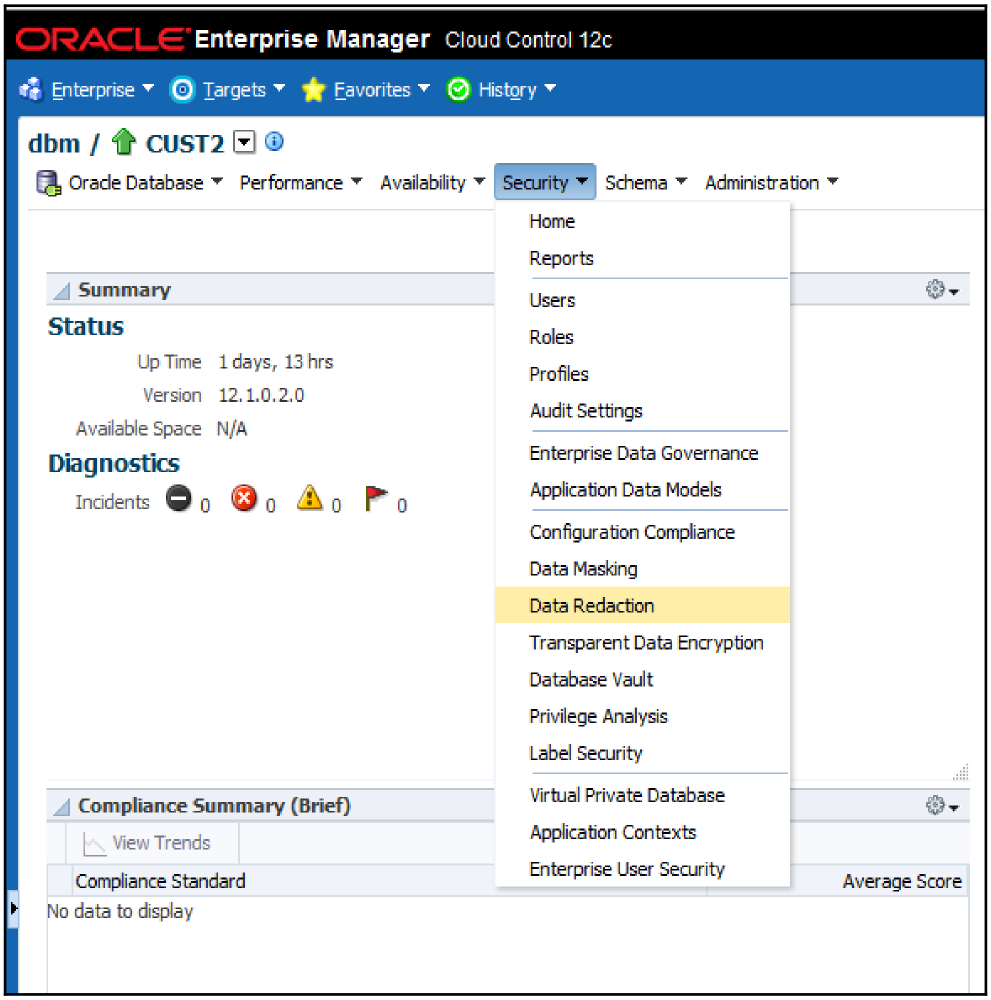
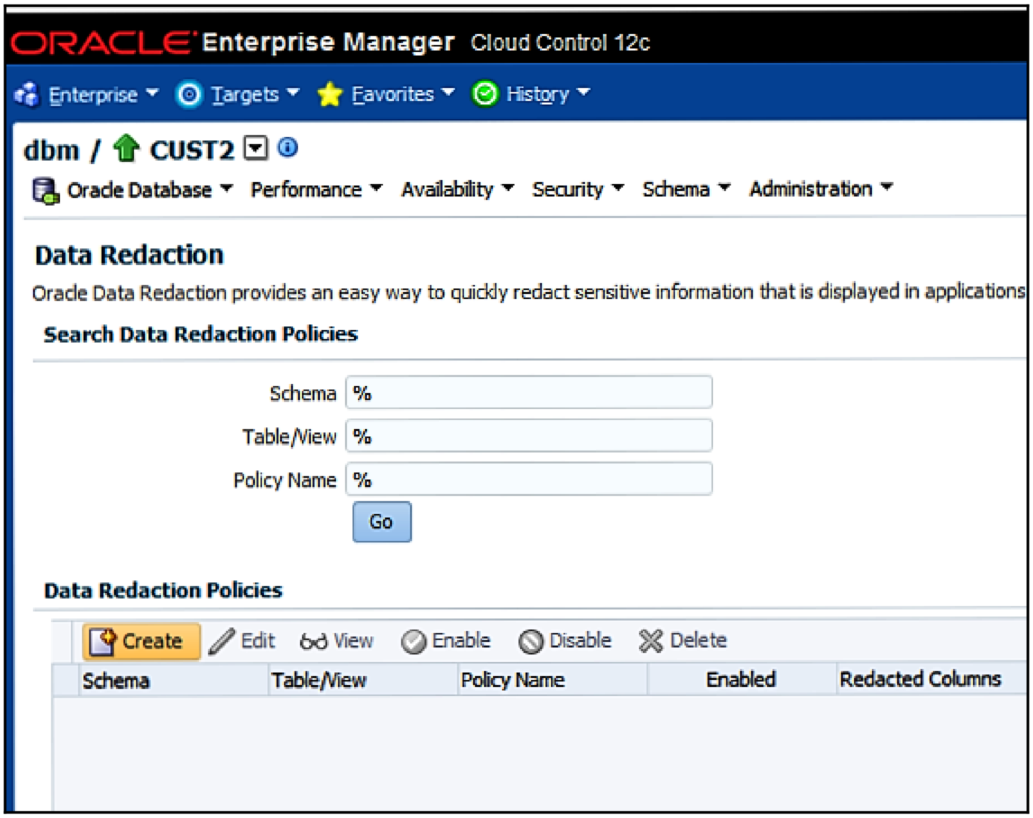


Figure 16 – Select Data Redaction

4. On the **Data Redaction** screen, select **Create** (Figure 17).



Data Redaction

Oracle Data Redaction provides an easy way to quickly redact sensitive information that is displayed in applications

Search Data Redaction Policies

Schema	%
Table/View	%
Policy Name	%

Go

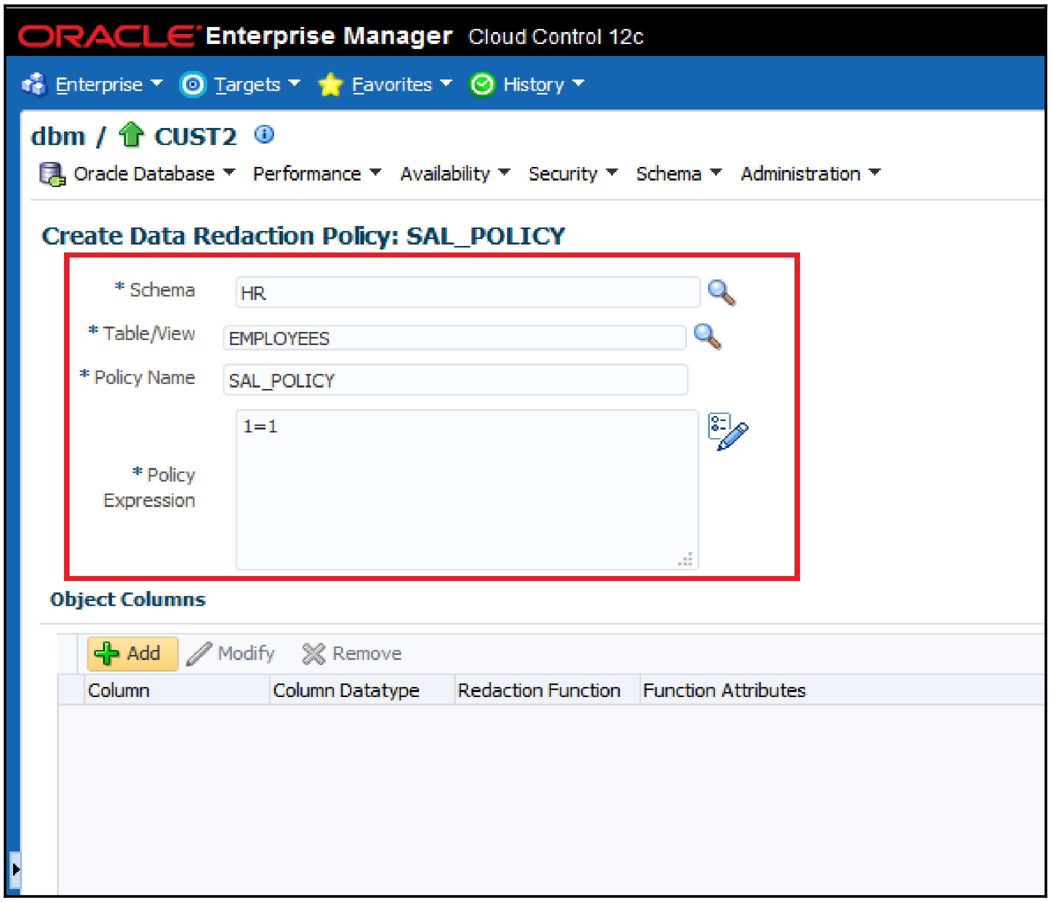
Data Redaction Policies

Create Edit View Enable Disable Delete

Schema	Table/View	Policy Name	Enabled	Redacted Columns

Figure 17 – Creating a redaction policy

5. Set **Schema** as `HR` and the table as **EMPLOYEES**. Enter `SAL_POLICY` as a policy name. Click on the **Add** button, to add column that is going to be redacted. (Figure 18).



Create Data Redaction Policy: SAL_POLICY

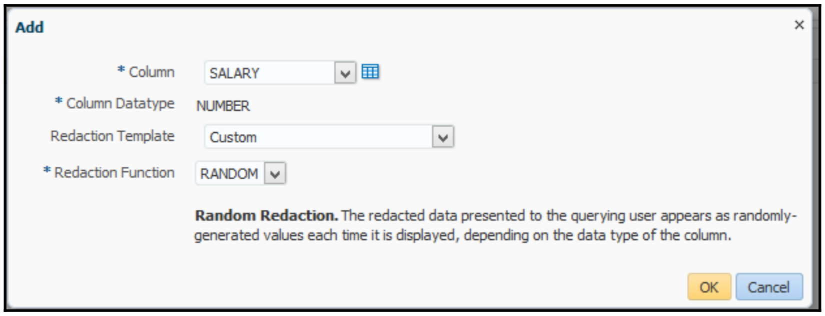
* Schema	HR
* Table/View	EMPLOYEES
* Policy Name	SAL_POLICY
* Policy Expression	1=1

Object Columns

Column	Column Datatype	Redaction Function	Function Attributes

Figure 18 – The addition of a column

6. Select the **SALARY** column and specify **RANDOM** as a **Redaction Function**. Click on **OK**. (Figure 19). On the next screen, click on **OK** at the top-right corner.

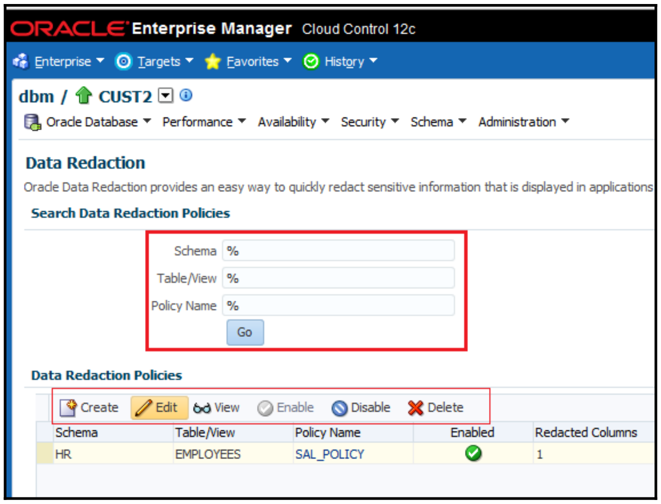


* Column	SALARY
* Column Datatype	NUMBER
Redaction Template	Custom
* Redaction Function	RANDOM

Random Redaction. The redacted data presented to the querying user appears as randomly-generated values each time it is displayed, depending on the data type of the column.

Figure 19 – Choose random redaction type

7. To edit **SAL_POLICY**, select it and click on **Edit** (you can search for policies by specifying schema, table, or policy name) (Figure 20).



Data Redaction

Oracle Data Redaction provides an easy way to quickly redact sensitive information that is displayed in applications

Search Data Redaction Policies

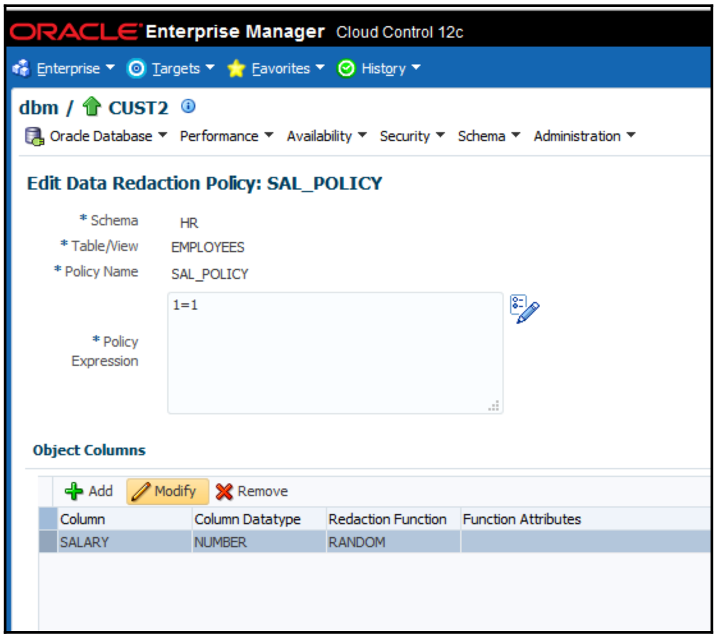
Schema	%
Table/View	%
Policy Name	%

Data Redaction Policies

Schema	Table/View	Policy Name	Enabled	Redacted Columns
HR	EMPLOYEES	SAL_POLICY	✓	1

Figure 20 – Alter policy

8. Select the **SALARY** column and click on **Modify** (Figure 21).



Edit Data Redaction Policy: SAL_POLICY

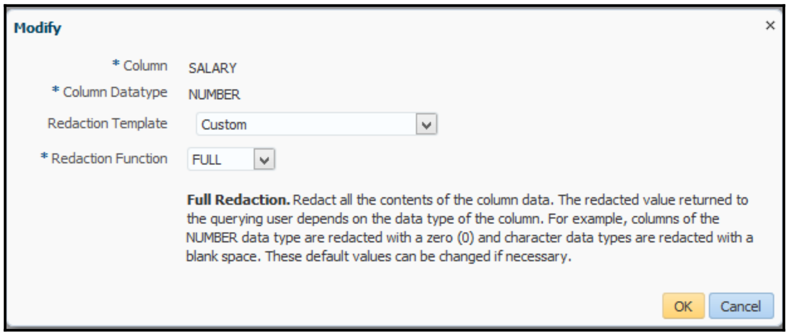
* Schema	HR
* Table/View	EMPLOYEES
* Policy Name	SAL_POLICY
* Policy Expression	1=1

Object Columns

Column	Column Datatype	Redaction Function	Function Attributes
SALARY	NUMBER	RANDOM	

Figure 21 – Modifying a column

9. Change **Redaction Function** from **RANDOM** to **FULL**. Click on **OK** (Figure 22).

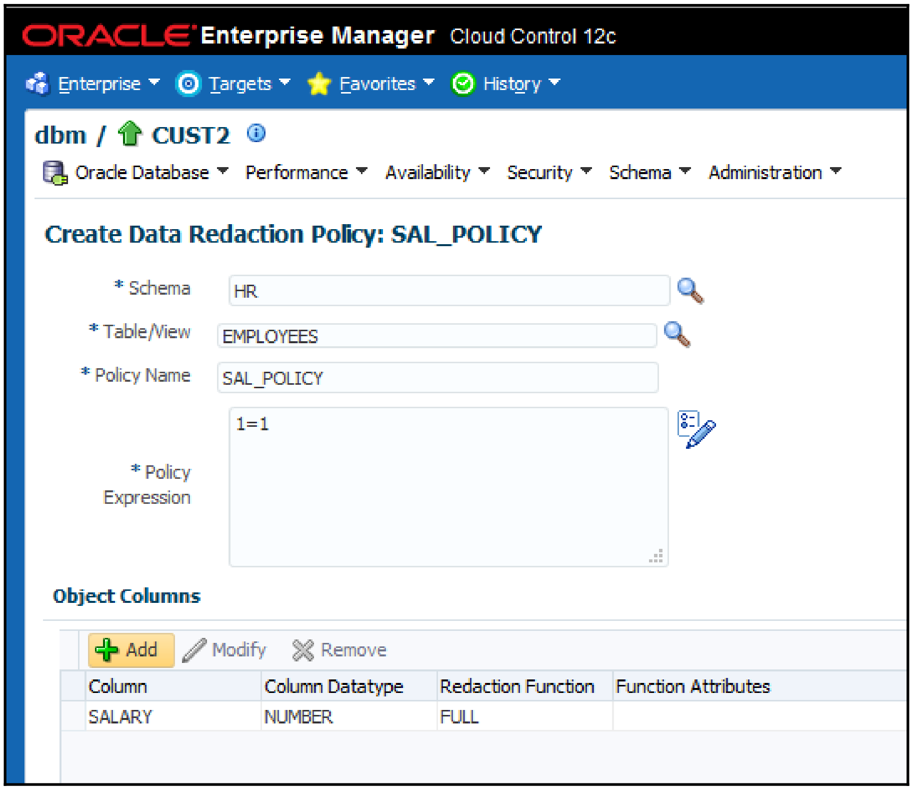

Modify

* Column	SALARY
* Column Datatype	NUMBER
Redaction Template	Custom
* Redaction Function	FULL

Full Redaction. Redact all the contents of the column data. The redacted value returned to the querying user depends on the data type of the column. For example, columns of the NUMBER data type are redacted with a zero (0) and character data types are redacted with a blank space. These default values can be changed if necessary.

Figure 22 – Changing redaction type for salary column

10. Click on **Add** in order to add one more column to the redaction policy. (Figure 23).



Create Data Redaction Policy: SAL_POLICY

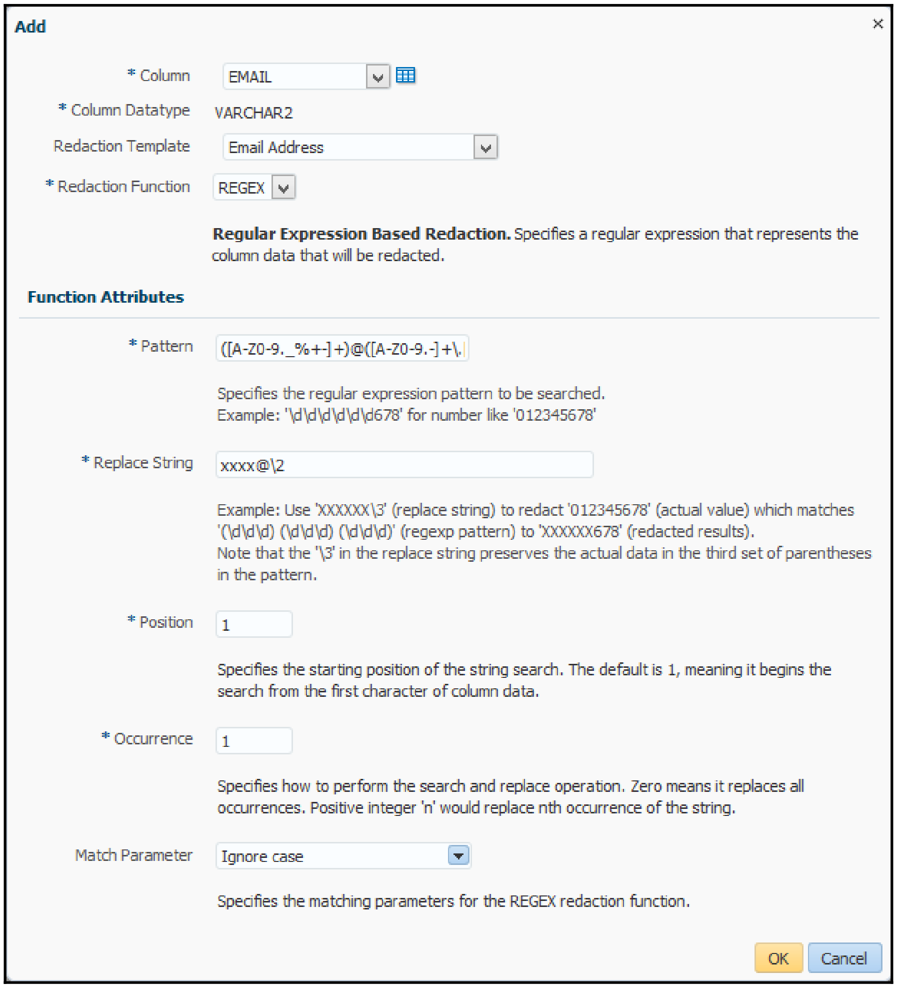
* Schema	HR
* Table/View	EMPLOYEES
* Policy Name	SAL_POLICY
* Policy Expression	1=1

Object Columns

Column	Column Datatype	Redaction Function	Function Attributes
SALARY	NUMBER	FULL	

Figure 23 – Adding a column to the redaction policy

11. Select the **EMAIL** column, and as **Redaction Template**. select **Email Address**. You can see that this pattern uses `Regular` expression type of **Data Redaction**. You can also change any of the parameters. Click on **OK**. (Figure 24).


Add

* Column: EMAIL

* Column Datatype: VARCHAR2

Redaction Template: Email Address

* Redaction Function: REGEX

Regular Expression Based Redaction. Specifies a regular expression that represents the column data that will be redacted.

Function Attributes

* Pattern: ([A-Z0-9._%+-]+)@([A-Z0-9.-]+\.

Specifies the regular expression pattern to be searched.
Example: '\d\d\d\d\d\d678' for number like '012345678'

* Replace String: xxxx@\2

Example: Use 'XXXXXX\3' (replace string) to redact '012345678' (actual value) which matches '(\d\d\d) (\d\d\d) (\d\d\d)' (regexp pattern) to 'XXXXXX678' (redacted results).
Note that the '\3' in the replace string preserves the actual data in the third set of parentheses in the pattern.

* Position: 1

Specifies the starting position of the string search. The default is 1, meaning it begins the search from the first character of column data.

* Occurrence: 1

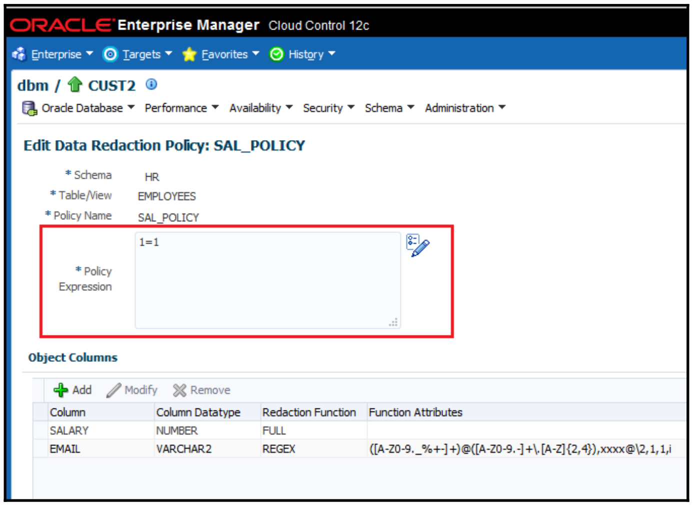
Specifies how to perform the search and replace operation. Zero means it replaces all occurrences. Positive integer 'n' would replace nth occurrence of the string.

Match Parameter: Ignore case

Specifies the matching parameters for the REGEX redaction function.

Figure 24 – Defining redaction type for email column

12. On next page you can change **Policy Expression**. Click **OK** on the top right corner.


ORACLE Enterprise Manager Cloud Control 12c
Enterprise Targets Favorites History
dbm / CUST2
Oracle Database Performance Availability Security Schema Administration
Add Modify Remove

Edit Data Redaction Policy: SAL_POLICY

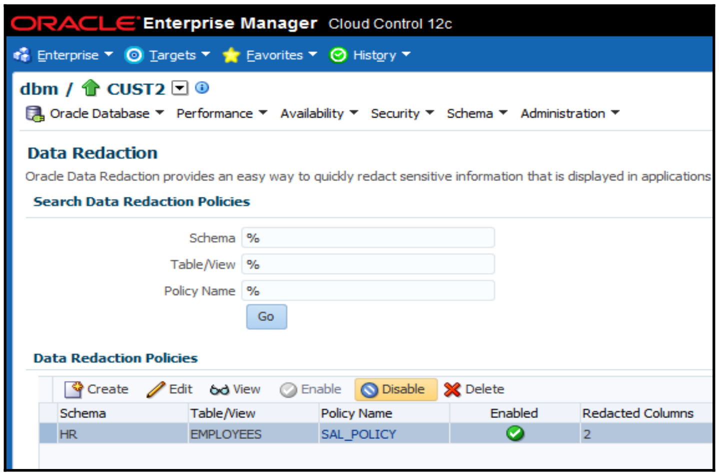
* Schema	HR
* Table/View	EMPLOYEES
* Policy Name	SAL_POLICY
* Policy Expression	1=1

Object Columns

Column	Column Datatype	Redaction Function	Function Attributes
SALARY	NUMBER	FULL	
EMAIL	VARCHAR2	REGEX	([A-Z0-9._%+-]+)@([A-Z0-9.-]+\.[A-Z]{2,4}),xxxx@\2,1,1,i

Figure 25 – You can change the policy expression

13. To disable **SAL_POLICY**, select it and click on **Disable**. (Figure 26).


ORACLE Enterprise Manager Cloud Control 12c
Enterprise Targets Favorites History
dbm / CUST2
Oracle Database Performance Availability Security Schema Administration
Go
Create Edit View Enable Disable Delete

Data Redaction

Oracle Data Redaction provides an easy way to quickly redact sensitive information that is displayed in applications

Search Data Redaction Policies

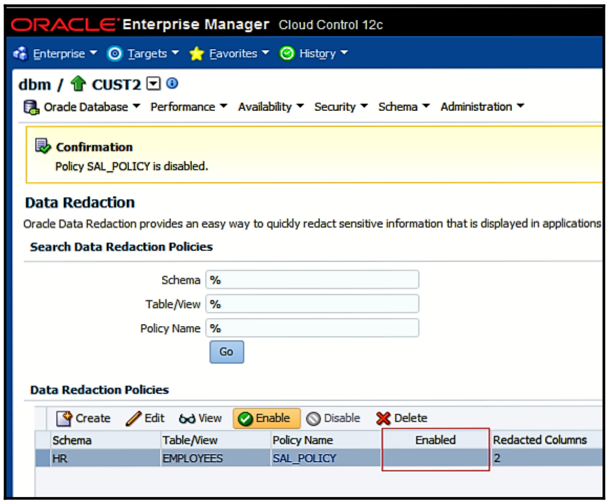
Schema	%
Table/View	%
Policy Name	%

Data Redaction Policies

Schema	Table/View	Policy Name	Enabled	Redacted Columns
HR	EMPLOYEES	SAL_POLICY	✓	2

Figure 26 – Disabling the sal_policy redaction policy

14. To enable **SAL_POLICY**, select it and click on **Enable**. (Figure 27).


ORACLE Enterprise Manager Cloud Control 12c
Enterprise Targets Favorites History
dbm / CUST2
Oracle Database Performance Availability Security Schema Administration
Create Edit View Enable Disable Delete
Go

Confirmation
Policy SAL_POLICY is disabled.

Data Redaction
Oracle Data Redaction provides an easy way to quickly redact sensitive information that is displayed in applications

Search Data Redaction Policies

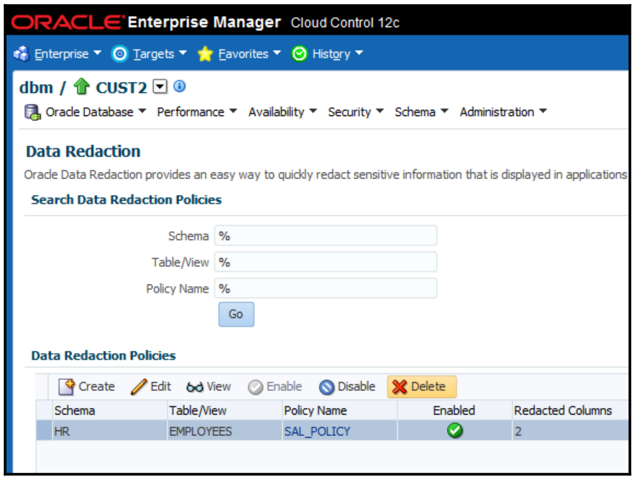
Schema %
Table/View %
Policy Name %

Data Redaction Policies

Schema	Table/View	Policy Name	Enabled	Redacted Columns
HR	EMPLOYEES	SAL_POLICY		2

Figure 27 – Enabling the sal_policy redaction policy

15. To delete **SAL_POLICY**, select it and click on **Delete**. (Figure 28).


ORACLE Enterprise Manager Cloud Control 12c
Enterprise Targets Favorites History
dbm / CUST2
Oracle Database Performance Availability Security Schema Administration
Create Edit View Enable Disable Delete
Go

Data Redaction
Oracle Data Redaction provides an easy way to quickly redact sensitive information that is displayed in applications

Search Data Redaction Policies

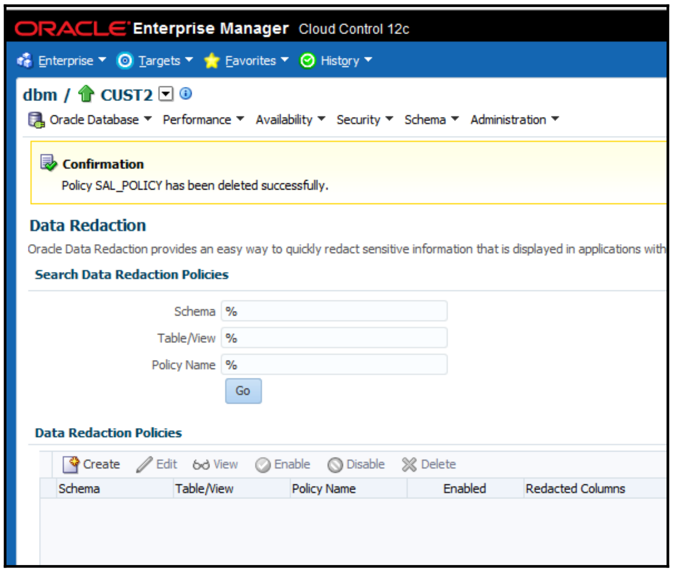
Schema %
Table/View %
Policy Name %

Data Redaction Policies

Schema	Table/View	Policy Name	Enabled	Redacted Columns
HR	EMPLOYEES	SAL_POLICY	✓	2

Figure 28 – Deleting the sal_policy redaction policy

16. You should see the **Confirmation** message (Figure 29).



Confirmation
Policy SAL_POLICY has been deleted successfully.

Data Redaction
Oracle Data Redaction provides an easy way to quickly redact sensitive information that is displayed in applications with

Search Data Redaction Policies

Schema	%
Table/View	%
Policy Name	%

Data Redaction Policies

Schema	Table/View	Policy Name	Enabled	Redacted Columns

Figure 29 – The SAL_POLICY policy has been successfully deleted

Changing the function parameters for a specified column

There are several ways in which you can change an existing redaction policy. In this recipe and the next one, you will:

- Change the function parameters for a specified column (the `a_tbl_partial` policy, which you created in the recipe *Creating a redaction policy when using partial redaction*)
- Add a column (`commission_pct` in the `hr.employees` table) to the redaction policy `EMP_POL` (you defined it in the *Creating a redaction policy when using random redaction* recipe)

Also, it is possible to remove column from the redaction policy, alter the policy expression, and modify the type of redaction for a specified column.

You concluded that the `a_tbl_partial` redaction policy doesn't satisfy the requirements for your application anymore because it redacts first four digits with 0 and leading zeros are not displayed in the application. You decide to alter the `a_tbl_partial` policy. You want all digits to be displayed and to have them redacted with some value (for example, `9`).

Getting ready

Before doing this recipe, you should have completed the *Creating a redaction policy when using partial redaction* recipe. You will use the `secmgr` user you created in the *Creating a redaction policy when using full redaction* recipe .

How to do it…

1. Connect to the database as the `secmgr` user and alter the policy `EMP_POL`:

```
$ sqlplus secmgr
SQL> BEGIN
  2  DBMS_REDACT.ALTER_POLICY(
  3  object_schema   => 'zoran',
  4  object_name     => 'tbl',
  5  policy_name     => 'a_tbl_partial',
  6  action          => DBMS_REDACT.MODIFY_COLUMN,
  7  column_name     => 'a',
  8  function_type   => DBMS_REDACT.PARTIAL,
  9  function_parameters    => '9,1,4');
 10  END;
 11  /
```

2. Connect as the user `usr2` to the database and view data in column `A` in the `zoran.tbl` table:

```
SQL> connect usr2/oracle2
Connected.

SQL> select a from zoran.tbl;

      A
----------
    999956
    999967
    999978
```

Add a column to the redaction policy

You have to modify the existing redaction policy in order to redact more than one column in the table. In the table `HR.EMPLOYEES`, besides the column `SALARY`, you want to redact the column `COMMISSION_PCT`. You will modify the redaction policy `EMP_POL`. You decide that you want to use full redaction type for the column `COMMISSION_PCT`.

Note that in the same redaction policy (in this case, `EMP_POL`) the different "protected" columns can use different redaction types (in this case, random and full redaction).

Getting ready

Before doing this recipe, you should have completed the *Creating redaction policy when using random redaction* recipe. You will use the `secmgr` user you created in the *Creating redaction policy when using full redaction* recipe.

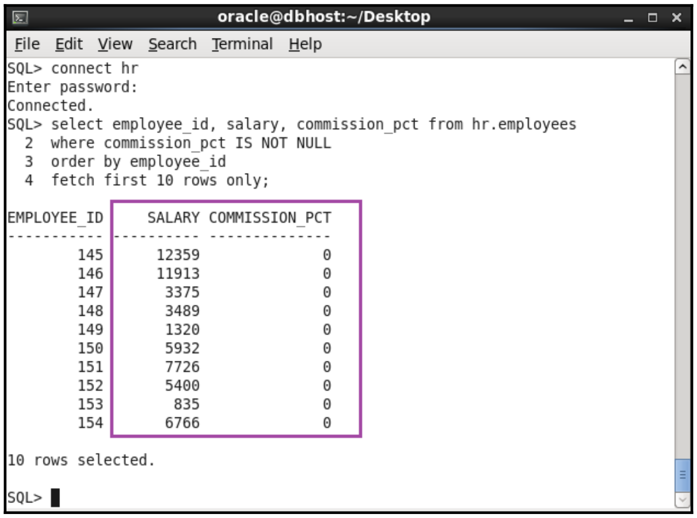
How to do it…

1. Connect to the database as the `secmgr` user and alter the `EMP_POL` policy:

```
$ sqlplus secmgr
SQL> BEGIN
  2   DBMS_REDACT.ALTER_POLICY(
  3   object_schema   => 'HR',
  4   object_name     => 'EMPLOYEES',
  5   policy_name     => 'EMP_POL',
  6   action          => DBMS_REDACT.ADD_COLUMN,
  7   column_name     => 'COMMISSION_PCT',
  8   function_type   => DBMS_REDACT.FULL);
  9   END;
 10   /

PL/SQL procedure successfully completed.
```

2. Connect the user `hr` to the database and execute the following query:

```
select employee_id, salary, commission_pct from hr.employees
where commission_pct IS NOT NULL order by employee_id fetch
first 10 rows only;
```



```
SQL> connect hr
Enter password:
Connected.
SQL> select employee_id, salary, commission_pct from hr.employees
  2  where commission_pct IS NOT NULL
  3  order by employee_id
  4  fetch first 10 rows only;

EMPLOYEE_ID     SALARY COMMISSION_PCT
----------- ---------- --------------
        145      12359              0
        146      11913              0
        147       3375              0
        148       3489              0
        149       1320              0
        150       5932              0
        151       7726              0
        152       5400              0
        153        835              0
        154       6766              0

10 rows selected.

SQL>
```

Figure 30 – Two columns are redacted

How it works…

You used the procedure `ALTER_POLICY` in the PL/SQL package `DMBS_REDACT` to change redaction policies. On line 6 (in both examples), you specified value for the `ACTION` parameter, which defines what kind of change will happen.

See also

- *Using Oracle Enterprise Manager Cloud Control 12c to manage redaction policies*

Enabling, disabling, and dropping redaction policy

In this recipe, you will perform the three basic tasks: enabling, disabling, and dropping the same redaction policy (`CUST_POL`), which you defined in the *Creating a redaction policy when using full redaction* recipe using SQL*Plus. Also, you will check which redaction policies exist in the database and whether they are enforced (enabled).

To minimize dependence on the previous recipes in this chapter, a result shown after querying data dictionary view is equivalent to the one you would get if you completed only the *Creating a redaction policy when using full redaction* recipe before starting to do this recipe. The only difference you may see in the result is the number of existing redaction policies in the database.

Getting ready

Before doing this recipe, you should have completed the *Creating a redaction policy when using full redaction* recipe.

How to do it…

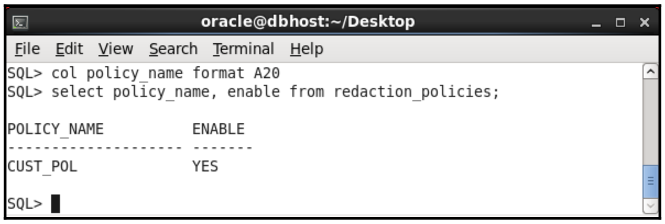
To complete the tasks, you will use procedures in the `dbms_redact` package (`disable_policy`, `enable_policy`, and `drop_policy`).

1. Connect to the database as a user who has an execute privilege on `dbms_redact` package and `select_catalog_role` role (for example, `secmgr` user):

```
$ sqlplus secmgr
```

2. Find out which redaction policies exist in the database by querying the `redaction_policies` view:

```
SQL> col policy_name format A20
select policy_name, enable from redaction_policies;
```

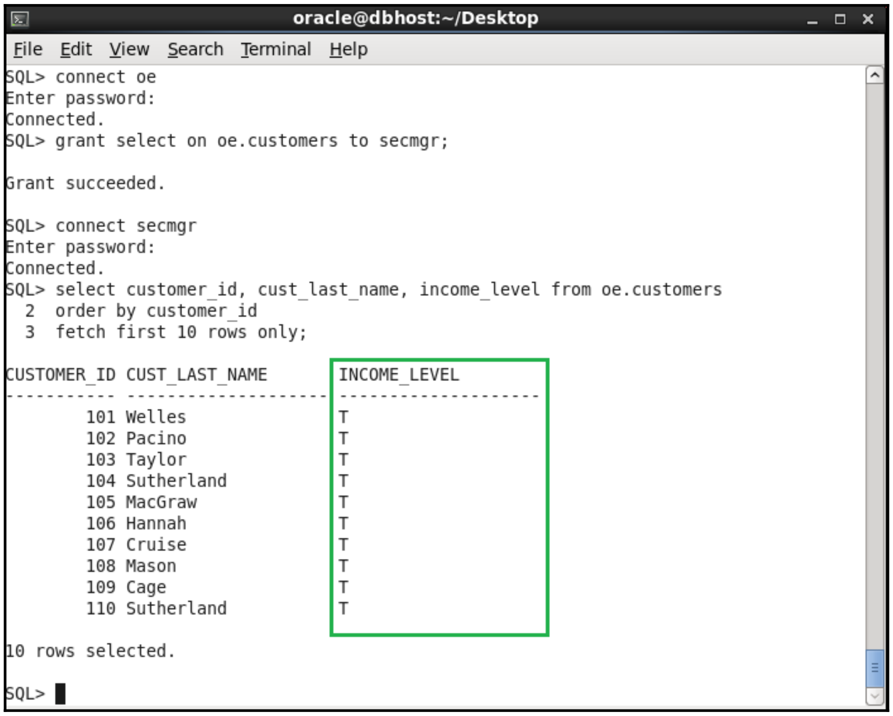


```
SQL> col policy_name format A20
SQL> select policy_name, enable from redaction_policies;

POLICY_NAME          ENABLE
-------------------- -------
CUST_POL             YES

SQL> 
```

Figure 31 – Finding defined redaction policies

3. Connect to the database as the `oe` user and grant the `SELECT` privilege on `OE.CUSTOMERS` to the `secmgr` user. Connect to the database as the `secmgr` user. Verify that the `secmgr` user can't see original data in the column `INCOME_LEVEL`:

```
SQL> connect oe

SQL> grant select on oe.customers to secmgr;

SQL> connect secmgr

SQL> select customer_id, cust_last_name, income_level
from oe.customers
  2  order by customer_id
  3  fetch first 10 rows only;
```



```
SQL> connect oe
Enter password:
Connected.
SQL> grant select on oe.customers to secmgr;

Grant succeeded.

SQL> connect secmgr
Enter password:
Connected.
SQL> select customer_id, cust_last_name, income_level from oe.customers
  2  order by customer_id
  3  fetch first 10 rows only;

CUSTOMER_ID CUST_LAST_NAME       INCOME_LEVEL
----------- -------------------- --------------------
        101 Welles               T
        102 Pacino               T
        103 Taylor               T
        104 Sutherland           T
        105 MacGraw              T
        106 Hannah               T
        107 Cruise               T
        108 Mason                T
        109 Cage                 T
        110 Sutherland           T

10 rows selected.

SQL>
```

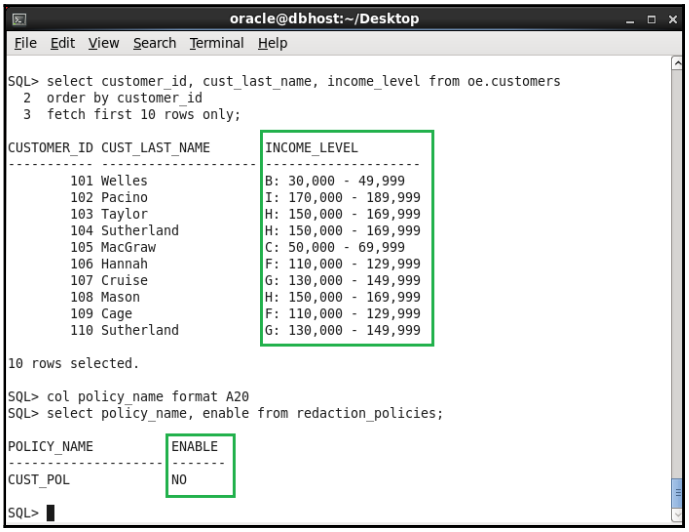
Figure 32 – Redacted data is displayed even to the user who created the policy

4. Disable the redaction policy `CUST_POL` (as the `secmgr` user):

```
SQL> begin
  2  dbms_redact.disable_policy
  3  (object_schema => 'OE',
  4  object_name => 'CUSTOMERS',
  5  policy_name => 'CUST_POL');
  6  end;
  7 /

PL/SQL procedure successfully completed.
```

5. Verify that now the `secmgr` user can view original data in the column `INCOME_LEVEL` and query the `redaction_policies` view by executing the following statements:

    - `select customer_id, cust_last_name, income_level from oe.customers order by customer_id fetch first 10 rows only;`
    - `col policy_name format A20`
    - `select policy_name, enable from redaction_policies;`



```
SQL> select customer_id, cust_last_name, income_level from oe.customers
  2  order by customer_id
  3  fetch first 10 rows only;

CUSTOMER_ID CUST_LAST_NAME       INCOME_LEVEL
----------- -------------------- --------------------
        101 Welles               B: 30,000 - 49,999
        102 Pacino               I: 170,000 - 189,999
        103 Taylor               H: 150,000 - 169,999
        104 Sutherland           H: 150,000 - 169,999
        105 MacGraw              C: 50,000 - 69,999
        106 Hannah               F: 110,000 - 129,999
        107 Cruise               G: 130,000 - 149,999
        108 Mason                H: 150,000 - 169,999
        109 Cage                 F: 110,000 - 129,999
        110 Sutherland           G: 130,000 - 149,999

10 rows selected.

SQL> col policy_name format A20
SQL> select policy_name, enable from redaction_policies;

POLICY_NAME          ENABLE
-------------------- -------
CUST_POL             NO

SQL>
```

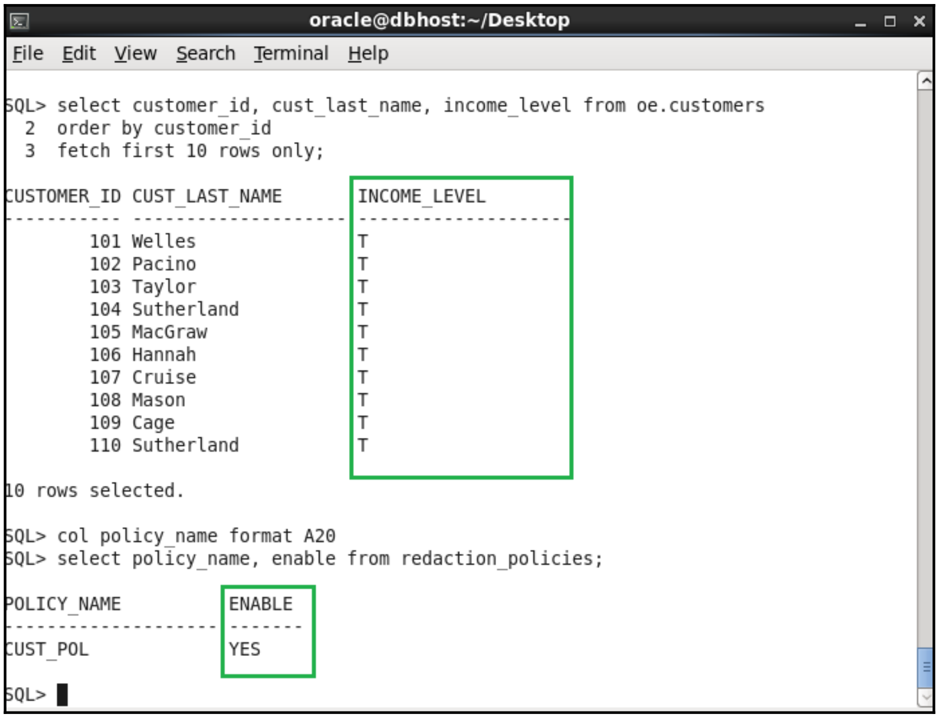
Figure 33 – secmgr can view unmasked data in the column income_level, because the cust_pol policy is disabled

- Enable the redaction policy `CUST_POL`:

```
SQL> begin
  2  dbms_redact.enable_policy
  3  (object_schema => 'OE',
  4  object_name => 'CUSTOMERS',
  5  policy_name => 'CUST_POL');
  6  end;
  7 /

PL/SQL procedure successfully completed.
```

6. Verify that redaction is working properly by executing the following statements:

   - `select customer_id, cust_last_name, income_level from oe.customers order by customer_id fetch first 10 rows only;`
   - `col policy_name format A20`
   - `select policy_name, enable from redaction_policies;`



```
SQL> select customer_id, cust_last_name, income_level from oe.customers
  2  order by customer_id
  3  fetch first 10 rows only;

CUSTOMER_ID CUST_LAST_NAME       INCOME_LEVEL
----------- -------------------- --------------------
        101 Welles               T
        102 Pacino               T
        103 Taylor               T
        104 Sutherland           T
        105 MacGraw              T
        106 Hannah               T
        107 Cruise               T
        108 Mason                T
        109 Cage                 T
        110 Sutherland           T

10 rows selected.

SQL> col policy_name format A20
SQL> select policy_name, enable from redaction_policies;

POLICY_NAME          ENABLE
-------------------- -------
CUST_POL             YES

SQL>
```

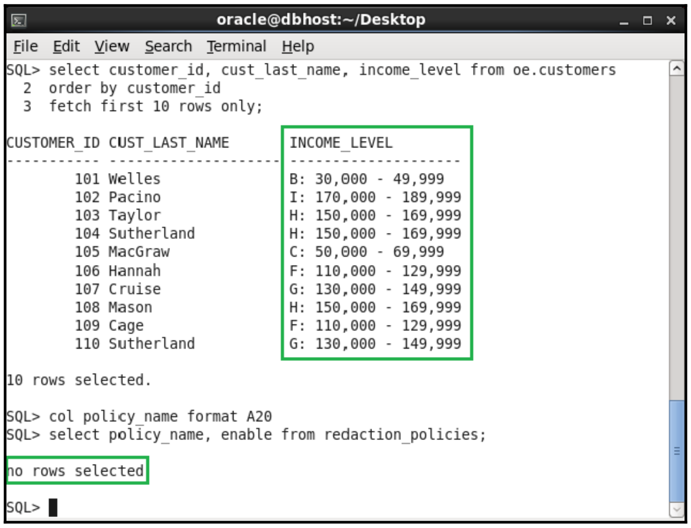
Figure 34 – Redacted data is displayed to the secmgr user because the cust_pol redaction policy is enabled

- Drop the redaction policy `CUST_POL`:

```
SQL> begin
  2  dbms_redact.drop_policy
  3  (object_schema => 'OE',
  4  object_name => 'CUSTOMERS',
  5  policy_name => 'CUST_POL');
  6  end;
  7 /

PL/SQL procedure successfully completed.
```

7. Verify that the redaction policy `CUST_POL` doesn't exist in the database by executing the following statements:

    - `select customer_id, cust_last_name, income_level from oe.customers order by customer_id fetch first 10 rows only;`
    - `col policy_name format A20`
    - `select policy_name, enable from redaction_policies;`



```
SQL> select customer_id, cust_last_name, income_level from oe.customers
  2  order by customer_id
  3  fetch first 10 rows only;

CUSTOMER_ID CUST_LAST_NAME       INCOME_LEVEL
----------- -------------------- --------------------
        101 Welles               B: 30,000 - 49,999
        102 Pacino               I: 170,000 - 189,999
        103 Taylor               H: 150,000 - 169,999
        104 Sutherland           H: 150,000 - 169,999
        105 MacGraw              C: 50,000 - 69,999
        106 Hannah               F: 110,000 - 129,999
        107 Cruise               G: 130,000 - 149,999
        108 Mason                H: 150,000 - 169,999
        109 Cage                 F: 110,000 - 129,999
        110 Sutherland           G: 130,000 - 149,999

10 rows selected.

SQL> col policy_name format A20
SQL> select policy_name, enable from redaction_policies;

no rows selected

SQL>
```

Figure 35 – The redaction policy cust_pol doesn't exist anymore

See also

- *Creating a redaction policy when using full redaction*
- *Using Oracle Enterprise Manager Cloud Control 12c to manage redaction policies*

Exempting users from data redaction policies

In this recipe, you will create a user and then exempt that user from Data Redaction. This user will be exempted from all redaction policies in the database.

Getting ready

Before doing this recipe, you should have completed the *Creating a redaction policy when using the partial redaction* recipe.

How to do it…

1. Connect to the database as a user who has a DBA role (for example, user `zoran`):

   ```
   $ sqlplus zoran/oracle
   ```

2. Create a new user (for example, `vipuser`) and grant him the `create session` privilege and select privilege on table customers in schema `zoran`:

   ```
   SQL> create user vipuser identified by oracle;

   SQL> grant create session to vipuser;

   SQL> grant select on zoran.customers to vipuser;
   ```

3. Connect as a newly created user and try to select from the `zoran.customers` table:

   ```
   SQL> connect vipuser/oracle

   SQL> select * from zoran.customers;

   NAME             CREDIT_CARD
   ---------------- ------------------------------
   tom              ############9132
   mike             ############5691
   john             ############5806
   ```

4. Connect again as the user `zoran`, and grant the `EXEMPT REDACTION POLICY` privilege to the `vipuser` user:

```
SQL> connect zoran/oracle

SQL> grant exempt redaction policy to vipuser;
```

5. As the user `vipuser`, now try to select from the table `zoran.customers`:

```
SQL> connect vipuser/oracle

SQL> select * from zoran.customers;

NAME            CREDIT_CARD
--------------- ------------------------------
tom             3455647456589132
mike            3734982321225691
john            3472586894975806
```

How it works…

There is a new system privilege that is used to control which users will be exempted from data redaction in Oracle Database. This privilege is `EXEMPT REDACTION POLICY`. Users who are granted this privilege will be able to see clear (unmasked) data in the whole database if they have (`select`) privilege to access that data. This means that all redaction policies in the database will not be applied to these users. The `DBA` *and* `EXP_FULL_DATABASE` roles both *contain this privilege*, so any *user that has* either of these roles *is exempt from data redaction*.

Backup/restore as well as import and export operations are not subject to data redaction. However, data redaction policies are included in export and import operations.

6
Transparent Sensitive Data Protection

In this chapter, we will cover the following tasks:

- Creating a sensitive type
- Determining sensitive columns
- Creating transparent sensitive data protection policy
- Associating transparent sensitive data protection policy with sensitive type
- Enabling, disabling, and dropping policy
- Altering transparent sensitive data protection policy

Introduction

Oracle **Transparent Sensitive Data Protection** (**TSDP**) is a new security feature, introduced in Oracle Database 12c (available only in Enterprise Edition). TSDP provides a way to create classes of sensitive data and enables more centralized control of how sensitive data is protected. In database versions 12.1.0.1 and 12.1.0.2, it leverages two Oracle security mechanisms:

- Oracle **Virtual Private Database** (**VPD**), described in `Chapter 4`, *Virtual Private Database*
- Oracle Data Redaction, explained in `Chapter 5`, *Data Redaction*

To implement TSDP, you should complete steps shown in Figure 1:

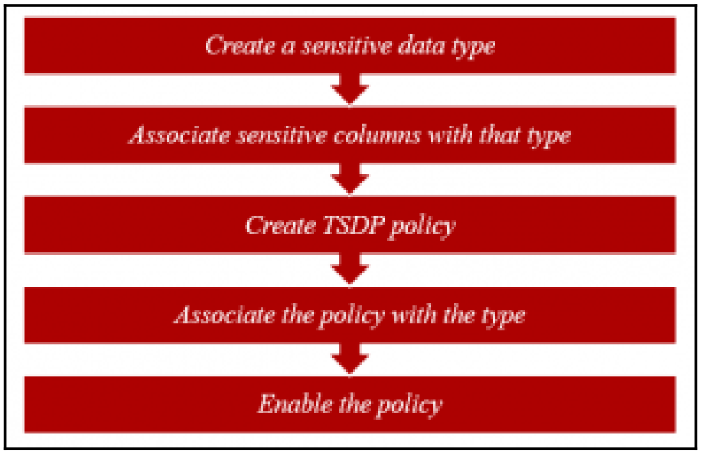

Create a sensitive data type
Associate sensitive columns with that type
Create TSDP policy
Associate the policy with the type
Enable the policy

Figure 1 – Steps to implement TSDP

For all recipes in this chapter, we assume that the database is up and running and each user has at least a create session privilege. In this chapter, it is assumed that user `c##zoran` has a DBA role and it executes privileges on the following packages:

- `DBMS_TSDP_MANAGE`
- `DBMS_TSDP_PROTECT`
- `DBMS_RLS`
- `DBMS_REDACT`

Recipes are tested on Oracle Database 12.1.0.2 in multitenant and non-CDB environment. If you use non-CDB, connect to that database instead of `pdb1` (as is done in recipes).

Creating a sensitive type

To create a sensitive type, you can use Oracle Enterprise Manager or a command-line interface. In this recipe, you'll use the command-line interface to execute a PL/SQL procedure. You decided that you want to protect e-mail addresses stored in your database, so first you are going to create sensitive type `email_type`.

Getting ready

To complete this recipe, you'll need an existing user who can create a sensitive type (for example, `c##zoran`).

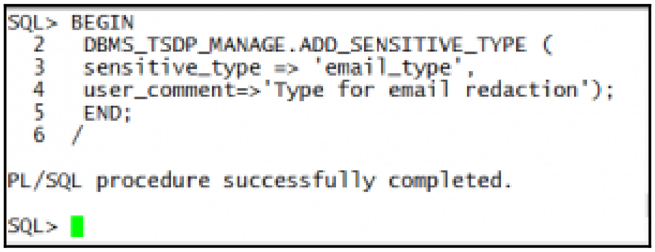
How to do it…

1. Connect to the database (for example, `pdb1`) as a user who has appropriate privileges (for example, `c##zoran`):

   ```
   $ sqlplus c##zoran@pdb1
   ```

2. Create a sensitive type (for example, `email_type`):

   ```
   SQL> BEGIN
    DBMS_TSDP_MANAGE.ADD_SENSITIVE_TYPE (
    sensitive_type => '<your_type>',
    user_comment=> '<description>');
    END;
    /
   ```



```
SQL> BEGIN
  2    DBMS_TSDP_MANAGE.ADD_SENSITIVE_TYPE (
  3    sensitive_type => 'email_type',
  4    user_comment=>'Type for email redaction');
  5    END;
  6  /

PL/SQL procedure successfully completed.

SQL>
```

Figure 2 – Creating a sensitive type

How it works…

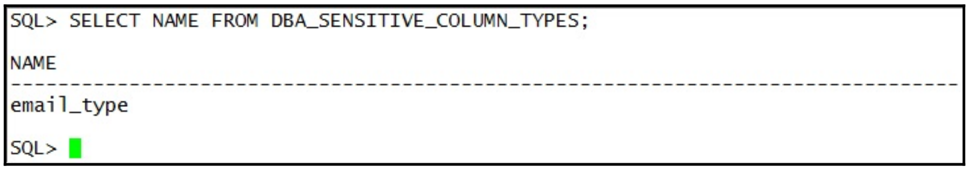
In step 2, you created a sensitive type (for example, `email_type`), which you can use to consistently mask (protect), in our case, e-mail information throughout the database. By creating a sensitive type, you only define that in the database, there exists a class of sensitive data and you name it. In later recipes in this chapter, you'll define where that sensitive data resides (in which columns) and the way that data will be protected.

The name of a sensitive type (for example, `email_type`) is case-sensitive.

There's more…

To view existing sensitive types, execute the following query:

```
select name from DBA_SENSITIVE_COLUMN_TYPES;
```



```
SQL> SELECT NAME FROM DBA_SENSITIVE_COLUMN_TYPES;

NAME
--------------------------------------------------------------------------------
email_type

SQL>
```

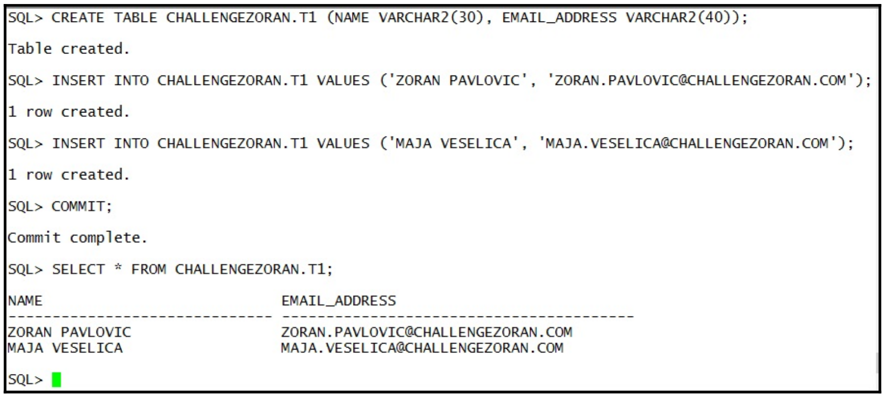
Figure 3 – Finding information about defined sensitive types

Determining sensitive columns

After you decide which data is sensitive, you'll need to find all places where that data is stored. Once you do that, you'll classify the data (associate sensitive columns with sensitive types). In this recipe, you'll associate two sensitive columns (from two tables) with sensitive type you created in the previous recipe.

Getting ready

To complete this recipe, create a user `challengezoran`, create table `T1`, and insert several values into the table (see Figure 1) or use your own table. Also, you'll need an existing user who has an execute privilege on `dbms_tsdp_manage` package (for example, `c##zoran`).



```
SQL> CREATE TABLE CHALLENGEZORAN.T1 (NAME VARCHAR2(30), EMAIL_ADDRESS VARCHAR2(40));

Table created.

SQL> INSERT INTO CHALLENGEZORAN.T1 VALUES ('ZORAN PAVLOVIC', 'ZORAN.PAVLOVIC@CHALLENGEZORAN.COM');

1 row created.

SQL> INSERT INTO CHALLENGEZORAN.T1 VALUES ('MAJA VESELICA', 'MAJA.VESELICA@CHALLENGEZORAN.COM');

1 row created.

SQL> COMMIT;

Commit complete.

SQL> SELECT * FROM CHALLENGEZORAN.T1;

NAME                           EMAIL_ADDRESS
------------------------------ ----------------------------------------
ZORAN PAVLOVIC                 ZORAN.PAVLOVIC@CHALLENGEZORAN.COM
MAJA VESELICA                  MAJA.VESELICA@CHALLENGEZORAN.COM

SQL>
```

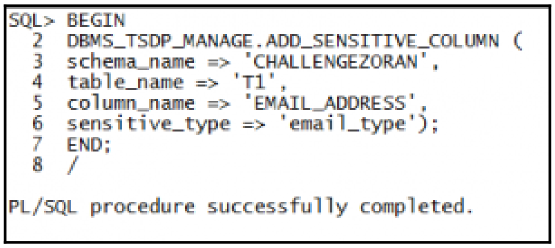
Figure 4 – Creating table T1

How to do it…

1. Connect to the database (for example, `pdb1`) as a user who has appropriate privileges (for example, `c##zoran` user):

   ```
   $ sqlplus c##zoran@pdb1
   ```

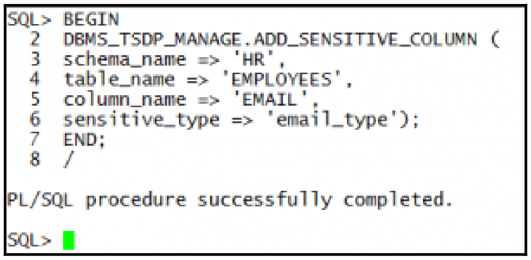
2. Associate a sensitive column (for example, schema `CHALLENGEZORAN`, table `T1`, column `EMAIL_ADDRESS`) with sensitive type you created in the previous recipe (for example, `email_type`)



```
SQL> BEGIN
  2  DBMS_TSDP_MANAGE.ADD_SENSITIVE_COLUMN (
  3  schema_name => 'CHALLENGEZORAN',
  4  table_name => 'T1',
  5  column_name => 'EMAIL_ADDRESS',
  6  sensitive_type => 'email_type');
  7  END;
  8  /

PL/SQL procedure successfully completed.
```

Figure 5 – Adding sensitive column email_address to email_type sensitive type

3. Associate another sensitive column (for example, schema `HR`, table `EMPLOYEES`, column `EMAIL`) with the same sensitive data type (for example, `email_type`).



```
SQL> BEGIN
  2  DBMS_TSDP_MANAGE.ADD_SENSITIVE_COLUMN (
  3  schema_name => 'HR',
  4  table_name => 'EMPLOYEES',
  5  column_name => 'EMAIL',
  6  sensitive_type => 'email_type');
  7  END;
  8  /

PL/SQL procedure successfully completed.

SQL>
```

Figure 6 – Adding sensitive column email to sensitive type email_type

How it works…

In step 2 and 3, you defined where sensitive data resides and associated it with previously created sensitive data type.

You can associate a column with only one sensitive type. If you try to associate it with another type, you'll receive ORA-45607.

Creating transparent sensitive data protection policy

This step defines the way you want to protect sensitive data. You can use **Data Redaction** or VPD settings for your TSDP policy. In this recipe, you'll use regular expression redaction to protect previously defined sensitive data.

Getting ready

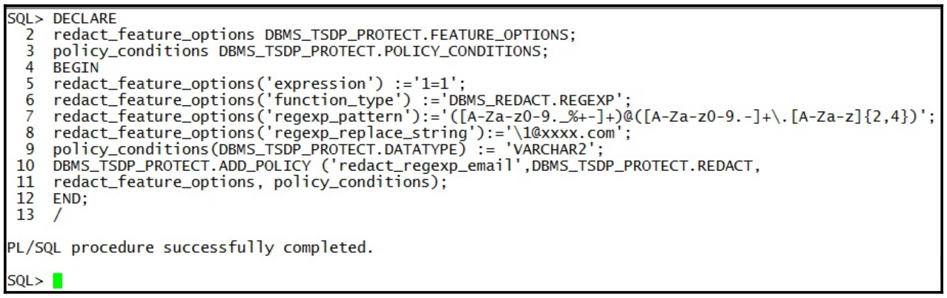
To complete this recipe, you'll need an existing user who has the execute privilege on the `dbms_tsdp_protect` package (for example, `c##zoran`).

How to do it…

1. Connect to the database (for example, `pdb1`) as a user who has appropriate privileges (for example, `c##zoran` user):

    ```
    $ sqlplus c##zoran@pdb1
    ```

2. Create TSDP policy using Data Redaction.



```
SQL> DECLARE
  2  redact_feature_options DBMS_TSDP_PROTECT.FEATURE_OPTIONS;
  3  policy_conditions DBMS_TSDP_PROTECT.POLICY_CONDITIONS;
  4  BEGIN
  5  redact_feature_options('expression') :='1=1';
  6  redact_feature_options('function_type') :='DBMS_REDACT.REGEXP';
  7  redact_feature_options('regexp_pattern'):='([A-Za-z0-9._%+-]+)@([A-Za-z0-9.-]+\.[A-Za-z]{2,4})';
  8  redact_feature_options('regexp_replace_string'):='\1@xxxx.com';
  9  policy_conditions(DBMS_TSDP_PROTECT.DATATYPE) := 'VARCHAR2';
 10  DBMS_TSDP_PROTECT.ADD_POLICY ('redact_regexp_email',DBMS_TSDP_PROTECT.REDACT,
 11  redact_feature_options, policy_conditions);
 12  END;
 13  /

PL/SQL procedure successfully completed.

SQL>
```

Figure 7 – TSDP policy using Oracle Data Redaction

How it works…

In step 2, lines 2 and 3 define variables `redact_features_options` and `policy_conditions`. Data redaction settings, for TSPD policy, are defined by using `redact_features_options` variable that holds parameter-value pairs that correspond with the parameters in `DBMS_REDACT.ADD_POLICY` procedure (lines 4-8). Line 9 specifies that data type of protected columns should be `VARCHAR2` in order for redaction settings to be applied on the column.

See also

- You can see `Chapter 5`, *Data Redaction*.

Associating transparent sensitive data protection policy with sensitive type

In this recipe, you'll associate TSDP policy and sensitive type you created in the previous recipes.

Getting ready

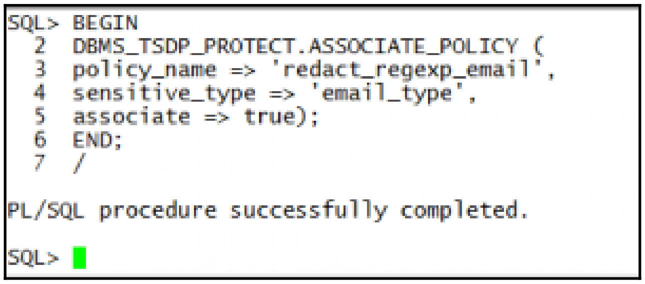
To complete this recipe, you'll need an existing user who has the execute privilege on the `dbms_tsdp_protect` package (for example, `c##zoran`).

How to do it…

1. Connect to the database as a user (for example, `pdb1`) who has appropriate privileges (for example, `c##zoran` user):

   ```
   $ sqlplus c##zoran@pdb1
   ```

2. Associate TSDP policy with sensitive type:



```
SQL> BEGIN
  2  DBMS_TSDP_PROTECT.ASSOCIATE_POLICY (
  3  policy_name => 'redact_regexp_email',
  4  sensitive_type => 'email_type',
  5  associate => true);
  6  END;
  7  /

PL/SQL procedure successfully completed.

SQL>
```

There's more…

To verify that you successfully associated the TSDP policy and the sensitive type, execute the following query:

```
SQL> SELECT POLICY_NAME, SENSITIVE_TYPE FROM DBA_TSDP_POLICY_TYPE;
```

See also

- *Creating a sensitive type*
- *Determining sensitive columns*
- *Creating transparent sensitive data protection policy*

Enabling, disabling, and dropping policy

In this recipe, you'll learn to enable, disable, and drop transparent sensitive data protection policies.

Getting ready

To complete this recipe, you'll need two existing users-one to manage TSDP policies and the other to view sensitive data.

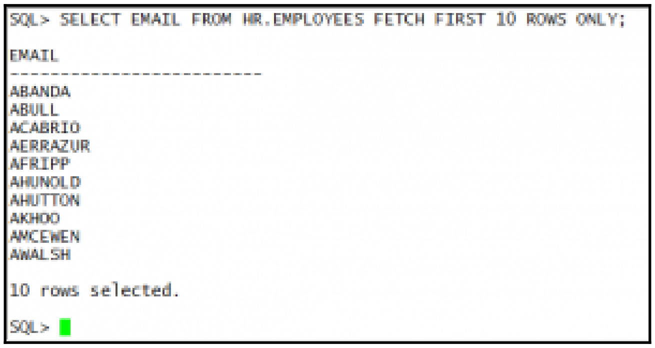
How to do it…

1. Connect to the database (for example, `pdb1`) as a user who has the `SELECT` privilege on the `HR.EMPLOYEES` table and the `CHALLENGEZORAN.T1` table or the `SELECT ANY TABLE` privilege (for example, `maja`).

   ```
   $ sqlplus maja@pdb1
   ```

2. View sensitive data by executing the following two queries:

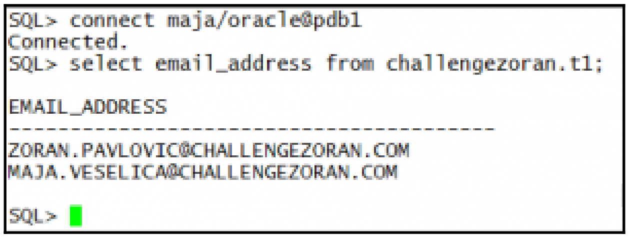
```
SELECT EMAIL FROM HR.EMPLOYEES FETCH FIRST 10 ROWS ONLY;
```



```
SQL> SELECT EMAIL FROM HR.EMPLOYEES FETCH FIRST 10 ROWS ONLY;

EMAIL
-------------------------
ABANDA
ABULL
ACABRIO
AERRAZUR
AFRIPP
AHUNOLD
AHUTTON
AKHOO
AMCEWEN
AWALSH

10 rows selected.

SQL>
```

Figure 9 – Before enabling the policy

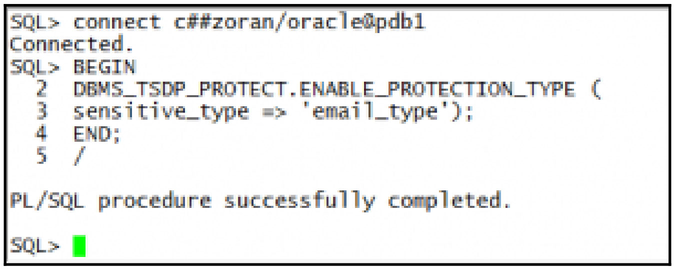
```
SELECT EMAIL_ADDRESS FROM CHALLENGEZORAN.T1;
```



```
SQL> connect maja/oracle@pdb1
Connected.
SQL> select email_address from challengezoran.t1;

EMAIL_ADDRESS
----------------------------------------
ZORAN.PAVLOVIC@CHALLENGEZORAN.COM
MAJA.VESELICA@CHALLENGEZORAN.COM

SQL>
```

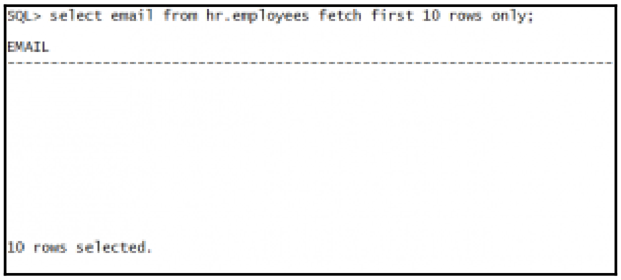
Figure 10 – Before enabling the policy

3. Connect to the database (for example, `pdb1`) as a user who can manage TSDP policies (for example, `c##zoran`). Enable the TSDP policy:



```
SQL> connect c##zoran/oracle@pdb1
Connected.
SQL> BEGIN
  2  DBMS_TSDP_PROTECT.ENABLE_PROTECTION_TYPE (
  3  sensitive_type => 'email_type');
  4  END;
  5  /

PL/SQL procedure successfully completed.

SQL>
```

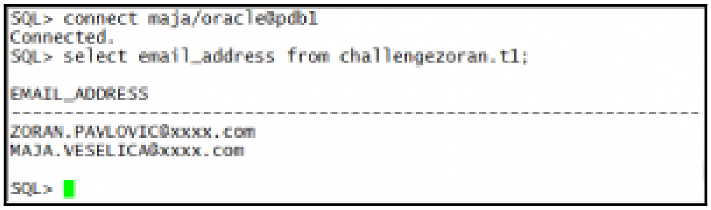
4. Repeat step 2 as user `maja`.



```
SQL> select email from hr.employees fetch first 10 rows only;

EMAIL
--------------------------------------------------------------------










10 rows selected.
```

Figure 12 – Sensitive data is protected

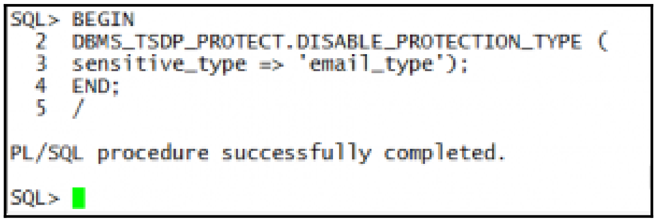
5. Result of the second query is shown in Figure 13:



```
SQL> connect maja/oracle@pdb1
Connected.
SQL> select email_address from challengezoran.t1;

EMAIL_ADDRESS
--------------------------------------------------------------------
ZORAN.PAVLOVIC@xxxx.com
MAJA.VESELICA@xxxx.com

SQL>
```

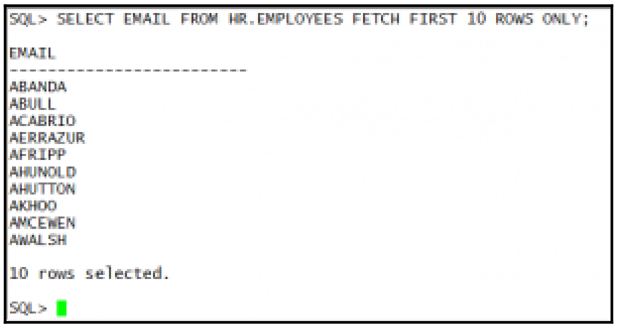
Figure 13 – After enabling the policy

6. Connect to the database (for example, `pdb1`) as a user who can manage TSDP policies (for example, `c##zoran`). Disable the TSDP policy.



```
SQL> BEGIN
  2  DBMS_TSDP_PROTECT.DISABLE_PROTECTION_TYPE (
  3  sensitive_type => 'email_type');
  4  END;
  5  /

PL/SQL procedure successfully completed.

SQL>
```

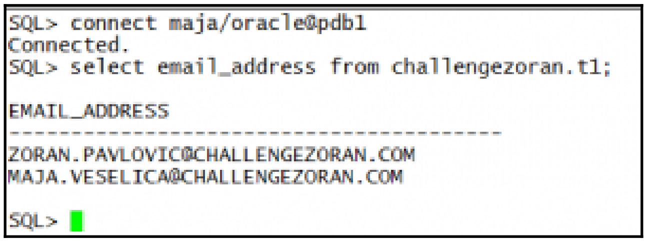
7. Repeat step 2 as user `maja`.



```
SQL> SELECT EMAIL FROM HR.EMPLOYEES FETCH FIRST 10 ROWS ONLY;

EMAIL
-------------------------
ABANDA
ABULL
ACABRIO
AERRAZUR
AFRIPP
AHUNOLD
AHUTTON
AKHOO
AMCEWEN
AWALSH

10 rows selected.

SQL>
```

Figure 15 – After the policy was disabled

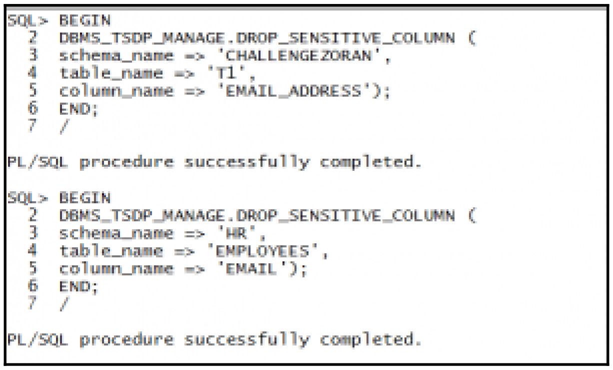
8. In Figure 16, the result of the second query is shown:



```
SQL> connect maja/oracle@pdb1
Connected.
SQL> select email_address from challengezoran.t1;

EMAIL_ADDRESS
----------------------------------------
ZORAN.PAVLOVIC@CHALLENGEZORAN.COM
MAJA.VESELICA@CHALLENGEZORAN.COM

SQL>
```

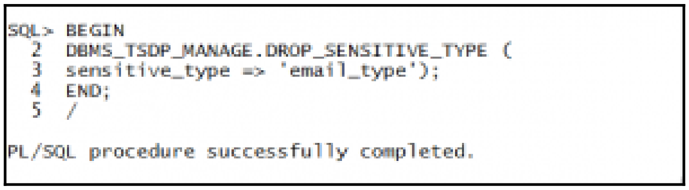
Figure 16 – After the policy was disabled

9. Connect to the database (for example, `pdb1`) as a user who can manage TSDP policies (for example, `c##zoran`). Drop both sensitive columns.



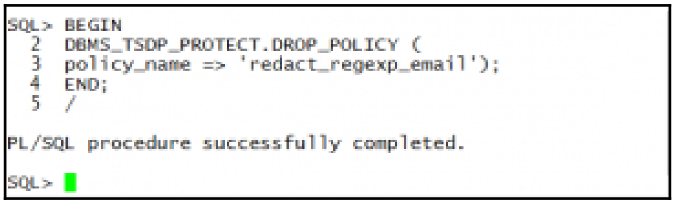
```
SQL> BEGIN
DBMS_TSDP_MANAGE.DROP_SENSITIVE_COLUMN (
schema_name => 'CHALLENGEZORAN',
table_name => 'T1',
column_name => 'EMAIL_ADDRESS');
END;
/

PL/SQL procedure successfully completed.

SQL> BEGIN
DBMS_TSDP_MANAGE.DROP_SENSITIVE_COLUMN (
schema_name => 'HR',
table_name => 'EMPLOYEES',
column_name => 'EMAIL');
END;
/

PL/SQL procedure successfully completed.
```

10. Drop the sensitive type.



```
SQL> BEGIN
DBMS_TSDP_MANAGE.DROP_SENSITIVE_TYPE (
sensitive_type => 'email_type');
END;
/

PL/SQL procedure successfully completed.
```

11. Drop the TSDP policy.



```
SQL> BEGIN
DBMS_TSDP_PROTECT.DROP_POLICY (
policy_name => 'redact_regexp_email');
END;
/

PL/SQL procedure successfully completed.

SQL>
```

How it works…

In step 4, you got correct result-column `email_address` in schema `challengezoran` was masked like specified in the policy and full redaction was applied on all values in column email in schema `HR` where data wasn't matched to the specified pattern. For more information about redaction policies, see `Chapter 5`, *Data Redaction* (the recipe *Creating redaction policy when using regular expression redaction*).

Before you drop the policy, you don't have to disable it.

There's more…

Another way to enable/disable protection is to use procedures `enable_protection_column` (`disable_protection_column`):

```
SQL> begin
 DBMS_TSDP_PROTECT.ENABLE_PROTECTION_COLUMN(
 schema_name =>'CHALLENGEZORAN',
 table_name =>'T1',
 column_name =>'EMAIL_ADDRESS',
 policy => 'redact_regexp_email');
 end;
 /
SQL> begin
 DBMS_TSDP_PROTECT.ENABLE_PROTECTION_COLUMN(
 schema_name =>'HR',
 table_name =>'EMPLOYEES',
 column_name =>'EMAIL',
 policy => 'redact_regexp_email');
 end;
 /
SQL> begin
 DBMS_TSDP_PROTECT.DISABLE_PROTECTION_COLUMN(
 schema_name =>'CHALLENGEZORAN',
 table_name =>'T1',
 column_name =>'EMAIL_ADDRESS',
 policy => 'redact_regexp_email');
 end;
 /
SQL> begin
 DBMS_TSDP_PROTECT.DISABLE_PROTECTION_COLUMN(
 schema_name =>'HR',
 table_name =>'EMPLOYEES',
 column_name =>'EMAIL',
 policy => 'redact_regexp_email');
```

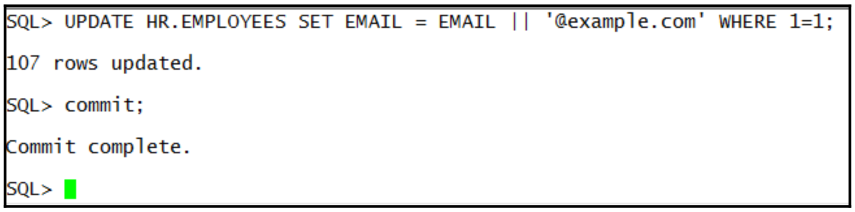
```
        end;
        /
```

Altering transparent sensitive data protection policy

In this recipe, you'll alter policy you created in recipe *Creating transparent sensitive data protection polic*y and enable it.

Getting ready

To complete this recipe, you'll need two existing users (for example, `c##zoran` and `maja`). Also, update the table `hr.employees`, as shown in Figure 20:



```
SQL> UPDATE HR.EMPLOYEES SET EMAIL = EMAIL || '@example.com' WHERE 1=1;

107 rows updated.

SQL> commit;

Commit complete.

SQL>
```

Figure 20 – Set new e-mail addresses in the hr.employees table

How to do it…

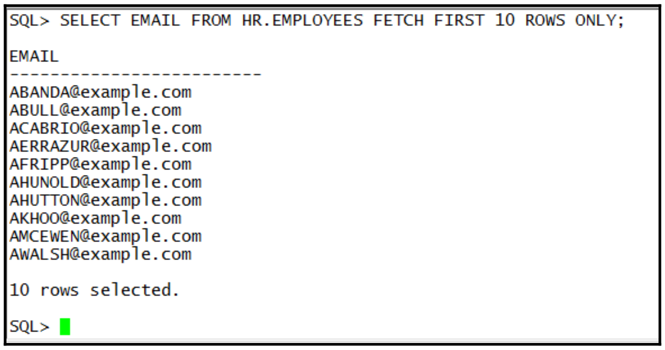
1. Connect to the database (for example, `pdb1`) as a user who can manage TSDP policies (for example, `c##zoran`):

   ```
   $ sqlplus c##zoran@pdb1
   ```

2. If the policy is enabled, disable it for all columns (for instructions how to disable the TSDP policy, see recipe *Enabling, disabling, and dropping policy*).

3. Connect to the database (for example, `pdb1`) as a user who can view sensitive data (for example, `maja)`. Execute the following queries:

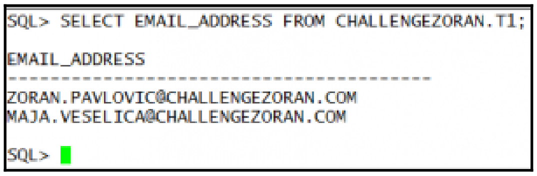
```
SELECT EMAIL FROM HR.EMPLOYEES FETCH FIRST 10 ROWS ONLY;
```



```
SQL> SELECT EMAIL FROM HR.EMPLOYEES FETCH FIRST 10 ROWS ONLY;

EMAIL
-------------------------
ABANDA@example.com
ABULL@example.com
ACABRIO@example.com
AERRAZUR@example.com
AFRIPP@example.com
AHUNOLD@example.com
AHUTTON@example.com
AKHOO@example.com
AMCEWEN@example.com
AWALSH@example.com

10 rows selected.

SQL>
```

Figure 21 – Before altering and enabling the policy

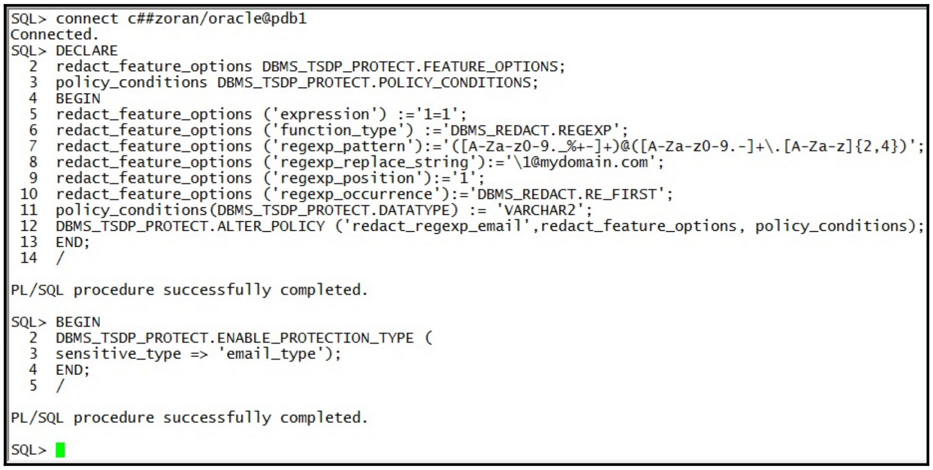
```
SELECT EMAIL_ADDRESS FROM CHALLENGEZORAN.T1;
```



```
SQL> SELECT EMAIL_ADDRESS FROM CHALLENGEZORAN.T1;

EMAIL_ADDRESS
----------------------------------------
ZORAN.PAVLOVIC@CHALLENGEZORAN.COM
MAJA.VESELICA@CHALLENGEZORAN.COM

SQL>
```

Figure 22 – Before altering and enabling the policy

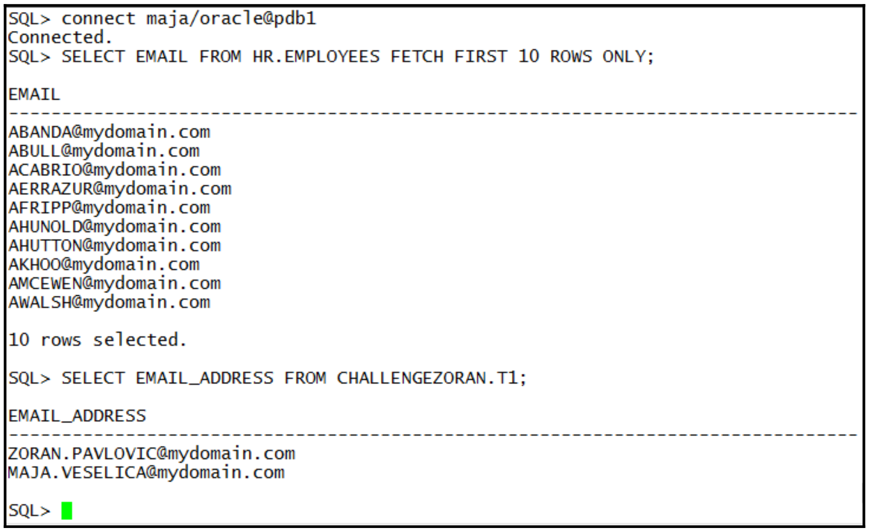
4. Connect to the database (for example, `pdb1`) as a user who can manage TSDP policies (for example, `c##zoran`). Alter the TSDP policy and enable it.



```
SQL> connect c##zoran/oracle@pdb1
Connected.
SQL> DECLARE
redact_feature_options DBMS_TSDP_PROTECT.FEATURE_OPTIONS;
policy_conditions DBMS_TSDP_PROTECT.POLICY_CONDITIONS;
BEGIN
redact_feature_options ('expression') :='1=1';
redact_feature_options ('function_type') :='DBMS_REDACT.REGEXP';
redact_feature_options ('regexp_pattern'):='([A-Za-z0-9._%+-]+)@([A-Za-z0-9.-]+\.[A-Za-z]{2,4})';
redact_feature_options ('regexp_replace_string'):='\1@mydomain.com';
redact_feature_options ('regexp_position'):='1';
redact_feature_options ('regexp_occurrence'):='DBMS_REDACT.RE_FIRST';
policy_conditions(DBMS_TSDP_PROTECT.DATATYPE) := 'VARCHAR2';
DBMS_TSDP_PROTECT.ALTER_POLICY ('redact_regexp_email',redact_feature_options, policy_conditions);
END;
/

PL/SQL procedure successfully completed.

SQL> BEGIN
DBMS_TSDP_PROTECT.ENABLE_PROTECTION_TYPE (
sensitive_type => 'email_type');
END;
/

PL/SQL procedure successfully completed.

SQL>
```

Figure 23 – Alter the TSDP policy

5. View sensitive data as the user `maja` (repeat step 3).



```
SQL> connect maja/oracle@pdb1
Connected.
SQL> SELECT EMAIL FROM HR.EMPLOYEES FETCH FIRST 10 ROWS ONLY;

EMAIL
--------------------------------------------------------------------------------
ABANDA@mydomain.com
ABULL@mydomain.com
ACABRIO@mydomain.com
AERRAZUR@mydomain.com
AFRIPP@mydomain.com
AHUNOLD@mydomain.com
AHUTTON@mydomain.com
AKHOO@mydomain.com
AMCEWEN@mydomain.com
AWALSH@mydomain.com

10 rows selected.

SQL> SELECT EMAIL_ADDRESS FROM CHALLENGEZORAN.T1;

EMAIL_ADDRESS
--------------------------------------------------------------------------------
ZORAN.PAVLOVIC@mydomain.com
MAJA.VESELICA@mydomain.com

SQL>
```

Figure 24 – After altering TSDP policy

How it works…

After you alter the policy, you have to manually enable it (it isn't automatically enabled).

See also

- *Creating transparent sensitive data protection policy*, from this chapter

7
Privilege Analysis

In this chapter, we will cover the following tasks:

- Creating a database analysis policy
- Creating a role analysis policy
- Creating a context analysis policy
- Creating a combined analysis policy
- Starting and stopping privilege analysis
- Reporting on used system privileges
- Reporting on used object privileges
- Reporting on unused system privileges
- Reporting on unused object privileges
- How to revoke unused privileges
- Dropping the analysis

Introduction

Privilege analysis is a new security feature, introduced in Oracle Database 12c. It is only available in Oracle Database Enterprise Edition, and from licensing viewpoint, it is part of Oracle Database Vault option.

Privilege analysis is very useful to implement and maintain the least privilege principle by identifying both privileges that users are actually using (used privileges) and those that are only granted to them (unused privileges).

General steps to analyze privileges using this feature are shown in Figure 1.

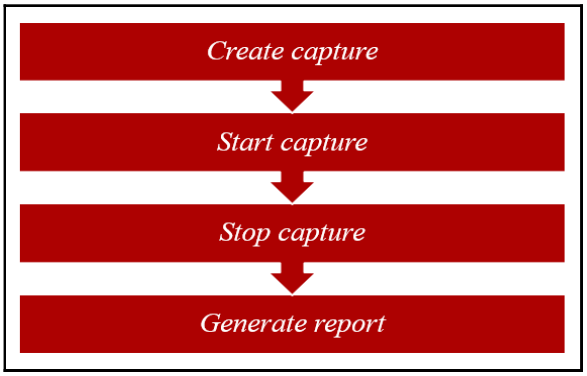


Figure 1 – The steps to analyzethe used and unused privileges

In this chapter, it is assumed that all users have a `create session` privilege, and in the following table, other privileges and roles granted to the users and roles are listed:

USER/ROLE	**HR.EMPLOYEES**	**OE.ORDERS**	**ROLES/SYS.PRIVS.**
`BARBARA`			`P1_ROLE`
`NICK`			`DBA`
`ALAN`	`SELECT, INSERT, UPDATE, DELETE`		
`STEVE`			`P2_ROLE`
`P1_ROLE`	`SELECT`		
`P2_ROLE`		`SELECT, INSERT, UPDATE, DELETE`	`SELECT ANY TABLE, CREATE TABLE`

Depending on your needs, you can create and use four different types of privilege analysis policies that differ in the scope of the analysis. This scope can be:

- An entire database
- Role-based
- Context-based
- Role- and context-based

Creating database analysis policy

In this recipe, you'll learn to create **database privilege analysis policy**. It analyzes privileges in the whole database (except privileges used by `SYS` user). You can use SQL*Plus and Enterprise Manager Cloud Control 12.1.0.3+ (in our case, EM12cR4) to create privilege analysis policies.

Getting ready

You'll need an existing user who can create a privilege analysis policy (has `CAPTURE_ADMIN` role and `SELECT ANY DICTIONARY` privilege), for example, `SYSTEM` user.

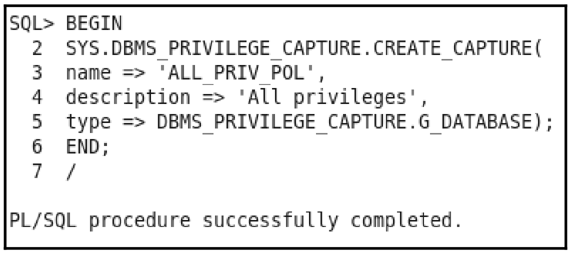
How to do it…

1. Connect to the database as system or a user who has appropriate privilege:

   ```
   $ sqlplus system
   ```

2. Create a privilege analysis policy that captures all the used privileges in the database:

   ```
   SQL> BEGIN
       SYS.DBMS_PRIVILEGE_CAPTURE.CREATE_CAPTURE(
       name => '<policy_name>',
       description => '<your_desc>',
       type => DBMS_PRIVILEGE_CAPTURE.G_DATABASE);
       END;
       /
   ```



```
SQL> BEGIN
  2  SYS.DBMS_PRIVILEGE_CAPTURE.CREATE_CAPTURE(
  3  name => 'ALL_PRIV_POL',
  4  description => 'All privileges',
  5  type => DBMS_PRIVILEGE_CAPTURE.G_DATABASE);
  6  END;
  7  /

PL/SQL procedure successfully completed.
```

Figure 2 – Database (unconditional) analysis policy

How it works…

In step 2, you created database-wide policy that will capture privileges, which are used (and which are granted, but are unused) by users (except the `SYS` user). However, to start gathering data about privilege usage, you have to enable the policy (see recipe *Starting and stopping privilege analysis*).

There's more…

Another way to create the same policy is to use Enterprise Manager Cloud Control 12c (EM).

1. Login to EM as a user who has appropriate privileges and select **Privilege Analysis** from **Security** drop-down menu (see Figure 3):

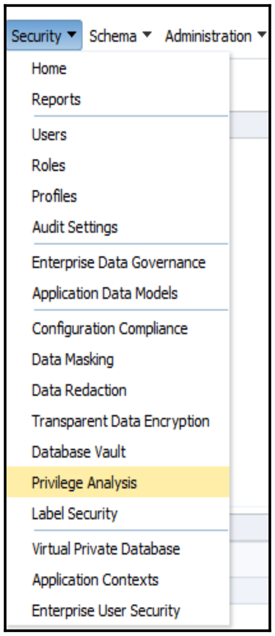
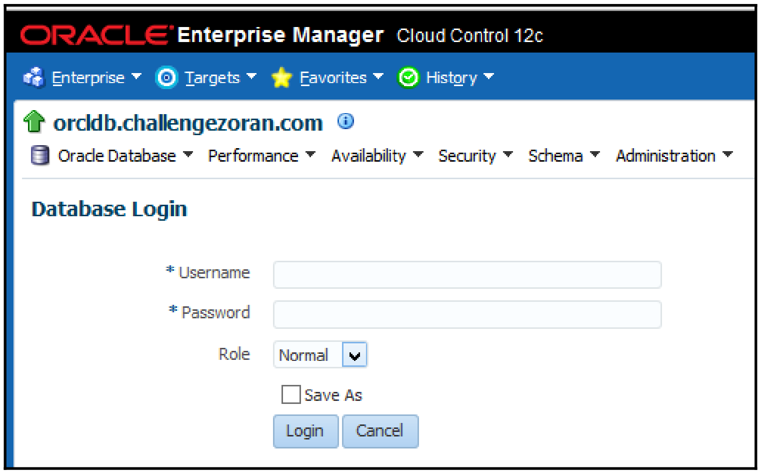


Figure 3 – The choose privilege analysis

2. Log in to the database as `SYSTEM` user or a user who has appropriate privileges (`CAPTURE_ADMIN` role and `SELECT ANY DICTIONARY` privilege).

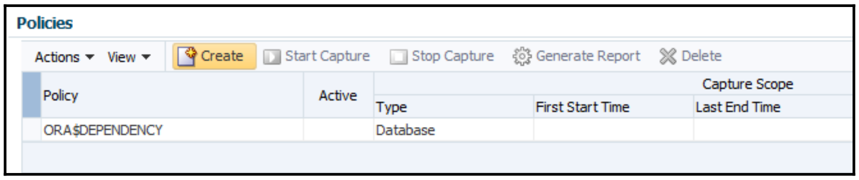


Database Login

* Username	
* Password	
Role	Normal
	☐ Save As

Figure 4 – The login screen

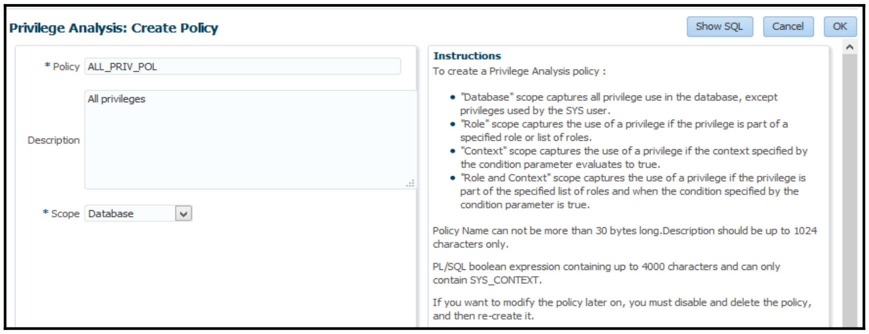
3. Click on the **Create** button in the **Policy** section (see Figure 5):



Policy	Active	Capture Scope		
		Type	First Start Time	Last End Time
ORA$DEPENDENCY		Database		

Figure 5 – Start the process of creating a privilege analysis policy

4. To create a database policy, choose that scope is **Database**, name the policy, and optionally write a description (see Figure 6). Click on the **OK** button:



Privilege Analysis: Create Policy

* Policy: ALL_PRIV_POL

Description: All privileges

* Scope: Database

Instructions

To create a Privilege Analysis policy :

- "Database" scope captures all privilege use in the database, except privileges used by the SYS user.
- "Role" scope captures the use of a privilege if the privilege is part of a specified role or list of roles.
- "Context" scope captures the use of a privilege if the context specified by the condition parameter evaluates to true.
- "Role and Context" scope captures the use of a privilege if the privilege is part of the specified list of roles and when the condition specified by the condition parameter is true.

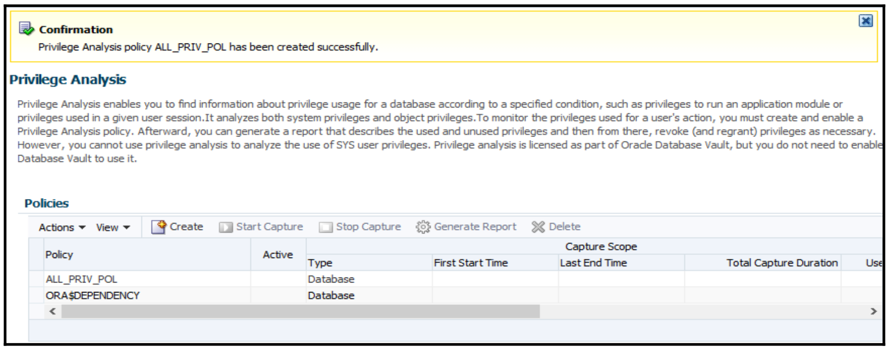
Policy Name can not be more than 30 bytes long.Description should be up to 1024 characters only.

PL/SQL boolean expression containing up to 4000 characters and can only contain SYS_CONTEXT.

If you want to modify the policy later on, you must disable and delete the policy, and then re-create it.

Figure 6 – The create policy

5. You should receive a confirmation message and see your newly created policy listed in the table (see Figure 7):



Confirmation

Privilege Analysis policy ALL_PRIV_POL has been created successfully.

Privilege Analysis

Privilege Analysis enables you to find information about privilege usage for a database according to a specified condition, such as privileges to run an application module or privileges used in a given user session.It analyzes both system privileges and object privileges.To monitor the privileges used for a user's action, you must create and enable a Privilege Analysis policy. Afterward, you can generate a report that describes the used and unused privileges and then from there, revoke (and regrant) privileges as necessary. However, you cannot use privilege analysis to analyze the use of SYS user privileges. Privilege analysis is licensed as part of Oracle Database Vault, but you do not need to enable Database Vault to use it.

Policies

Policy	Active	Capture Scope				
		Type	First Start Time	Last End Time	Total Capture Duration	Use
ALL_PRIV_POL		Database				
ORA$DEPENDENCY		Database				

Figure 7 – A successful message

See also

- You can see the *Starting and stopping privilege analysis* recipe.

Creating role analysis policy

In this recipe, you'll create a **role analysis policy** using SQL*Plus and Enterprise Manager Cloud Control 12c (EM). The usage of directly and indirectly granted privileges to the roles listed in the policy, will be captured if the roles are active for the session.

Getting ready

You'll need an existing user who can create a privilege analysis policy (has a `CAPTURE_ADMIN` role and a `SELECT ANY DICTIONARY` privilege), for example, `SYSTEM` user.

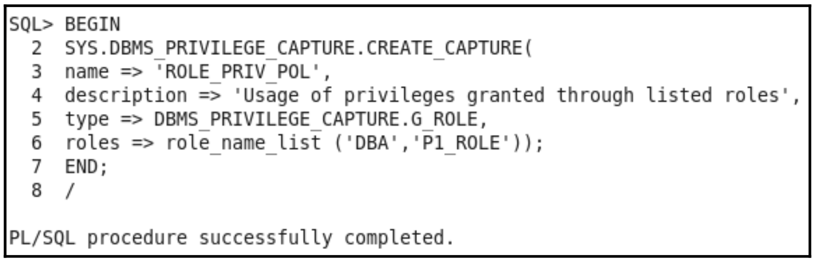
How to do it…

1. Connect to the database as system or a user who has appropriate privileges:

   ```
   $ sqlplus system
   ```

2. Create a privilege analysis policy that captures all the used privileges granted through roles `DBA` and `P1_ROLE`:

   ```
   SQL> BEGIN
        SYS.DBMS_PRIVILEGE_CAPTURE.CREATE_CAPTURE(
        name => '<policy_name>',
        description => '<your_desc>',
        type => DBMS_PRIVILEGE_CAPTURE.G_ROLE,
        roles => role_name_list (<'role1',...,'role10'>));
        END;
        /
   ```

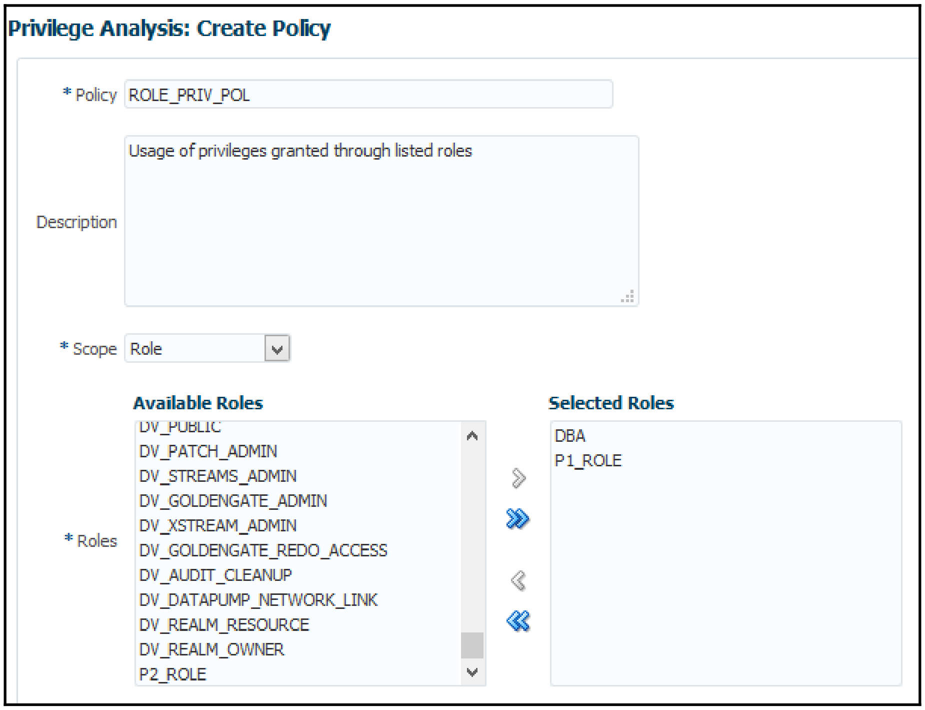


```
SQL> BEGIN
  2  SYS.DBMS_PRIVILEGE_CAPTURE.CREATE_CAPTURE(
  3  name => 'ROLE_PRIV_POL',
  4  description => 'Usage of privileges granted through listed roles',
  5  type => DBMS_PRIVILEGE_CAPTURE.G_ROLE,
  6  roles => role_name_list ('DBA','P1_ROLE'));
  7  END;
  8  /

PL/SQL procedure successfully completed.
```

Figure 8 – The role analysis policy

There's more…

Another way to create a role privilege analysis policy is to use EM12c. Repeat steps 1, 2, and 3 from the *There's more…* section in the previous recipe. Name the policy, select roles, optionally write a description, and click on OK button (see Figure 9):



Privilege Analysis: Create Policy

* Policy: ROLE_PRIV_POL

Description: Usage of privileges granted through listed roles

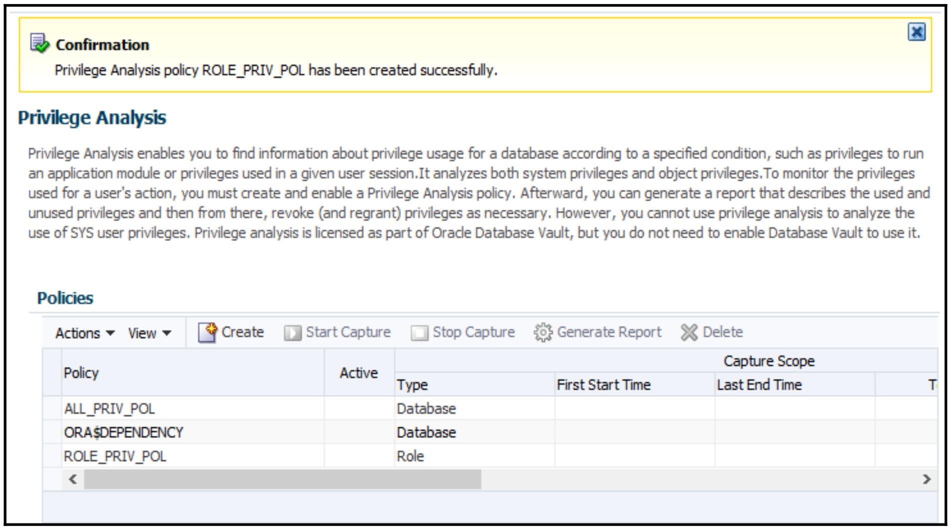
* Scope: Role

* Roles

Available Roles	Selected Roles
DV_PUBLIC	DBA
DV_PATCH_ADMIN	P1_ROLE
DV_STREAMS_ADMIN	
DV_GOLDENGATE_ADMIN	
DV_XSTREAM_ADMIN	
DV_GOLDENGATE_REDO_ACCESS	
DV_AUDIT_CLEANUP	
DV_DATAPUMP_NETWORK_LINK	
DV_REALM_RESOURCE	
DV_REALM_OWNER	
P2_ROLE	

Figure 9 – Creating a role policy

You should receive a confirmation message and see your newly created policy listed in the table (see Figure 10):



Confirmation
Privilege Analysis policy ROLE_PRIV_POL has been created successfully.

Privilege Analysis

Privilege Analysis enables you to find information about privilege usage for a database according to a specified condition, such as privileges to run an application module or privileges used in a given user session.It analyzes both system privileges and object privileges.To monitor the privileges used for a user's action, you must create and enable a Privilege Analysis policy. Afterward, you can generate a report that describes the used and unused privileges and then from there, revoke (and regrant) privileges as necessary. However, you cannot use privilege analysis to analyze the use of SYS user privileges. Privilege analysis is licensed as part of Oracle Database Vault, but you do not need to enable Database Vault to use it.

Policies

Policy	Active	Capture Scope			
		Type	First Start Time	Last End Time	T
ALL_PRIV_POL		Database			
ORA$DEPENDENCY		Database			
ROLE_PRIV_POL		Role			

Figure 10 – The successful creation of the policy

See also

- You can refer to the *Starting and stopping privilege analysis* recipe.

Creating context analysis policy

In this recipe, you'll create a **context analysis policy**. After the policy is enabled, it will capture privileges when the condition specified in the policy evaluates to `true`.

Getting ready

You'll need an existing user who can create a privilege analysis policy (has the `CAPTURE_ADMIN` role and the `SELECT ANY DICTIONARY` privilege), for example, the `SYSTEM` user.

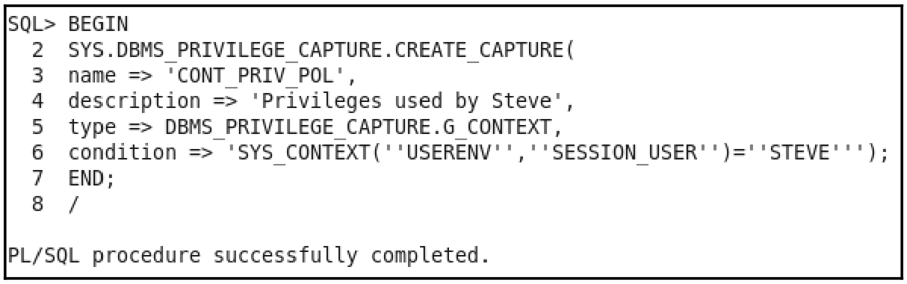
How to do it…

1. Connect to the database as system or a user who has appropriate privileges:

   ```
   $ sqlplus system
   ```

2. Create a privilege analysis policy that captures all the used (and unused) privileges by `Steve`:

   ```
   SQL> BEGIN
        SYS.DBMS_PRIVILEGE_CAPTURE.CREATE_CAPTURE(
        name => '<policy_name>',
        description => '<your_desc>',
        type => DBMS_PRIVILEGE_CAPTURE.G_CONTEXT,
        condition => '<your_condition>');
        END;
       /
   ```

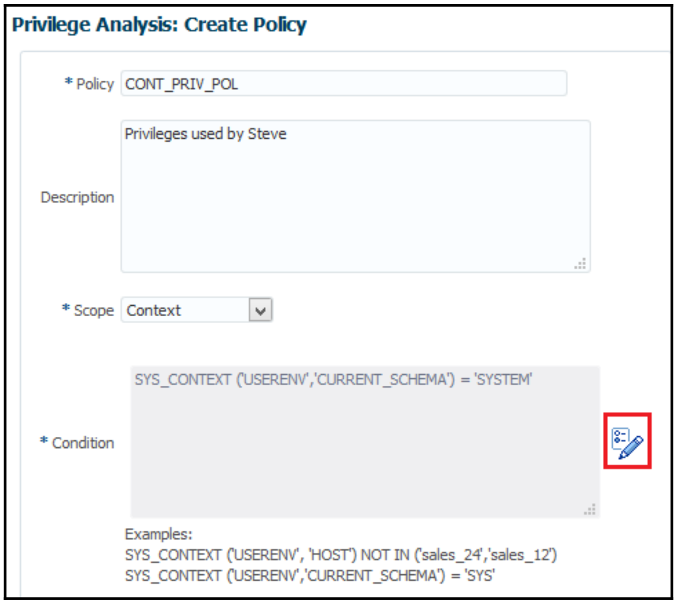


```
SQL> BEGIN
  2  SYS.DBMS_PRIVILEGE_CAPTURE.CREATE_CAPTURE(
  3  name => 'CONT_PRIV_POL',
  4  description => 'Privileges used by Steve',
  5  type => DBMS_PRIVILEGE_CAPTURE.G_CONTEXT,
  6  condition => 'SYS_CONTEXT(''USERENV'',''SESSION_USER'')=''STEVE''');
  7  END;
  8  /

PL/SQL procedure successfully completed.
```

Figure 11 – The context analysis policy

There's more…

Another way to create a context privilege analysis policy is to use EM12c. Repeat steps 1, 2, and 3 from the *There's more…* section in the *Creating database analysis policy* recipe. Name the policy and optionally write a description (see Figure 12):



* Policy: CONT_PRIV_POL

Description: Privileges used by Steve

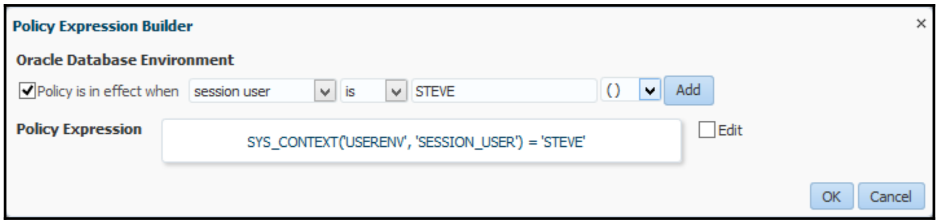
* Scope: Context

* Condition: SYS_CONTEXT ('USERENV','CURRENT_SCHEMA') = 'SYSTEM'

Examples:
SYS_CONTEXT ('USERENV', 'HOST') NOT IN ('sales_24','sales_12')
SYS_CONTEXT ('USERENV','CURRENT_SCHEMA') = 'SYS'

Figure 12 – The create context policy

Click on the **Build Context Expression** button (a pencil icon; see Figure 13). You can enter expression manually (select **Edit** checkbox) or use the built-in help (select the checkbox **Policy is in effect when** select appropriate options from drop-down menus, click on the **Add** button). Click on the **OK** button.



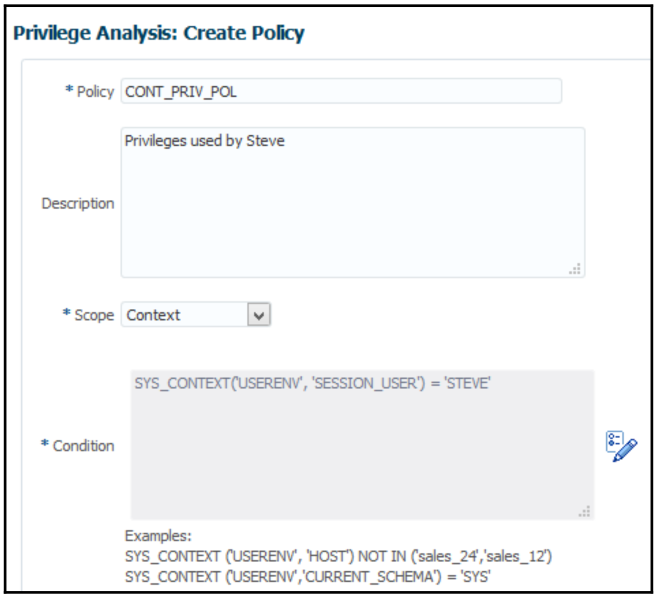
[✓] Policy is in effect when: session user | is | STEVE | ()

Policy Expression: SYS_CONTEXT('USERENV', 'SESSION_USER') = 'STEVE'

[ ] Edit

Figure 13 – The Expression Builder

Make sure that you chose options you wanted (see Figure 14) and then click on the **OK** button:



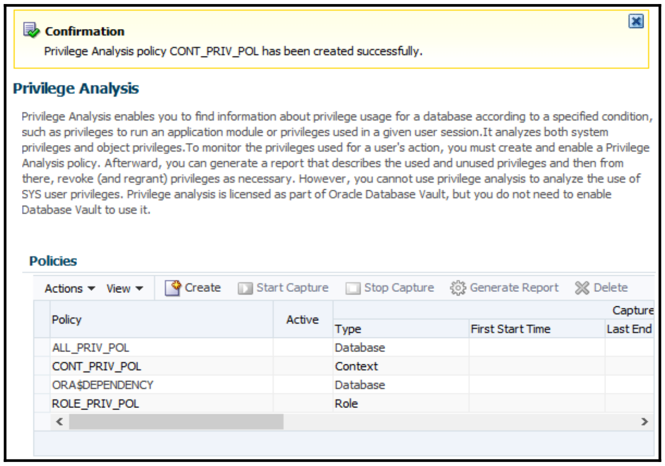
Privilege Analysis: Create Policy

* Policy	CONT_PRIV_POL
Description	Privileges used by Steve
* Scope	Context
* Condition	SYS_CONTEXT('USERENV', 'SESSION_USER') = 'STEVE'

Examples:
SYS_CONTEXT ('USERENV', 'HOST') NOT IN ('sales_24','sales_12')
SYS_CONTEXT ('USERENV','CURRENT_SCHEMA') = 'SYS'

Figure 14 – Checking the filled-out context policy

You should receive a confirmation message and see your newly created policy listed in the table (see Figure 15):


Confirmation
Privilege Analysis policy CONT_PRIV_POL has been created successfully.

Privilege Analysis

Privilege Analysis enables you to find information about privilege usage for a database according to a specified condition, such as privileges to run an application module or privileges used in a given user session.It analyzes both system privileges and object privileges.To monitor the privileges used for a user's action, you must create and enable a Privilege Analysis policy. Afterward, you can generate a report that describes the used and unused privileges and then from there, revoke (and regrant) privileges as necessary. However, you cannot use privilege analysis to analyze the use of SYS user privileges. Privilege analysis is licensed as part of Oracle Database Vault, but you do not need to enable Database Vault to use it.

Policies

Policy	Active	Type	First Start Time	Capture Last End
ALL_PRIV_POL		Database		
CONT_PRIV_POL		Context		
ORA$DEPENDENCY		Database		
ROLE_PRIV_POL		Role		

Figure 15 – The context policy has been successfully created

See also

- You can refer to the *Starting and stopping privilege analysis* recipe. For more information about application contexts, see `Chapter 12`, *Appendix – Application Contexts*.

Creating combined analysis policy

In this recipe, you'll create a combined analysis policy. This type of policy defines that the usage of directly and indirectly granted privilege to specified roles will be gathered if roles are enabled in the session and the context condition is satisfied. The context condition can consist of one or more conditions (you can use the `AND` or `OR` Boolean operators).

Getting ready

You'll need an existing user who can create a privilege analysis policy (has the `CAPTURE_ADMIN` role and the `SELECT ANY DICTIONARY` privilege), for example, the `SYSTEM` user.

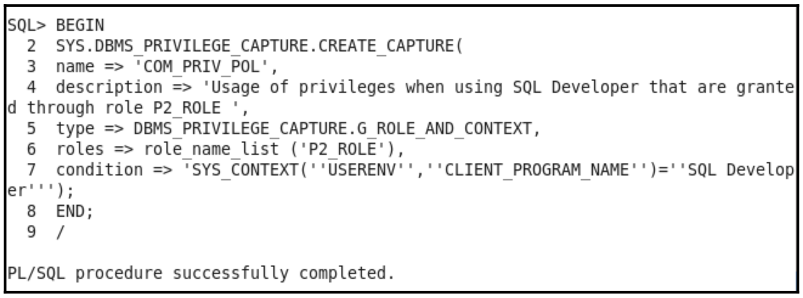
How to do it…

1. Connect to the database as system or a user who has appropriate privileges:

   ```
   $ sqlplus system
   ```

2. Create a privilege analysis policy that captures the usage of privileges, when using SQL Developer, which are granted through the role `P2_ROLE`:

   ```
   SQL> BEGIN
        SYS.DBMS_PRIVILEGE_CAPTURE.CREATE_CAPTURE(
        name => '<policy_name>',
        description => '<your_desc>',
        type => DBMS_PRIVILEGE_CAPTURE.G_ROLE_AND_CONTEXT,
        roles => role_name_list (<'role1',...,'role10'>),
        condition => '<your_condition>');
        END;
        /
   ```

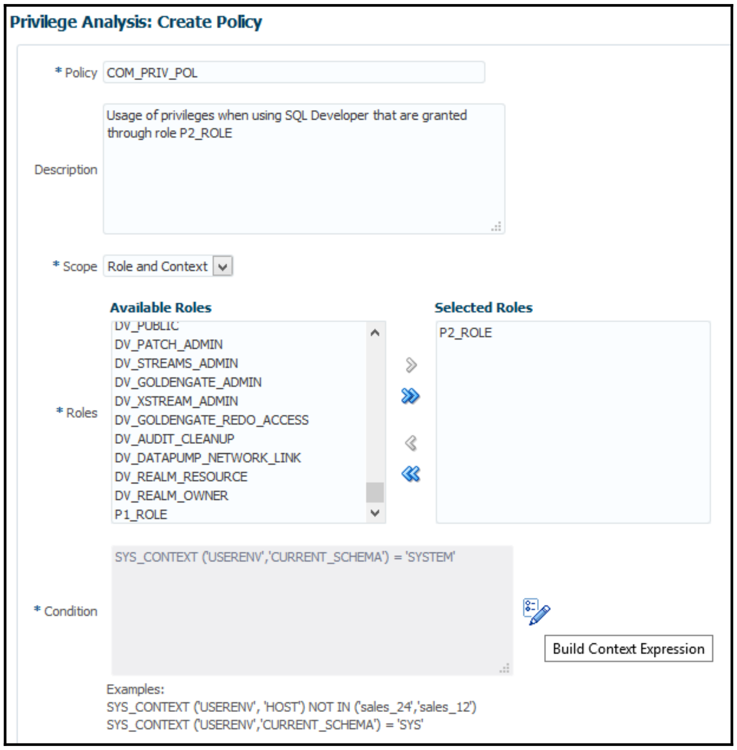


```
SQL> BEGIN
     SYS.DBMS_PRIVILEGE_CAPTURE.CREATE_CAPTURE(
     name => 'COM_PRIV_POL',
     description => 'Usage of privileges when using SQL Developer that are grante
d through role P2_ROLE ',
     type => DBMS_PRIVILEGE_CAPTURE.G_ROLE_AND_CONTEXT,
     roles => role_name_list ('P2_ROLE'),
     condition => 'SYS_CONTEXT(''USERENV'',''CLIENT_PROGRAM_NAME'')=''SQL Develop
er''');
     END;
     /

PL/SQL procedure successfully completed.
```

Figure 16 – The combined analysis policy

There's more…

Another way to create a context privilege analysis policy is to use EM12c. Repeat steps 1, 2, and 3 from the *There's more…* section in the recipe *Creating database analysis policy*. Name the policy, select roles, and optionally write a description. Click on **Build Context Expression** (see Figure 17).


Privilege Analysis: Create Policy

* Policy	COM_PRIV_POL
Description	Usage of privileges when using SQL Developer that are granted through role P2_ROLE
* Scope	Role and Context

Available Roles	Selected Roles
DV_PUBLIC	P2_ROLE
DV_PATCH_ADMIN	
DV_STREAMS_ADMIN	
DV_GOLDENGATE_ADMIN	
DV_XSTREAM_ADMIN	
DV_GOLDENGATE_REDO_ACCESS	
DV_AUDIT_CLEANUP	
DV_DATAPUMP_NETWORK_LINK	
DV_REALM_RESOURCE	
DV_REALM_OWNER	
P1_ROLE	

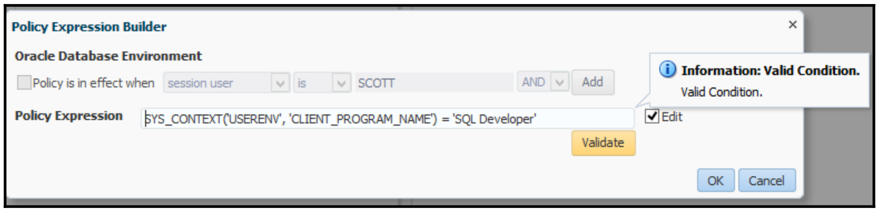
* Condition: SYS_CONTEXT ('USERENV','CURRENT_SCHEMA') = 'SYSTEM'

Build Context Expression

Examples:
SYS_CONTEXT ('USERENV', 'HOST') NOT IN ('sales_24','sales_12')
SYS_CONTEXT ('USERENV','CURRENT_SCHEMA') = 'SYS'

Figure 17 – Creating the combined policy

Manually write the policy expression. Click on the **Validate** button and then on the **OK** button (see Figure 18):


Policy Expression Builder

Oracle Database Environment

Policy is in effect when session user is SCOTT AND Add

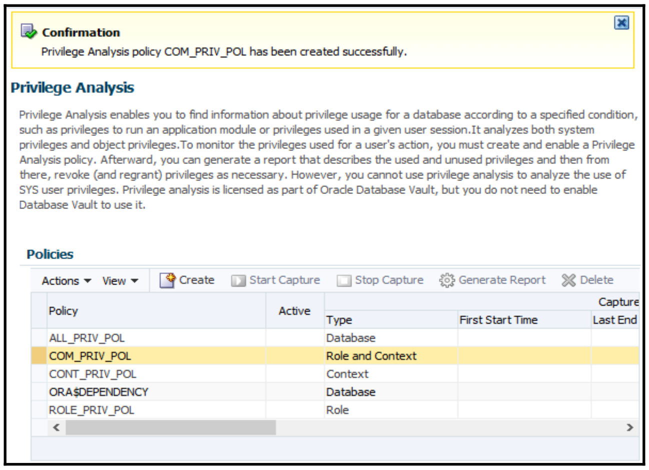
Policy Expression: SYS_CONTEXT('USERENV', 'CLIENT_PROGRAM_NAME') = 'SQL Developer'

Edit ✓

Information: Valid Condition.
Valid Condition.

Figure 18 – Manually write expression in the Policy Expression Builder

You should receive a confirmation message and see your newly created policy listed in the table (see Figure 19).



Confirmation
Privilege Analysis policy COM_PRIV_POL has been created successfully.

Privilege Analysis

Privilege Analysis enables you to find information about privilege usage for a database according to a specified condition, such as privileges to run an application module or privileges used in a given user session.It analyzes both system privileges and object privileges.To monitor the privileges used for a user's action, you must create and enable a Privilege Analysis policy. Afterward, you can generate a report that describes the used and unused privileges and then from there, revoke (and regrant) privileges as necessary. However, you cannot use privilege analysis to analyze the use of SYS user privileges. Privilege analysis is licensed as part of Oracle Database Vault, but you do not need to enable Database Vault to use it.

Policies

Policy	Active	Type	First Start Time	Capture Last End
ALL_PRIV_POL		Database		
COM_PRIV_POL		Role and Context		
CONT_PRIV_POL		Context		
ORA$DEPENDENCY		Database		
ROLE_PRIV_POL		Role		

Figure 19 – The successful message

See also

- You can refer to the *Starting and stopping privilege analysis* recipe. For more information about application contexts, see `Chapter 12`, *Appendix – Application Contexts*.

Starting and stopping privilege analysis

To start capturing privileges, you'll enable privilege analysis policies you created in the previous recipes.

Getting ready

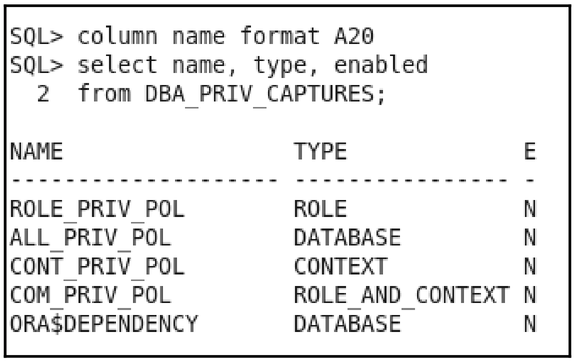
You'll need an existing user who can manage privilege analysis policies (has the `CAPTURE_ADMIN` role and the `SELECT ANY DICTIONARY` privilege), for example, the `SYSTEM` user.

How to do it…

1. Connect to the database as system or a user who has appropriate privileges:

```
$ sqlplus system
```

2. List all existing privilege analysis policies by querying `DBA_PRIV_CAPTURES`.

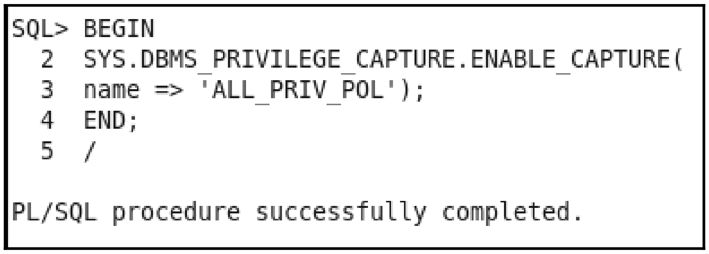


```
SQL> column name format A20
SQL> select name, type, enabled
  2  from DBA_PRIV_CAPTURES;

NAME                 TYPE             E
-------------------- ---------------- -
ROLE_PRIV_POL        ROLE             N
ALL_PRIV_POL         DATABASE         N
CONT_PRIV_POL        CONTEXT          N
COM_PRIV_POL         ROLE_AND_CONTEXT N
ORA$DEPENDENCY       DATABASE         N
```

Figure 20 – Finding all defined policies

3. Enable a privilege analysis (for example, `ALL_PRIV_POL`, which you created in the first recipe in this chapter):

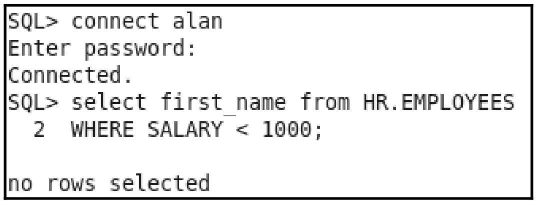
```
SQL> BEGIN
    SYS.DBMS_PRIVILEGE_CAPTURE.ENABLE_CAPTURE(
    name => '<policy_name>');
    END;
    /
```



```
SQL> BEGIN
  2  SYS.DBMS_PRIVILEGE_CAPTURE.ENABLE_CAPTURE(
  3  name => 'ALL_PRIV_POL');
  4  END;
  5  /

PL/SQL procedure successfully completed.
```

Figure 21 – Start capturing all privileges

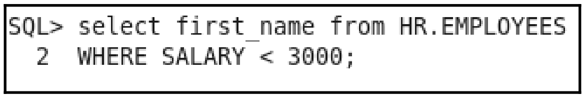
4. Connect to the database as the user `alan` and view the first names of employees who have salary less than `1000`:



```
SQL> connect alan
Enter password:
Connected.
SQL> select first_name from HR.EMPLOYEES
  2  WHERE SALARY < 1000;

no rows selected
```

Figure 22 – the first test of select privilege

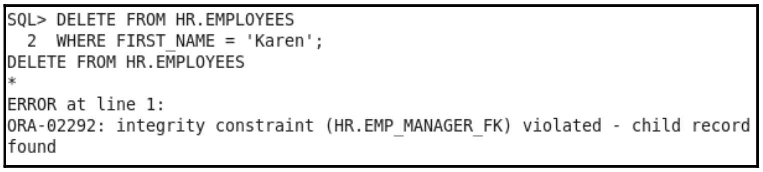
5. Find first names of employees who earn less than `3 000`.



```
SQL> select first_name from HR.EMPLOYEES
  2  WHERE SALARY < 3000;
```

Figure 23 – The second test of select privilege

6. Try to delete all employees whose first name is `Karen`.

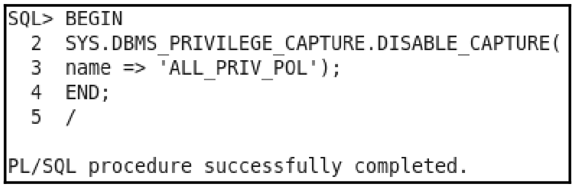


```
SQL> DELETE FROM HR.EMPLOYEES
  2  WHERE FIRST_NAME = 'Karen';
DELETE FROM HR.EMPLOYEES
*
ERROR at line 1:
ORA-02292: integrity constraint (HR.EMP_MANAGER_FK) violated - child record
found
```

Figure 24 – The test of delete privilege: integrity constraint violation

7. Connect to the database as system or a user who has appropriate privileges. Stop collecting data about privileges:

```
SQL> connect system
SQL> BEGIN
    SYS.DBMS_PRIVILEGE_CAPTURE.DISABLE_CAPTURE(
    name => '<policy_name>');
    END;
    /
```

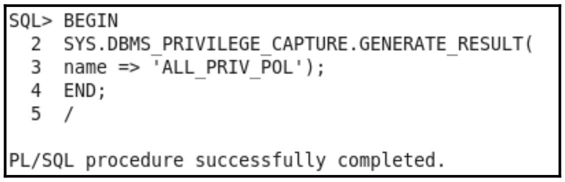


```
SQL> BEGIN
  2  SYS.DBMS_PRIVILEGE_CAPTURE.DISABLE_CAPTURE(
  3  name => 'ALL_PRIV_POL');
  4  END;
  5  /

PL/SQL procedure successfully completed.
```

Figure 25 – Stop capturing

8. Generate the result:

```
SQL> BEGIN
     SYS.DBMS_PRIVILEGE_CAPTURE.GENERATE_RESULT(
     name => '<policy_name>');
     END;
     /
```



```
SQL> BEGIN
  2  SYS.DBMS_PRIVILEGE_CAPTURE.GENERATE_RESULT(
  3  name => 'ALL_PRIV_POL');
  4  END;
  5  /

PL/SQL procedure successfully completed.
```

Figure 26 – Generating the report

How it works…

In step 3, you started capturing privileges according to the policy `ALL_PRIV_POL`. Then, you executed several statements as the user `ALAN`. The point of those statements is to generate records, you'll see in the next recipes.

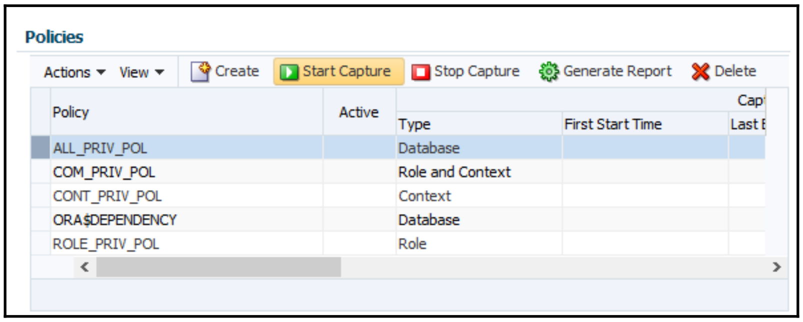
Delete operation wasn't able to delete row(s) because of integrity constraint violation, but you will see in the next recipes it generated record that `DELETE` privilege was used.

In step 7, you stopped capturing the privilege usage. In step 8, you populated `DBA_USED_XXX` and `DBA_UNUSED_XXX` data dictionary views. You can see how to use the results of capture later in this chapter.

There's more…

You can also use Enterprise Manager Cloud Control 12c to manage privilege analysis policies. Repeat steps 1 and 2 from the *There's more…* section in the recipe *Creating database analysis policy*.

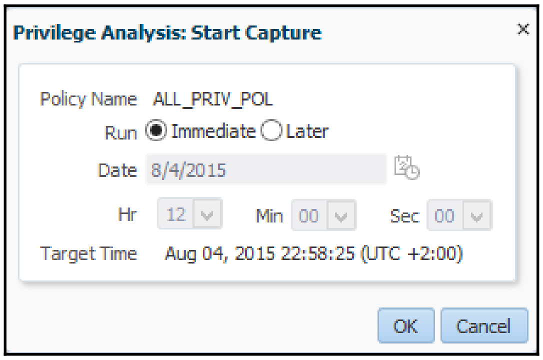
Select the database policy and click on the **Start Capture** button (see Figure 27):



Policy	Active	Type	First Start Time	Last E
ALL_PRIV_POL		Database		
COM_PRIV_POL		Role and Context		
CONT_PRIV_POL		Context		
ORA$DEPENDENCY		Database		
ROLE_PRIV_POL		Role		

Figure 27 – Enabling a policy

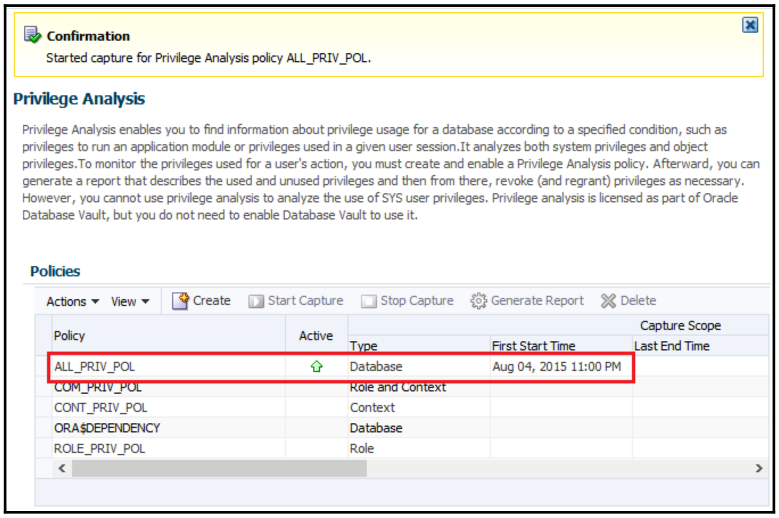
You can either start capture immediately or schedule it. Leave the defaults and click on the **OK** button (see Figure 28):


Privilege Analysis: Start Capture

Policy Name ALL_PRIV_POL
Run [✓ Immediate] Later
Date 8/4/2015
Hr 12 Min 00 Sec 00
Target Time Aug 04, 2015 22:58:25 (UTC +2:00)

Figure 28 – Start capture immediately

You should receive a confirmation message and see that your policy is active (see Figure 29).


Confirmation
Started capture for Privilege Analysis policy ALL_PRIV_POL.

Privilege Analysis

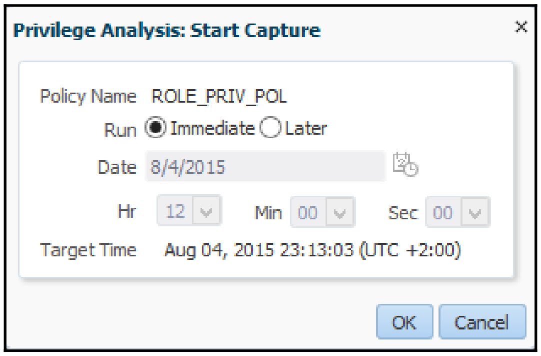
Privilege Analysis enables you to find information about privilege usage for a database according to a specified condition, such as privileges to run an application module or privileges used in a given user session.It analyzes both system privileges and object privileges.To monitor the privileges used for a user's action, you must create and enable a Privilege Analysis policy. Afterward, you can generate a report that describes the used and unused privileges and then from there, revoke (and regrant) privileges as necessary. However, you cannot use privilege analysis to analyze the use of SYS user privileges. Privilege analysis is licensed as part of Oracle Database Vault, but you do not need to enable Database Vault to use it.

Policies

Policy	Active	Capture Scope		
		Type	First Start Time	Last End Time
ALL_PRIV_POL	⇧	Database	Aug 04, 2015 11:00 PM	
COM_PRIV_POL		Role and Context		
CONT_PRIV_POL		Context		
ORA$DEPENDENCY		Database		
ROLE_PRIV_POL		Role		

Figure 29 – An active capture

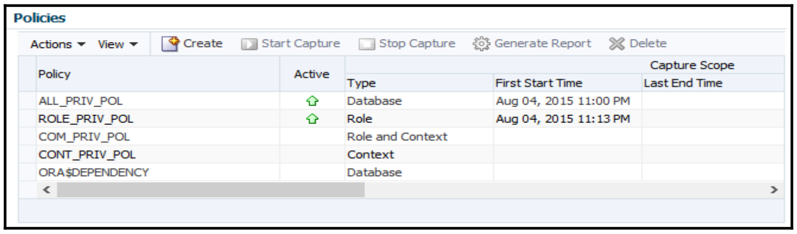
Select the role policy and click on **Start Capture** (see Figure 30):


Privilege Analysis: Start Capture

Policy Name	ROLE_PRIV_POL
Run	[✓ Immediate] Later
Date	8/4/2015
Hr	12
Min	00
Sec	00
Target Time	Aug 04, 2015 23:13:03 (UTC +2:00)

Figure 30 – Enabling role policy

You should see under the **Policies** section that both policies are active (see Figure 31):



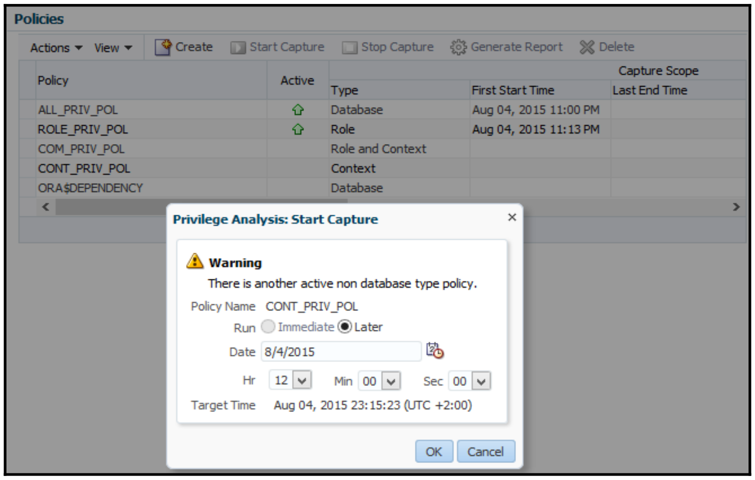
Policies

Policy	Active	Type	First Start Time	Last End Time
ALL_PRIV_POL	⇧	Database	Aug 04, 2015 11:00 PM	
ROLE_PRIV_POL	⇧	Role	Aug 04, 2015 11:13 PM	
COM_PRIV_POL		Role and Context		
CONT_PRIV_POL		Context		
ORA$DEPENDENCY		Database		

Figure 31 – Active policies

Keep in mind that only one policy whose type is `Database` and one policy whose type is not `Database` could be active at any given time.

Verify that you can't enable another non-database policy while role policy is active. Select `CONT_PRIV_POL` and click on the **Start Capture** button. You'll receive warning message, and you'll only be able to schedule job to run at later point in time (see Figure 32).



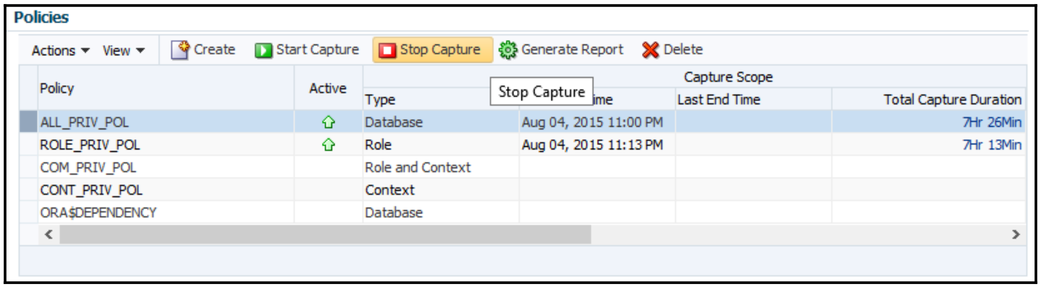
Privilege Analysis: Start Capture

Warning
There is another active non database type policy.

Policy Name CONT_PRIV_POL
Run Immediate [✓ Later]
Date 8/4/2015
Hr 12 Min 00 Sec 00
Target Time Aug 04, 2015 23:15:23 (UTC +2:00)

Figure 32 – Warning message

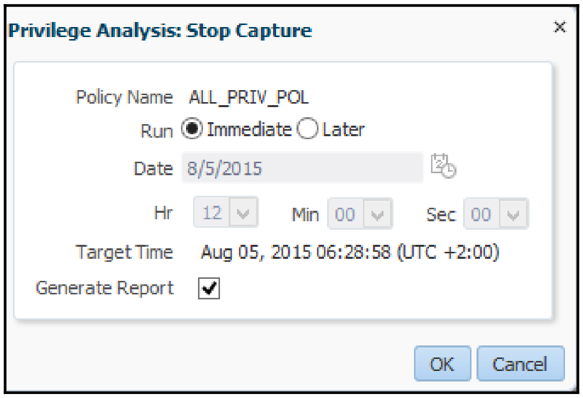
To disable capture, select an active policy (for example, `ALL_PRIV_POL`) and click on the button **Stop Capture** (see Figure 33):



Policy	Active	Type	Capture Scope ime	Last End Time	Total Capture Duration
ALL_PRIV_POL	⇧	Database	Aug 04, 2015 11:00 PM		7Hr 26Min
ROLE_PRIV_POL	⇧	Role	Aug 04, 2015 11:13 PM		7Hr 13Min
COM_PRIV_POL		Role and Context			
CONT_PRIV_POL		Context			
ORA$DEPENDENCY		Database			

Figure 33 – Stop capture

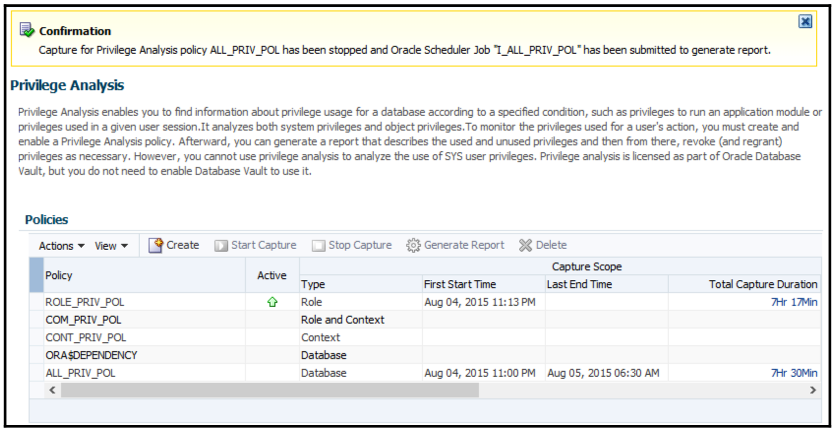
Choose to immediately stop capture and tick generate report checkbox. Click on the **OK** button (see Figure 34).



Policy Name	ALL_PRIV_POL
Run	[✓ Immediate] Later
Date	8/5/2015
Hr	12
Min	00
Sec	00
Target Time	Aug 05, 2015 06:28:58 (UTC +2:00)
Generate Report	✓

Figure 34 – Stop capture and generate report

You should receive confirmation message that capture has been stopped and that job has been submitted (see Figure 35):



Confirmation
Capture for Privilege Analysis policy ALL_PRIV_POL has been stopped and Oracle Scheduler Job "I_ALL_PRIV_POL" has been submitted to generate report.

Privilege Analysis

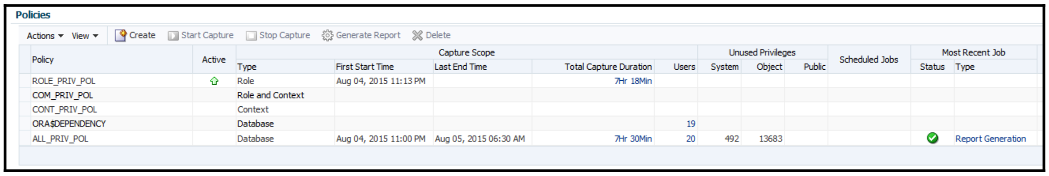
Privilege Analysis enables you to find information about privilege usage for a database according to a specified condition, such as privileges to run an application module or privileges used in a given user session.It analyzes both system privileges and object privileges.To monitor the privileges used for a user's action, you must create and enable a Privilege Analysis policy. Afterward, you can generate a report that describes the used and unused privileges and then from there, revoke (and regrant) privileges as necessary. However, you cannot use privilege analysis to analyze the use of SYS user privileges. Privilege analysis is licensed as part of Oracle Database Vault, but you do not need to enable Database Vault to use it.

Policies

Policy	Active	Capture Scope			
		Type	First Start Time	Last End Time	Total Capture Duration
ROLE_PRIV_POL	⇧	Role	Aug 04, 2015 11:13 PM		7Hr 17Min
COM_PRIV_POL		Role and Context			
CONT_PRIV_POL		Context			
ORA$DEPENDENCY		Database			
ALL_PRIV_POL		Database	Aug 04, 2015 11:00 PM	Aug 05, 2015 06:30 AM	7Hr 30Min

Figure 35 – Confirmation

Refresh page (it may take up to several minutes to complete). You should receive result similar to the one shown in Figure 36.



Policies

Policy	Active	Capture Scope					Unused Privileges			Scheduled Jobs	Most Recent Job	
		Type	First Start Time	Last End Time	Total Capture Duration	Users	System	Object	Public		Status	Type
ROLE_PRIV_POL	⇧	Role	Aug 04, 2015 11:13 PM		7Hr 18Min							
COM_PRIV_POL		Role and Context										
CONT_PRIV_POL		Context										
ORA$DEPENDENCY		Database				19						
ALL_PRIV_POL		Database	Aug 04, 2015 11:00 PM	Aug 05, 2015 06:30 AM	7Hr 30Min	20	492	13683			✓	Report Generation

Figure 36 – The generated report

Test all policies you have created in the previous recipes.

Reporting on used system privileges

In this recipe, you'll view collected data about the usage of system privileges during a capture interval.

Getting ready

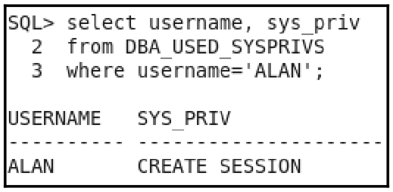
You'll need an existing user who can create a privilege analysis policy (has the `CAPTURE_ADMIN` role and the `SELECT ANY DICTIONARY` privilege), for example, the `SYSTEM` user.

How to do it…

1. Connect to the database as system or a user who has appropriate privileges:

   ```
   $ sqlplus system
   ```

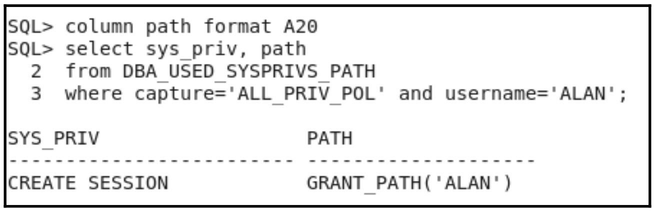
2. View system privileges that the user `ALAN` used:



```
SQL> select username, sys_priv
  2  from DBA_USED_SYSPRIVS
  3  where username='ALAN';

USERNAME   SYS_PRIV
---------- ---------------------
ALAN       CREATE SESSION
```

Figure 37 – The used system privileges

3. View grant path for the used system privileges generated by `ALL_PRIV_POL` for the user `ALAN`:

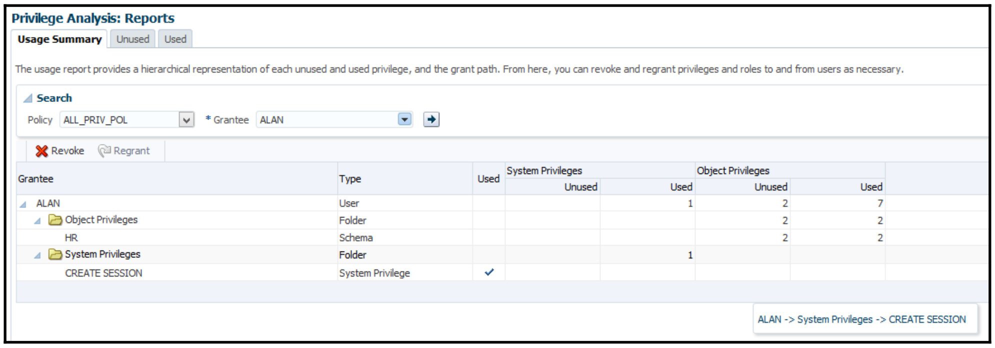


```
SQL> column path format A20
SQL> select sys_priv, path
  2  from DBA_USED_SYSPRIVS_PATH
  3  where capture='ALL_PRIV_POL' and username='ALAN';

SYS_PRIV                   PATH
-------------------------- --------------------
CREATE SESSION             GRANT_PATH('ALAN')
```

Figure 38 – The Grant path

There's more…

In EM 12c, after you have generated the report, select the policy and from **Actions** drop-down menu, select **Reports**. The **Usage Summary** report will open (see Figure 39).



Privilege Analysis: Reports

Usage Summary | Unused | Used

The usage report provides a hierarchical representation of each unused and used privilege, and the grant path. From here, you can revoke and regrant privileges and roles to and from users as necessary.

Search

Policy: ALL_PRIV_POL * Grantee: ALAN

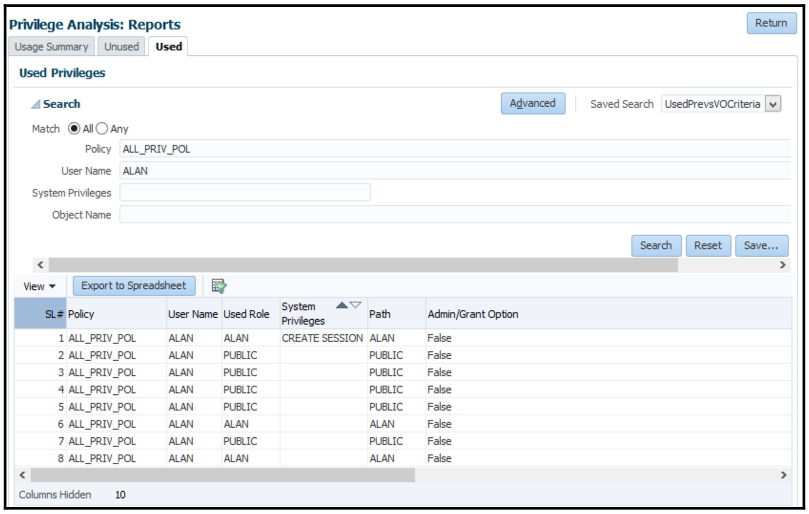
Revoke Regrant

Grantee	Type	Used	System Privileges		Object Privileges	
			Unused	Used	Unused	Used
ALAN	User			1	2	7
Object Privileges	Folder				2	2
HR	Schema				2	2
System Privileges	Folder			1		
CREATE SESSION	System Privilege	✓				

ALAN -> System Privileges -> CREATE SESSION

Figure 39 – Usage Summary

Click on the tab **Used** and choose **All** for **Match** radio button, **Policy:** `ALL_PRIV_POL`, **User Name:** `ALAN`, and click on the **Search** button. Results are shown in Figure 40:



Privilege Analysis: Reports

Usage Summary | Unused | Used

Used Privileges

Search

Match: [✓ All] Any

Policy: ALL_PRIV_POL

User Name: ALAN

System Privileges:

Object Name:

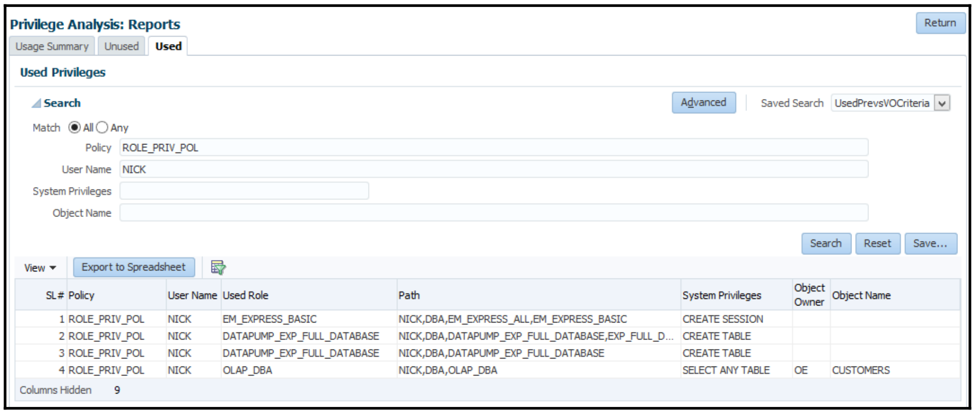
Saved Search: UsedPrevsVOCriteria

SL#	Policy	User Name	Used Role	System Privileges	Path	Admin/Grant Option
1	ALL_PRIV_POL	ALAN	ALAN	CREATE SESSION	ALAN	False
2	ALL_PRIV_POL	ALAN	PUBLIC		PUBLIC	False
3	ALL_PRIV_POL	ALAN	PUBLIC		PUBLIC	False
4	ALL_PRIV_POL	ALAN	PUBLIC		PUBLIC	False
5	ALL_PRIV_POL	ALAN	PUBLIC		PUBLIC	False
6	ALL_PRIV_POL	ALAN	ALAN		ALAN	False
7	ALL_PRIV_POL	ALAN	PUBLIC		PUBLIC	False
8	ALL_PRIV_POL	ALAN	ALAN		ALAN	False

Columns Hidden 10

Figure 40 – Report the used privileges recorded for the user Alan based on the database policy

If you haven't generated report for the role policy, do it now and return to this tab (the **Used** tab). Find all records generated by `ROLE_PRIV_POL` for user `Nick` (who has a DBA role). Results are presented in Figure 41:



Match [✓ All] Any

Policy	ROLE_PRIV_POL
User Name	NICK
System Privileges	
Object Name	

SL#	Policy	User Name	Used Role	Path	System Privileges	Object Owner	Object Name
1	ROLE_PRIV_POL	NICK	EM_EXPRESS_BASIC	NICK,DBA,EM_EXPRESS_ALL,EM_EXPRESS_BASIC	CREATE SESSION		
2	ROLE_PRIV_POL	NICK	DATAPUMP_EXP_FULL_DATABASE	NICK,DBA,DATAPUMP_EXP_FULL_DATABASE,EXP_FULL_D...	CREATE TABLE		
3	ROLE_PRIV_POL	NICK	DATAPUMP_EXP_FULL_DATABASE	NICK,DBA,DATAPUMP_EXP_FULL_DATABASE	CREATE TABLE		
4	ROLE_PRIV_POL	NICK	OLAP_DBA	NICK,DBA,OLAP_DBA	SELECT ANY TABLE	OE	CUSTOMERS

Columns Hidden 9

Figure 41 – The used privileges recorded for the user Nick based on role policy

Reporting on used object privileges

In this recipe, you'll view collected data about the usage of object privileges during the capture interval.

Getting ready

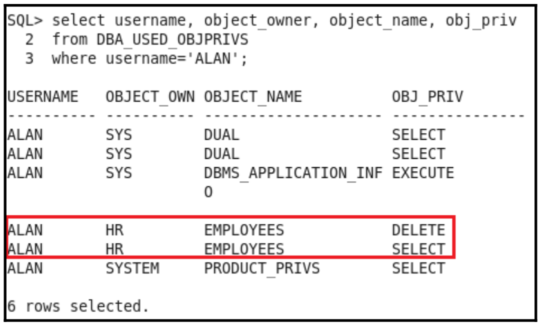
You'll need an existing user who can create a privilege analysis policy (has the `CAPTURE_ADMIN` role and the `SELECT ANY DICTIONARY` privilege), for example, the `SYSTEM` user.

How to do it…

1. Connect to the database as system or a user who has appropriate privileges:

```
$ sqlplus system
```

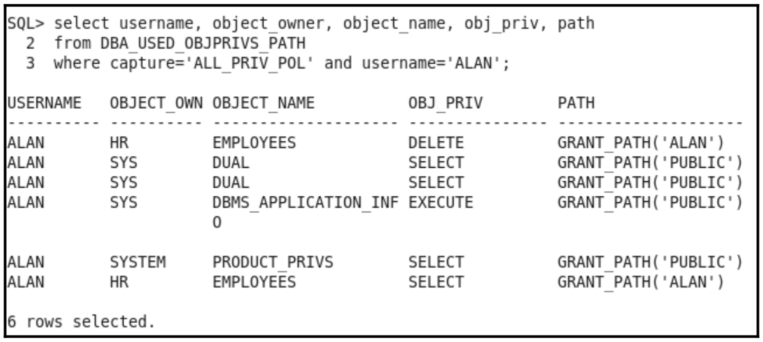
2. View which object privileges the user `Alan` has used while database policy `ALL_PRIV_POL` has been active.



```
SQL> select username, object_owner, object_name, obj_priv
  2  from DBA_USED_OBJPRIVS
  3  where username='ALAN';

USERNAME   OBJECT_OWN OBJECT_NAME          OBJ_PRIV
---------- ---------- -------------------- ---------------
ALAN       SYS        DUAL                 SELECT
ALAN       SYS        DUAL                 SELECT
ALAN       SYS        DBMS_APPLICATION_INF EXECUTE
                      O

ALAN       HR         EMPLOYEES            DELETE
ALAN       HR         EMPLOYEES            SELECT
ALAN       SYSTEM     PRODUCT_PRIVS        SELECT

6 rows selected.
```

Figure 42 – The used object privileges

3. View grant path by querying `DBA_USED_OBJPRIVS_PATH`:

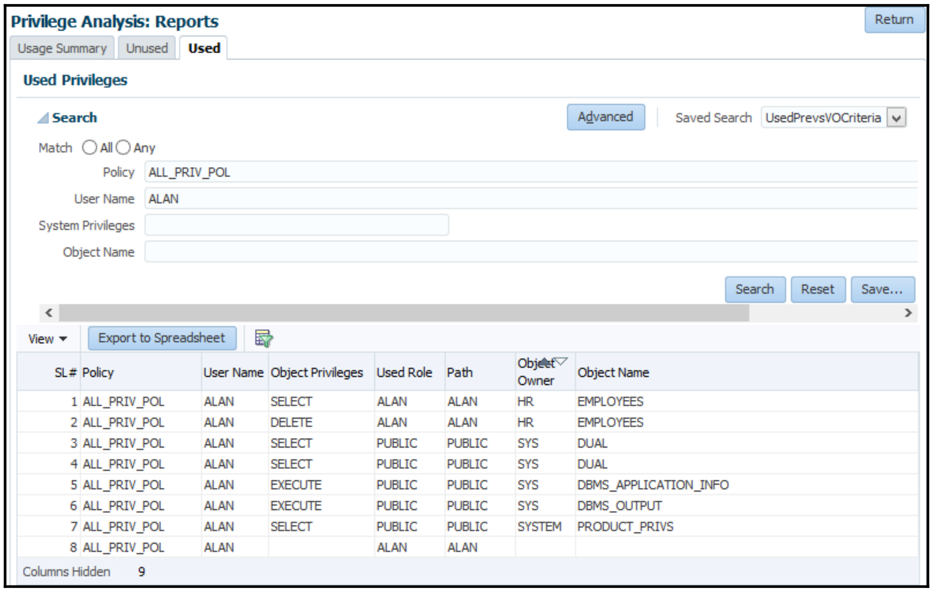


```
SQL> select username, object_owner, object_name, obj_priv, path
  2  from DBA_USED_OBJPRIVS_PATH
  3  where capture='ALL_PRIV_POL' and username='ALAN';

USERNAME   OBJECT_OWN OBJECT_NAME          OBJ_PRIV        PATH
---------- ---------- -------------------- --------------- --------------------
ALAN       HR         EMPLOYEES            DELETE          GRANT_PATH('ALAN')
ALAN       SYS        DUAL                 SELECT          GRANT_PATH('PUBLIC')
ALAN       SYS        DUAL                 SELECT          GRANT_PATH('PUBLIC')
ALAN       SYS        DBMS_APPLICATION_INF EXECUTE         GRANT_PATH('PUBLIC')
                      O

ALAN       SYSTEM     PRODUCT_PRIVS        SELECT          GRANT_PATH('PUBLIC')
ALAN       HR         EMPLOYEES            SELECT          GRANT_PATH('ALAN')

6 rows selected.
```

Figure 43 – Object privileges grant path

There's more…

In EM 12c, after you have generated the report, select the policy, and from **Actions** drop-down menu, select **Reports**. The **Usage Summary** report will open. Click on the **Used** tab and verify that the user `Alan` has used the `SELECT` and `DELETE` privileges while `ALL_PRIV_POL` has been active (see Figure 44):



Saved Search: UsedPrevsVOCriteria

Match ◯ All ◯ Any

Policy	ALL_PRIV_POL
User Name	ALAN
System Privileges	
Object Name	

SL#	Policy	User Name	Object Privileges	Used Role	Path	Object Owner	Object Name
1	ALL_PRIV_POL	ALAN	SELECT	ALAN	ALAN	HR	EMPLOYEES
2	ALL_PRIV_POL	ALAN	DELETE	ALAN	ALAN	HR	EMPLOYEES
3	ALL_PRIV_POL	ALAN	SELECT	PUBLIC	PUBLIC	SYS	DUAL
4	ALL_PRIV_POL	ALAN	SELECT	PUBLIC	PUBLIC	SYS	DUAL
5	ALL_PRIV_POL	ALAN	EXECUTE	PUBLIC	PUBLIC	SYS	DBMS_APPLICATION_INFO
6	ALL_PRIV_POL	ALAN	EXECUTE	PUBLIC	PUBLIC	SYS	DBMS_OUTPUT
7	ALL_PRIV_POL	ALAN	SELECT	PUBLIC	PUBLIC	SYSTEM	PRODUCT_PRIVS
8	ALL_PRIV_POL	ALAN		ALAN	ALAN		

Columns Hidden 9

Figure 44 – Reports

Reporting on unused system privileges

In this recipe, you'll view the collected data about the unused system privileges during the capture interval.

Getting ready

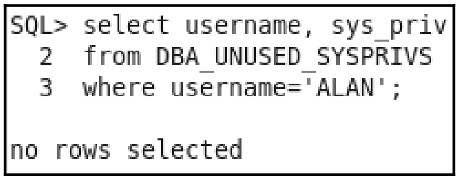
You'll need an existing user who can create a privilege analysis policy (has the `CAPTURE_ADMIN` role and the `SELECT ANY DICTIONARY` privilege), for example, the `SYSTEM` user.

How to do it...

1. Connect to the database as system or a user who has appropriate privileges:

```
$ sqlplus system
```

2. View that the user `Alan` has used all system privileges that have been granted to him (there are no unused system privileges):



```
SQL> select username, sys_priv
  2  from DBA_UNUSED_SYSPRIVS
  3  where username='ALAN';

no rows selected
```

Figure 45 – The unused system privileges for the user Alan during the database policy ALL_PRIV_POL capture interval

There's more…

To view report about the unused system privileges in EM12c, see instructions to view the used system privileges and under **Privilege Analysis: Reports**, choose the **Unused** tab instead of the **Used** tab.

Reporting on unused object privileges

In this recipe, you'll view collected data about the unused object privileges during the capture interval.

Getting ready

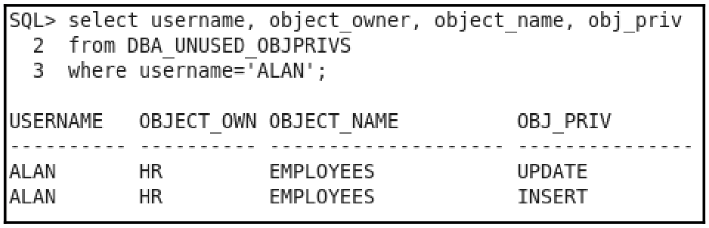
You'll need an existing user who can create a privilege analysis policy (has the `CAPTURE_ADMIN` role and the `SELECT ANY DICTIONARY` privilege), for example, the `SYSTEM` user.

How to do it…

1. Connect to the database as system or a user who has appropriate privileges:

```
$ sqlplus system
```

2. View which object privileges the user `Alan` has used during the database policy capture interval:

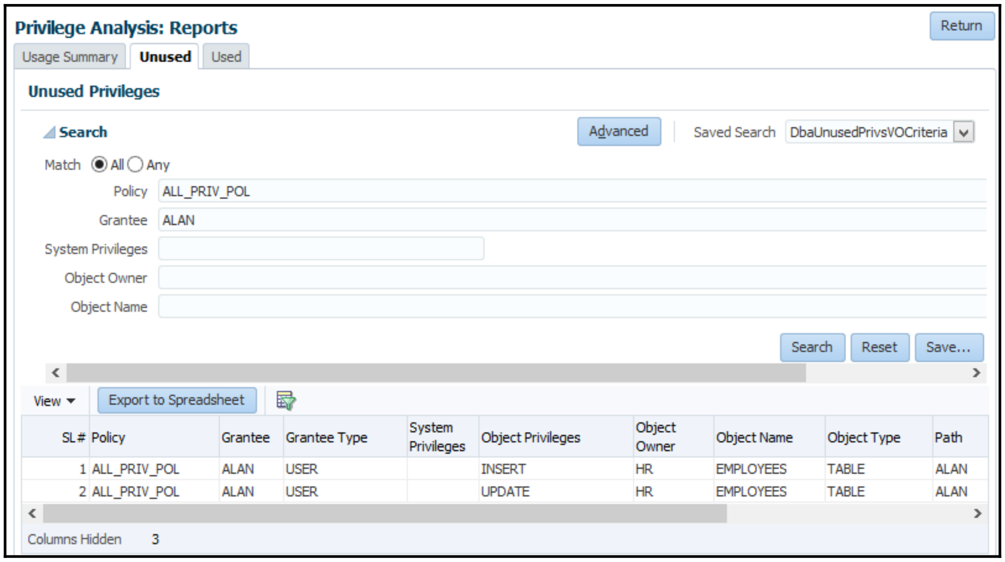


```
SQL> select username, object_owner, object_name, obj_priv
  2  from DBA_UNUSED_OBJPRIVS
  3  where username='ALAN';

USERNAME   OBJECT_OWN OBJECT_NAME          OBJ_PRIV
---------- ---------- -------------------- ---------------
ALAN       HR         EMPLOYEES            UPDATE
ALAN       HR         EMPLOYEES            INSERT
```

Figure 46 – The unused object privileges

There's more…

In EM 12c, after you have generated the report, select the policy, and from **Actions** drop-down menu, select **Reports**. The **Usage Summary** report will open. Click on the **Unused** tab and verify that the user `Alan` hasn't used the `INSERT` and `UPDATE` privileges while `ALL_PRIV_POL` has been active.



Match [✓ All] Any

Policy	ALL_PRIV_POL
Grantee	ALAN
System Privileges	
Object Owner	
Object Name	

SL#	Policy	Grantee	Grantee Type	System Privileges	Object Privileges	Object Owner	Object Name	Object Type	Path
1	ALL_PRIV_POL	ALAN	USER		INSERT	HR	EMPLOYEES	TABLE	ALAN
2	ALL_PRIV_POL	ALAN	USER		UPDATE	HR	EMPLOYEES	TABLE	ALAN

Columns Hidden 3

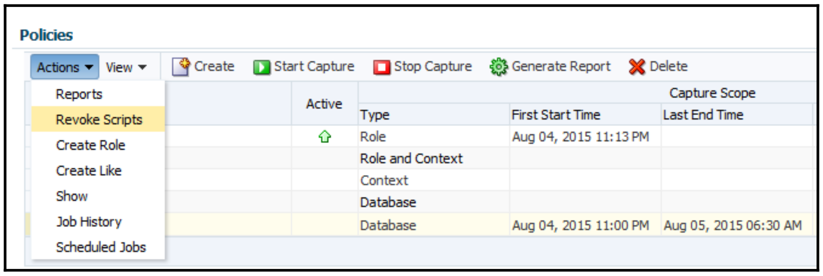
Figure 47 – The Unused object privileges report

How to revoke unused privileges

You can manually revoke unused privileges one by one from users, write your own scripts to complete that task, or use Enterprise Manager Cloud Control 12c. In this recipe, you'll use EM12c to efficiently revoke unused privileges based on reports you generated in the previous recipes.

How to do it…

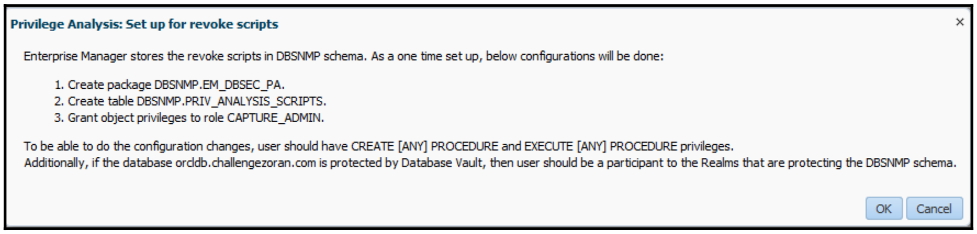
1. Select policy, and from **Actions** drop-down menu, choose **Revoke Scripts** (see Figure 48):



	Active	Type	First Start Time	Last End Time
			Capture Scope	
	⇧	Role	Aug 04, 2015 11:13 PM	
		Role and Context		
		Context		
		Database		
		Database	Aug 04, 2015 11:00 PM	Aug 05, 2015 06:30 AM

Figure 48 – Create revoke scripts

2. You'll see a message about required privileges (see Figure 49). Click on the **OK** button.



Privilege Analysis: Set up for revoke scripts

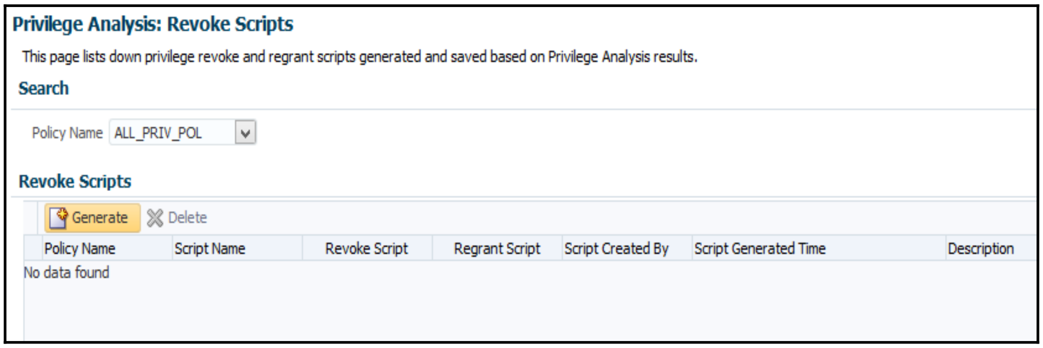
Enterprise Manager stores the revoke scripts in DBSNMP schema. As a one time set up, below configurations will be done:

1. Create package DBSNMP.EM_DBSEC_PA.
2. Create table DBSNMP.PRIV_ANALYSIS_SCRIPTS.
3. Grant object privileges to role CAPTURE_ADMIN.

To be able to do the configuration changes, user should have CREATE [ANY] PROCEDURE and EXECUTE [ANY] PROCEDURE privileges.
Additionally, if the database orcldb.challengezoran.com is protected by Database Vault, then user should be a participant to the Realms that are protecting the DBSNMP schema.

Figure 49 – The info message

3. Select policy (**Policy Name**) and click on the **Generate** button (see Figure 50):



Privilege Analysis: Revoke Scripts

This page lists down privilege revoke and regrant scripts generated and saved based on Privilege Analysis results.

Search

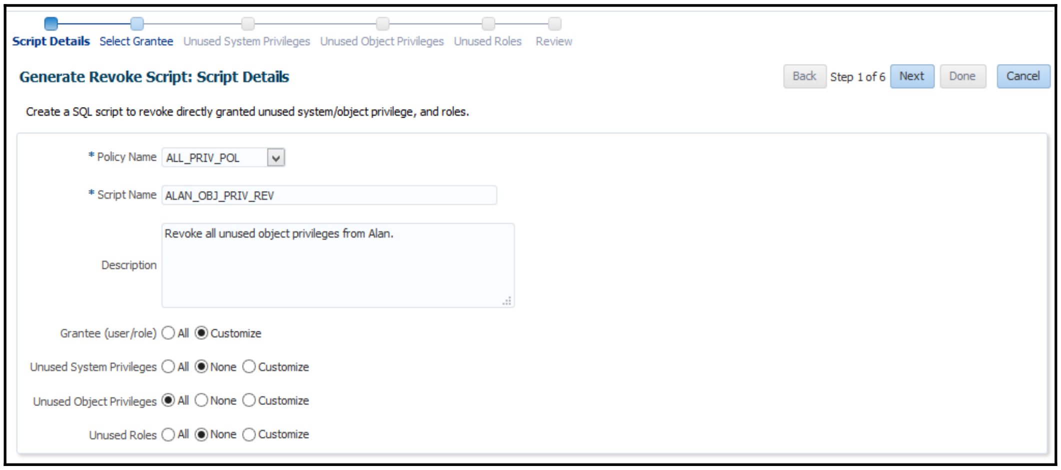
Policy Name: ALL_PRIV_POL

Revoke Scripts

Policy Name	Script Name	Revoke Script	Regrant Script	Script Created By	Script Generated Time	Description
No data found						

Figure 50 – Generating a script

4. Generate script to revoke all the unused object privileges from the user `Alan`. Fill out form as shown in Figure 51 and click on the **Next** button:



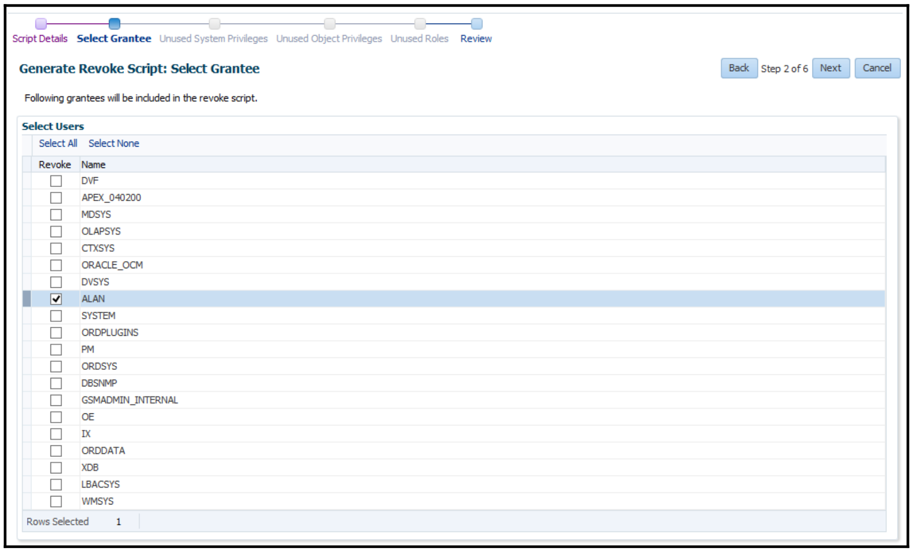
Generate Revoke Script: Script Details

Create a SQL script to revoke directly granted unused system/object privilege, and roles.

* Policy Name	ALL_PRIV_POL
* Script Name	ALAN_OBJ_PRIV_REV
Description	Revoke all unused object privileges from Alan.
Grantee (user/role)	All [✓ Customize]
Unused System Privileges	All [✓ None] Customize
Unused Object Privileges	[✓ All] None Customize
Unused Roles	All [✓ None] Customize

Figure 51 – Revoking the script configuration

5. Click on the **Select None** link and tick revoke checkbox for the user `Alan` (see Figure 52):



Generate Revoke Script: Select Grantee

Following grantees will be included in the revoke script.

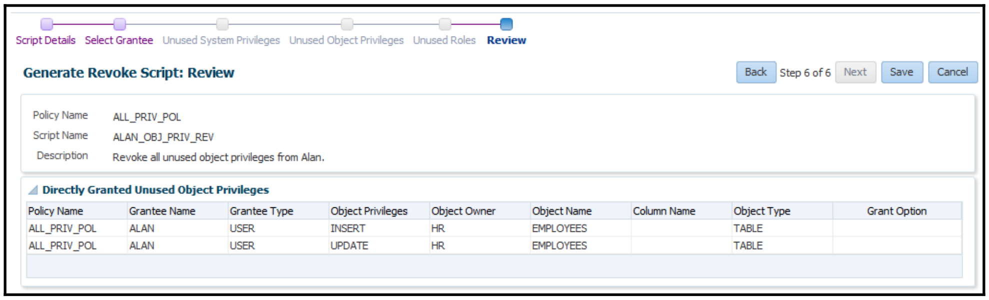
Select Users

Revoke	Name
☐	DVF
☐	APEX_040200
☐	MDSYS
☐	OLAPSYS
☐	CTXSYS
☐	ORACLE_OCM
☐	DVSYS
✓	ALAN
☐	SYSTEM
☐	ORDPLUGINS
☐	PM
☐	ORDSYS
☐	DBSNMP
☐	GSMADMIN_INTERNAL
☐	OE
☐	IX
☐	ORDDATA
☐	XDB
☐	LBACSYS
☐	WMSYS

Rows Selected 1

Figure 52 – Choose to revoke privilege only from the user Alan

Click on the **Next** button. Review your choices and click on the **Save** button (see Figure 53):



Generate Revoke Script: Review

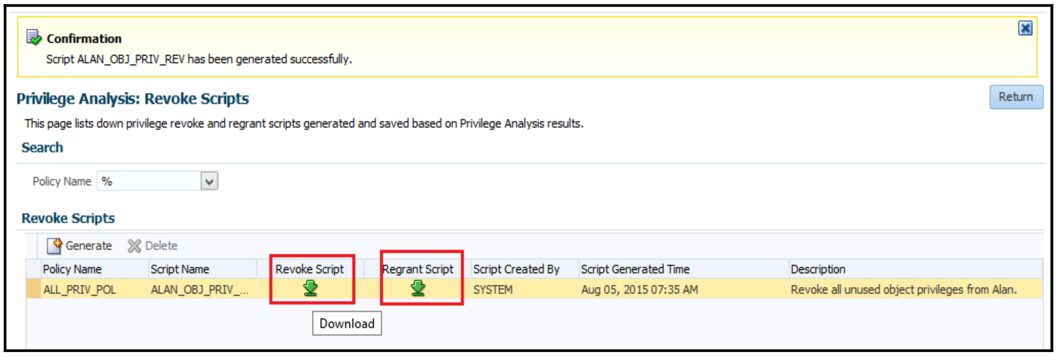
Policy Name	ALL_PRIV_POL
Script Name	ALAN_OBJ_PRIV_REV
Description	Revoke all unused object privileges from Alan.

Directly Granted Unused Object Privileges

Policy Name	Grantee Name	Grantee Type	Object Privileges	Object Owner	Object Name	Column Name	Object Type	Grant Option
ALL_PRIV_POL	ALAN	USER	INSERT	HR	EMPLOYEES		TABLE	
ALL_PRIV_POL	ALAN	USER	UPDATE	HR	EMPLOYEES		TABLE	

Figure 53 – Review

You should receive confirmation similar to the one shown in Figure 54:



Confirmation

Script ALAN_OBJ_PRIV_REV has been generated successfully.

Privilege Analysis: Revoke Scripts

This page lists down privilege revoke and regrant scripts generated and saved based on Privilege Analysis results.

Search

Policy Name %

Revoke Scripts

Policy Name	Script Name	Revoke Script	Regrant Script	Script Created By	Script Generated Time	Description
ALL_PRIV_POL	ALAN_OBJ_PRIV_...			SYSTEM	Aug 05, 2015 07:35 AM	Revoke all unused object privileges from Alan.

Figure 54- The confirmation message

6. Click on the green arrow in the **Revoke Script** column (Figure 54) to download the generated revoke script. Note that **Regrant Script** has also been generated.
7. View the generated revoke script- `ALAN_OBJ_PRIV_REV_revokeScript.sql` (see Figure 55):

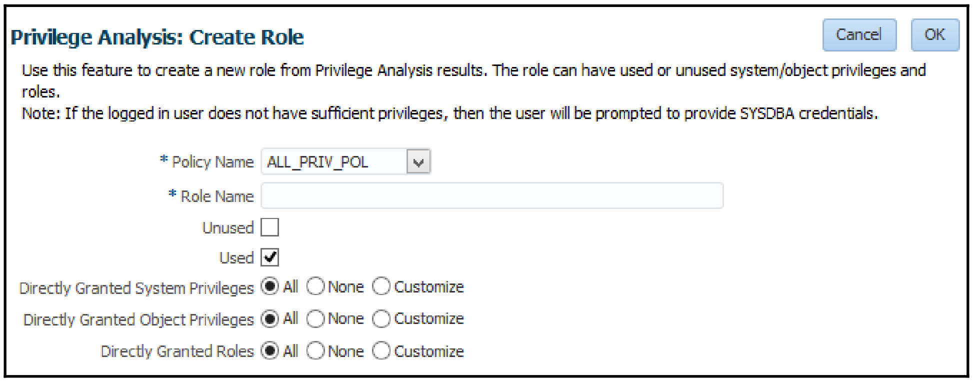
```
-- REVOKE SCRIPT GENERATED BY SYSTEM AT Aug 05, 2015 07:35 AM.
-- SCRIPT FOR REVOKING DIRECTLY GRANTED UNUSED OBJECT
PRIVILEGES :

REVOKE INSERT ON HR.EMPLOYEES FROM ALAN;
REVOKE UPDATE ON HR.EMPLOYEES FROM ALAN;
```

Figure 55 – The generated revoke script

There's more…

In EM 12c, there is another excellent option to create a new role based on privilege analysis results. This way, you won't change an existing role (and affect other users and roles who have that role), but create a new one and afterwards revoke the old role and grant a newly created one.

You can select it from the **Actions** menu (**Create Role**). In Figure 56, the configuration part of a process for creating a new role is shown:



Use this feature to create a new role from Privilege Analysis results. The role can have used or unused system/object privileges and roles.
Note: If the logged in user does not have sufficient privileges, then the user will be prompted to provide SYSDBA credentials.

* Policy Name	ALL_PRIV_POL
* Role Name	
Unused	☐
Used	✓
Directly Granted System Privileges	[✓ All] None Customize
Directly Granted Object Privileges	[✓ All] None Customize
Directly Granted Roles	[✓ All] None Customize

Figure 56 – Create a new role based on policy

Dropping the analysis

In this recipe, you'll drop an existing privilege analysis policy. It has to be disabled before dropping; otherwise, you'll receive an error.

Getting ready

You'll need an existing user who can manage privilege analysis policies (has the `CAPTURE_ADMIN` role and the `SELECT ANY DICTIONARY` privilege), for example, the `SYSTEM` user and an existing privilege analysis policy.

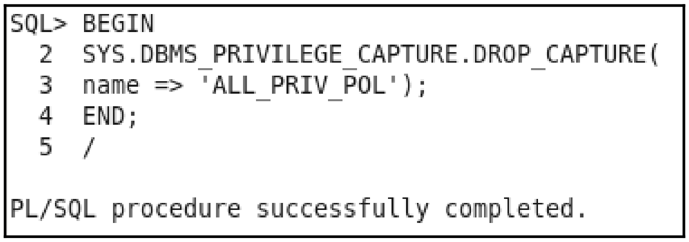
How to do it...

1. Connect to the database as system or a user who has appropriate privileges:

```
$ sqlplus system
```

2. Drop a privilege analysis policy (for example, `ALL_PRIV_POL`, which you created in the first recipe in this chapter):

```
SQL> BEGIN
     SYS.DBMS_PRIVILEGE_CAPTURE.DROP_CAPTURE(
     name => '<policy_name>');
     END;
     /
```

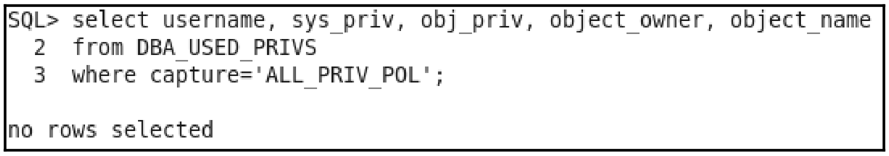


```
SQL> BEGIN
  2  SYS.DBMS_PRIVILEGE_CAPTURE.DROP_CAPTURE(
  3  name => 'ALL_PRIV_POL');
  4  END;
  5  /

PL/SQL procedure successfully completed.
```

Figure 57 – Drop policy

3. Verify that all the records about the used and unused privileges, which have been gathered according to the policy, are also dropped:

```
SQL> SELECT username, sys_priv, obj_priv, object_owner,
object_name
     FROM DBA_USED_PRIVS
     WHERE capture='<policy_name>';
```



```
SQL> select username, sys_priv, obj_priv, object_owner, object_name
  2  from DBA_USED_PRIVS
  3  where capture='ALL_PRIV_POL';

no rows selected
```

Figure 58 – Records doesn't exist anymore

There's more…

In EM 12c under the **Policies** section, select policy you want to drop and click on the **Delete** button.

8 Transparent Data Encryption

In this chapter, we will cover the following tasks:

- Configuring a keystore location in `sqlnet.ora`
- Creating and opening the keystore
- Setting a master encryption key in a software keystore
- Column encryption – adding a new encrypted column to a table
- Column encryption – creating a new table that has encrypted column(s)
- Using salt and MAC
- Column encryption – encrypting the existing column
- Autologin keystore
- Encrypting tablespace
- Rekeying
- Backup and recovery

Introduction

Encryption is a very important security mechanism used to enforce confidentiality of data. There are two types of encryption that can be used in the Oracle Database. The first type is application-based encryption, which is implemented using the **DBMS_CRYPTO** PL/SQL package (this type is not covered in this book), and the second type is **Transparent Data Encryption** (**TDE**). TDE is a part of Advanced Security option of Oracle Database Enterprise Edition. It can be used to encrypt data in rest (table columns and tablespaces inside the database) and in transit (network, **Recovery Manager** (**RMAN**) backups, and Data Pump Exports).

The word t*ransparent* in Transparent Data Encryption means that application is not aware that data is encrypted in any way. In other words, application will never see the encrypted data-if user is not authorized to see the data, error (for example, insufficient privileges, table, or view does not exist) will be shown. The only way that a user will see encrypted data is if he or she tries to avoid Oracle Database Access Controls, by reading data files directly.

TDE should never be used as a mechanism of access control. For this purpose, there is a large portfolio of access control mechanisms in Oracle Database (standard Discretionary Access Control, Mandatory Access Control-Oracle Label Security, Virtual Private Database, Database Vault, and so on).

There are two types of TDE: column and tablespace.

In column encryption, only user-selected columns (in user-selected tables) are encrypted. This encryption type is more suitable for systems with small number of columns that need to be encrypted. Encrypting large number of columns can lead to significant performance degradation. This type even encrypts data in memory, which prevents cold boot attacks. There are several encryption algorithms that can be chosen from: AES128, AES192, AES256, and 3DES168. The default one is AES192. Because these are block cyphers, each row that is going to be encrypted need to be padded to a multiple of 16 bytes (for example, if the size of value in row is 11 bytes, additional 5 bytes of storage is needed to encrypt this row). By default, salt and MAC are used (salt and MAC are covered in the *Using salt and MAC* recipe). There are several restrictions of column encryption:

- Foreign key constraints are not supported because each table has a different table key
- B-Tree indexes are not supported when using salt
- Bitmap indexes are not supported
- Transportable tablespaces are not supported
- Synchronous **Change Data Capture** (**CDC**) is not supported
- External **Large Objects** (**LOBs**) are not supported
- `SYS` schema objects cannot be encrypted

Tablespace encryption is the second type of TDE, which has better performance and has fewer restrictions. This type of TDE is usually more suitable for systems that need to encrypt large portion of data in the database. Using this type, all data that resides inside encrypted tablespace is encrypted (no restrictions on data types). Encryption/decryption is performed on the I/O level, so performance overhead can be expected to be seen on that level. Tablespace encryption doesn't require additional storage. Unlike column encryption, tablespace encryption supports the following:

- Foreign keys
- Bitmap indexes
- Transportable tablespaces (as long as platforms are of the same endian and the same keystore exists on both locations)
- All data types

However, there are still some limitations. Following things are not supported in tablespace encryption:

- BFILE cannot be encrypted
- External tables cannot be encrypted
- UNDO tablespace cannot be encrypted
- TEMP tablespace cannot be encrypted
- SYSTEM tablespace cannot be encrypted
- Key for tablespace cannot be rekeyed (workaround is to create another encrypted tablespace and move all data to this newly created tablespace)

TDE uses two-tier key architecture. For column encryption, columns are encrypted using column (also known as table) keys. There is only one key per table regardless of number of columns that are encrypted in that particular table. For tablespace encryption, tablespaces are encrypted using tablespace keys. Both table and tablespace keys are stored in data dictionary inside Oracle Database. These keys are encrypted using a master key. There is only one master key per database (in Oracle multitenant environment, there is one master key per pluggable database). This master key is stored in a keystore outside the Oracle Database. This keystore can be a software keystore (in previous versions of Oracle Database, it's been named **Oracle Wallet**) or a hardware keystore (for example, Hardware Security Module). There is only one keystore per database (in Oracle Multitenant environment, there is only one keystore per whole container database). This means that in Oracle Multitenant, there will be one keystore (software or hardware) per container database, which contains multiple master keys (one for each pluggable database that is plugged in that particular container database). A keystore is secured by a password, which is used during maintenance operations (keystore opening and closing, rekeying master key, and so on).

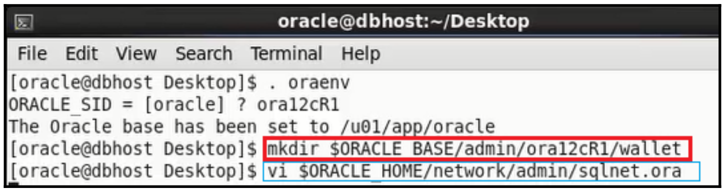
Keystore's password is not the same as the master key.

Configuring keystore location in sqlnet.ora

In this recipe, you're going to configure the location of a software keystore in a regular file system. If you want to use **Hardware Security Module** (**HSM**), see the official Oracle documentation (Chapter 3 in *Oracle Advanced Security Guide*, part named *Configuring Hardware Keystore*).

How to do it…

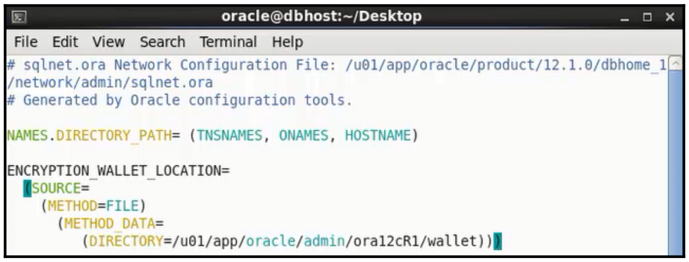
1. Create a directory, to hold a keystore, that is accessible to the owner of Oracle software (for example, `$ORACLE_BASE/admin/ora12cR1/wallet`). See Figure 1:



```
[oracle@dbhost Desktop]$ . oraenv
ORACLE_SID = [oracle] ? ora12cR1
The Oracle base has been set to /u01/app/oracle
[oracle@dbhost Desktop]$ mkdir $ORACLE_BASE/admin/ora12cR1/wallet
[oracle@dbhost Desktop]$ vi $ORACLE_HOME/network/admin/sqlnet.ora
```

Figure 1 – Create a directory and edit sqlnet.ora

2. Edit `sqlnet.ora` and add entry to specify the location of the keystore (see Figure 1 and 2). This step is optional if you are using default location for the wallet, which is `$ORACLE_HOME/admin/<db_name>/wallet`.



```
# sqlnet.ora Network Configuration File: /u01/app/oracle/product/12.1.0/dbhome_1
/network/admin/sqlnet.ora
# Generated by Oracle configuration tools.

NAMES.DIRECTORY_PATH= (TNSNAMES, ONAMES, HOSTNAME)

ENCRYPTION_WALLET_LOCATION=
  (SOURCE=
    (METHOD=FILE)
      (METHOD_DATA=
         (DIRECTORY=/u01/app/oracle/admin/ora12cR1/wallet))
```

Figure 2 – Define ENCRYPTION_WALLET_LOCATION parameter

Creating and opening the keystore

In this recipe, you're going to create a password-based keystore. Open it and learn to check its status.

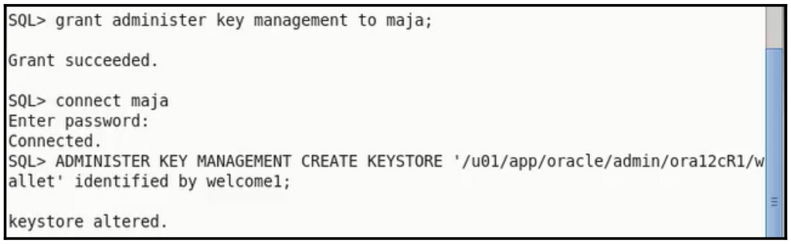
Getting ready

It is assumed that the keystore location is already configured (instructions are given in the recipe *Configuring keystore location in sqlnet.ora*). In this recipe, you'll grant, as the `SYS` user, administer key management privilege, or `SYSKM` administrative privilege to an existing user (for example, `maja`).

How to do it…

1. Connect to the database as a user who can grant administer key management privilege (for example, `SYS`) and grant the privilege to an existing user (for example, `maja`).
2. To create a password-based software keystore, connect to the database as the user in the previous step (for example, `maja`) and execute the following statement (after you change parameters so that they are appropriate for your environment) (an example is shown in Figure 3):

```
SQL> ADMINISTER KEY MANAGEMENT CREATE KEYSTORE 'keystore_location'
IDENTIFIED BY keystore_password;
```

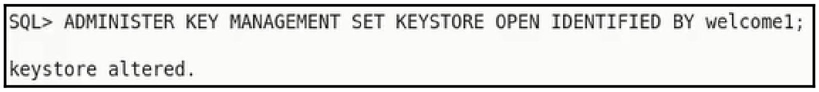


```
SQL> grant administer key management to maja;

Grant succeeded.

SQL> connect maja
Enter password:
Connected.
SQL> ADMINISTER KEY MANAGEMENT CREATE KEYSTORE '/u01/app/oracle/admin/ora12cR1/w
allet' identified by welcome1;

keystore altered.
```

Figure 3 – Creating a password-based software keystore

3. Open the keystore you created in the previous step by executing the following statement (see Figure 4):

   ```
   SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY
   keystore_password;
   ```



```
SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY welcome1;

keystore altered.
```

Figure 4 – Opening the password-based keystore

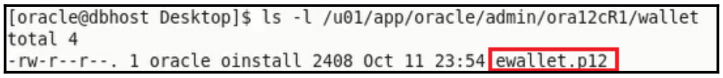
How it works…

In step 2, you create a new wallet, which is a file with `.p12` extension, in a wallet directory.

In step 3, you opened the keystore. It will remain open until you manually close it.

There's more…

Verify that the keystore has been successfully created in step 2 by checking that the file `ewallet.p12` exists in the directory you specified as a keystore location (`ENCRYPTION_WALLET_LOCATION` parameter in `sqlnet.ora`). You should get the similar result to the one shown in Figure 5.



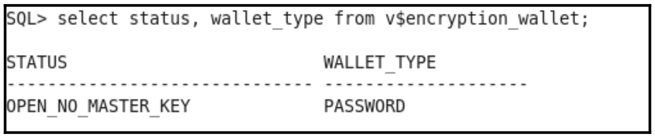
```
[oracle@dbhost Desktop]$ ls -l /u01/app/oracle/admin/ora12cR1/wallet
total 4
-rw-r--r--. 1 oracle oinstall 2408 Oct 11 23:54 ewallet.p12
```

Figure 5

To view the status of the keystore execute the following statements:

```
$ sqlplus / as syskm
SQL> SELECT STATUS, WALLET_TYPE FROM V$ENCRYPTION_WALLET;
```

You should receive the same result as shown in Figure 6. The `OPEN_NO_MASTER_KEY` status means that the keystore is opened, but a master key hasn't been generated yet.



```
SQL> select status, wallet_type from v$encryption_wallet;

STATUS                         WALLET_TYPE
------------------------------ --------------------
OPEN_NO_MASTER_KEY             PASSWORD
```

Figure 6

Setting master encryption key in software keystore

In this recipe, you're going to create the first master key for the password-based software keystore you created and opened in the previous recipe.

Getting ready

It is assumed that software keystore is already opened. To complete this recipe, you'll need an existing user who has the `SYSKM` administrative or administer key management privilege (for example, `maja`).

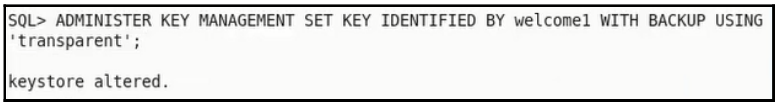
How to do it…

1. Connect to the database as a user who has the `SYSKM` administrative or administer key management privilege (for example, `maja`):

   ```
   $ sqlplus maja
   ```

2. Create a master key for the password-based keystore (Figure 7 shows the creation of master key for the keystore you created in the recipe *Creating and opening the keystore*):

```
SQL> ADMINISTER KEY MANAGEMENT SET KEY IDENTIFIED BY
keystore_password
WITH BACKUP
USING 'desc_purpose';
```



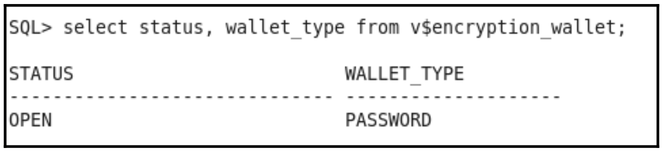
```
SQL> ADMINISTER KEY MANAGEMENT SET KEY IDENTIFIED BY welcome1 WITH BACKUP USING
'transparent';

keystore altered.
```

Figure 7

There's more…

The `WITH BACKUP` clause in step 2 instructs Oracle Database to create a backup of a keystore before the creation of a master key. This backup is created in the same directory where keystore resides and is created in the form `ewallet_timestamp.p12` (where timestamp represents timestamp of backup creation).

Verify the status of the keystore (Figure 8):



```
SQL> select status, wallet_type from v$encryption_wallet;

STATUS                         WALLET_TYPE
------------------------------ --------------------
OPEN                           PASSWORD
```

Figure 8 – The status of the keystore after master key was created

See also

- If you want to learn to change a master key, see the *Rekeying* recipe.

Column encryption – adding new encrypted column to table

In this recipe, you'll add a new column, which will be encrypted using a nondefault encryption algorithm, to an existing table.

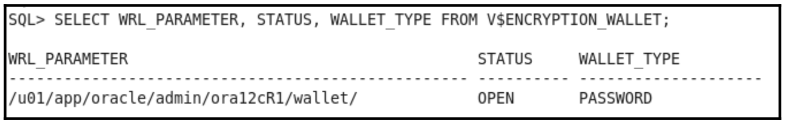
Getting ready

It is assumed that a keystore is opened and a master key is created.

How to do it…

1. Connect to the database as a user who has administer key privilege or `SYSKM` privilege (for example, `maja`) and verify that the keystore is in the `OPEN` status. You should get the result similar to the one depicted in Figure 9:

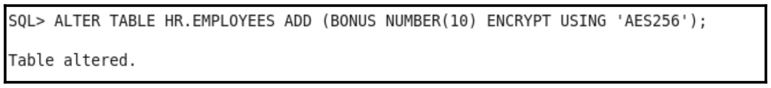
```
$ sqlplus maja
```



```
SQL> SELECT WRL_PARAMETER, STATUS, WALLET_TYPE FROM V$ENCRYPTION_WALLET;

WRL_PARAMETER                                      STATUS     WALLET_TYPE
-------------------------------------------------- ---------- --------------------
/u01/app/oracle/admin/ora12cR1/wallet/             OPEN       PASSWORD
```

Figure 9

2. Add a column (for example, `bonus`) to a table (for example, `hr.employees`), encrypted using the AES 256 algorithm.



```
SQL> ALTER TABLE HR.EMPLOYEES ADD (BONUS NUMBER(10) ENCRYPT USING 'AES256');

Table altered.
```

Figure 10 – Adding the new encrypted column to the table

Column encryption – creating new table that has encrypted column(s)

In this recipe, you're going to learn to use TDE column encryption to encrypt columns in a newly created table.

Getting ready

It is assumed that a keystore is opened and a master key is created.

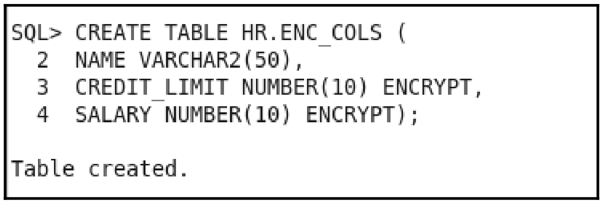
How to do it…

1. Connect to the database as a user who has administer key privilege or `SYSKM` privilege (for example, `maja`):

   ```
   $ sqlplus maja
   ```

2. Create a new table (for example, table `enc_cols` in schema `hr`) that has, for example, the following structure:

Column name	**Column type**	**Encrypted**
`NAME`	`VARCHAR2` (50)	No
`CREDIT_LIMIT`	`NUMBER` (10)	Yes, AES192
`SALARY`	`NUMBER` (10)	Yes, AES192



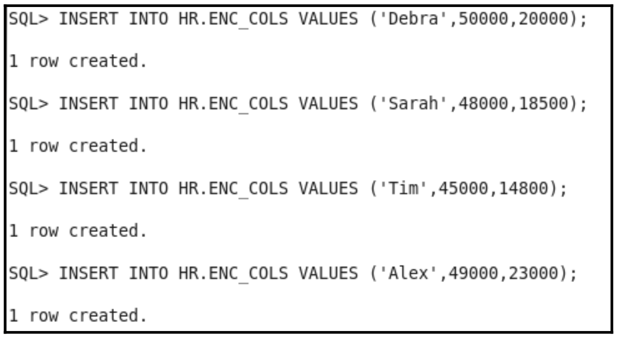
```
SQL> CREATE TABLE HR.ENC_COLS (
  2  NAME VARCHAR2(50),
  3  CREDIT_LIMIT NUMBER(10) ENCRYPT,
  4  SALARY NUMBER(10) ENCRYPT);

Table created.
```

Figure 11 – A syntax to create the table hr.enc_cols

3. Connect to the database as a user who can insert and view data in the table (for example, `hr` user):

```
SQL> connect hr
```

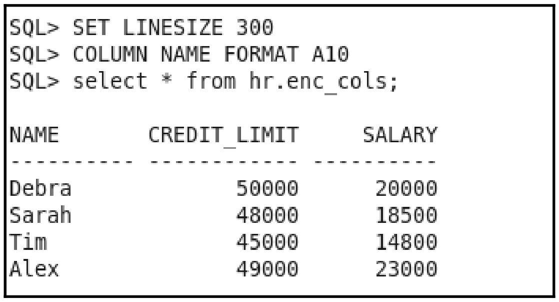
4. Insert several arbitrary values into the table `HR.ENC_COLS`.



```
SQL> INSERT INTO HR.ENC_COLS VALUES ('Debra',50000,20000);

1 row created.

SQL> INSERT INTO HR.ENC_COLS VALUES ('Sarah',48000,18500);

1 row created.

SQL> INSERT INTO HR.ENC_COLS VALUES ('Tim',45000,14800);

1 row created.

SQL> INSERT INTO HR.ENC_COLS VALUES ('Alex',49000,23000);

1 row created.
```

Figure 12 – Test values

5. Verify that the user can view unencrypted values in all columns.

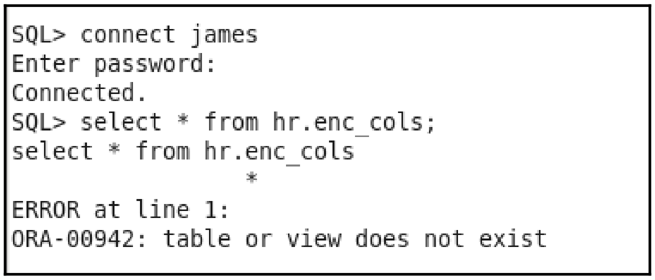


```
SQL> SET LINESIZE 300
SQL> COLUMN NAME FORMAT A10
SQL> select * from hr.enc_cols;

NAME       CREDIT_LIMIT     SALARY
---------- ------------ ----------
Debra             50000      20000
Sarah             48000      18500
Tim               45000      14800
Alex              49000      23000
```

Figure 13- Encryption is transparent

6. Connect to the database as a user who can't view data in the table (for example, `james`) and try to view data in all columns:

```
SQL> connect james
SQL> select * from hr.enc_cols;
```



```
SQL> connect james
Enter password:
Connected.
SQL> select * from hr.enc_cols;
select * from hr.enc_cols
                 *
ERROR at line 1:
ORA-00942: table or view does not exist
```

Figure 14 – User who doesn't have "view" privilege(s) won't see encrypted values

Using salt and MAC

In this recipe, you'll understand when you should use salt and MAC.

Getting ready

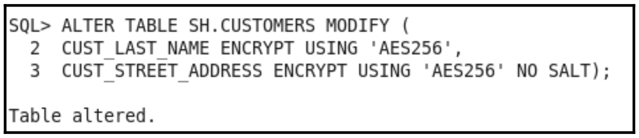
It is assumed that a keystore is opened and a master key is created.

How to do it…

1. Connect to the database as a user who has administer key privilege or `SYSKM` privilege (for example, `maja`):

```
$ connect maja
```

2. Encrypt two columns in an existing table (for example, `sh.customers`)



```
SQL> ALTER TABLE SH.CUSTOMERS MODIFY (
  2  CUST_LAST_NAME ENCRYPT USING 'AES256',
  3  CUST_STREET_ADDRESS ENCRYPT USING 'AES256' NO SALT);

Table altered.
```

Figure 15 – Using salt and MAC

How it works…

In step 2:

- You encrypted the `last_name` column using the AES256 algorithm with salt and used MAC
- You encrypted the `cust_street_address` column using the AES256 algorithm with no salt and used MAC

In general, you have to use same encryption algorithm for all encrypted columns at the same time. You can choose a `SALT` option on the encrypted column level in a table, but you have to choose either the `MAC` or `NOMAC` option on a table level (meaning that all encryption columns in a table must use the same option).

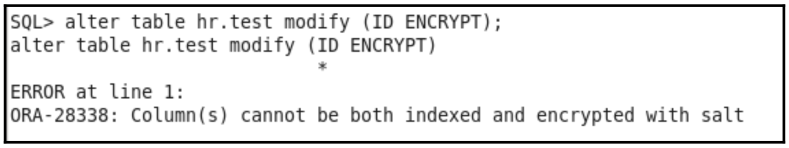
There's more…

To understand why salt is important, let's consider a basic scenario that doesn't use salt. For example, if we have 100 rows and they contain only values *A*, *B*, *C*, and *D*, this will mean that there are only 4 different values in 100 rows. If we know that value *A* exists in 3 rows, value *B* exists in 20, value C exists in 30, and value *D* exists in 47 rows, we can then check **cyphertexts** (because there will be only 4 different values in cyphertext as well). By evaluating it, we can find that one cyphertext that exists in 3 rows will be value *A*, one that exists in 20 rows will be value *B*, and so on. In order to avoid this problem, we can introduce salt. Salt is used to ensure that each encrypted row has different cyphertext regardless of number of same values in plaintext rows. In our previous example, if we used salt, even though there were only 4 different plaintext values in 100 rows, there will be 100 different cyphertext values in 100 rows, which will be almost impossible for attacker to presume which value corresponds to which row. Consequently, there is no need for salt if plaintext values are unique. There is additional storage cost of 16 bytes per row for salt.

Salt cannot be used on indexed columns.

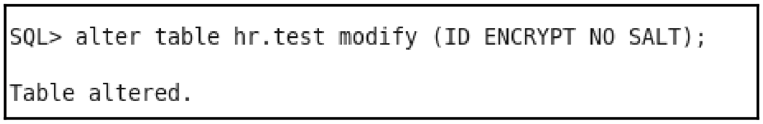
MAC (short for **Message Authentication Code**) is a hash value computed on encrypted data, which is used for data integrity verification. There is the additional storage cost of 20 bytes per row.

By default, both salt and MAC are used.



```
SQL> alter table hr.test modify (ID ENCRYPT);
alter table hr.test modify (ID ENCRYPT)
                               *
ERROR at line 1:
ORA-28338: Column(s) cannot be both indexed and encrypted with salt
```

Figure 16 – TDE column restriction



```
SQL> alter table hr.test modify (ID ENCRYPT NO SALT);

Table altered.
```

Figure 17 – Encrypted primary key with no salt

It is not possible to have salt on indexed column. In Figure 16, it is shown that column ID (which is primary key) cannot be encrypted with salt. In Figure 17 is shown that after changing attribute to `NOSALT`, the primary key column is successfully encrypted.

Column encryption – encrypting existing column

It is common case that organizations first create database and later decide that they want to implement encryption. In this recipe, you're going to encrypt an existing column using TDE column encryption.

Getting ready

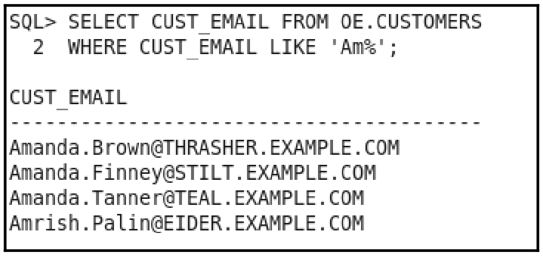
It is assumed that a keystore is opened and a master key is created.

How to do it…

1. Connect to the database as a user who can read data from the `OE.CUSTOMERS` table (for example, the `oe` user):

   ```
   $ sqlplus oe
   ```

2. Select data from column you want to encrypt (for example, `cust_email`), just to verify that the user can view it.



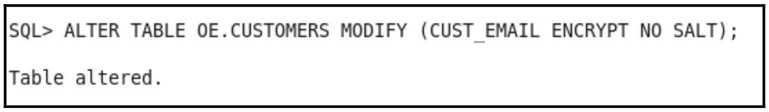
```
SQL> SELECT CUST_EMAIL FROM OE.CUSTOMERS
  2  WHERE CUST_EMAIL LIKE 'Am%';

CUST_EMAIL
----------------------------------------
Amanda.Brown@THRASHER.EXAMPLE.COM
Amanda.Finney@STILT.EXAMPLE.COM
Amanda.Tanner@TEAL.EXAMPLE.COM
Amrish.Palin@EIDER.EXAMPLE.COM
```

Figure 18 – A test query

3. Connect to the database as a user who has administer key privilege or `SYSKM` privilege (for example, `maja`):

   ```
   SQL> connect maja
   ```

4. Encrypt the `cust_email` column in the `oe.customers` table using the default encryption algorithm (AES192) and no salt.



```
SQL> ALTER TABLE OE.CUSTOMERS MODIFY (CUST_EMAIL ENCRYPT NO SALT);

Table altered.
```

Figure 19 – Encrypting an existing column, which has an index

5. Execute steps 1 and 2 again to verify that there is no change in the way user/application views data after TDE column encryption is applied.

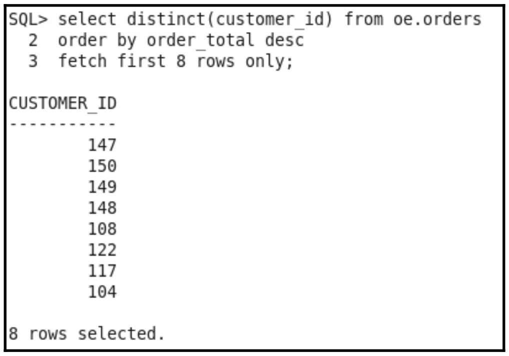
There's more…

This example demonstrates that you can't use TDE column encryption to encrypt column, which is a foreign key. If you need to encrypt that kind of column, use TDE tablespace encryption.

1. Connect to the database as a user who can select data from a table, for example, `OE.ORDERS` (for example, the `oe` user):

   ```
   $ sqlplus oe
   ```

2. Select data from the foreign key column you want to encrypt (for example, `customer_id`), just to verify the user can view it.



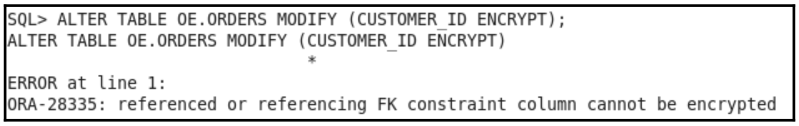
```
SQL> select distinct(customer_id) from oe.orders
  2  order by order_total desc
  3  fetch first 8 rows only;

CUSTOMER_ID
-----------
        147
        150
        149
        148
        108
        122
        117
        104

8 rows selected.
```

Figure 20 – A simple test query

3. Connect to the database as a user who has administer key privilege or `SYSKM` privilege (for example, `maja`):

```
SQL>  connect maja
```

4. Encrypt the `customer_id` column in the `oe.orders` table using the default encryption algorithm (AES192).



```
SQL> ALTER TABLE OE.ORDERS MODIFY (CUSTOMER_ID ENCRYPT);
ALTER TABLE OE.ORDERS MODIFY (CUSTOMER_ID ENCRYPT)
                              *
ERROR at line 1:
ORA-28335: referenced or referencing FK constraint column cannot be encrypted
```

Figure 21 – A TDE column encryption restriction

Auto-login keystore

Autologin keystore is a type of keystore that doesn't need to be manually opened. The local autologin keystore can be opened only from computer where it has been created. Autologin keystores have system-generated passwords. They are less secure than password-based keystores. They are created from password-based software keystores.

Getting ready

It is assumed that password-based software keystore is created.

How to do it…

1. Connect to the database as a user who has administer key privilege or `SYSKM` privilege (for example, `maja`):

```
$ sqlplus maja
```

2. Create (local) an autologin keystore. In our case, `keystore_location` is `/u01/app/oracle/admin/ora12cR1/wallet and keystore_password` is `welcome1`:

    ```
    SQL> ADMINISTER KEY MANAGEMENT CREATE LOCAL AUTO_LOGIN KEYSTORE FROM
    KEYSTORE 'keystore_location' IDENTIFIED BY keystore_password;
    OR
    SQL> ADMINISTER KEY MANAGEMENT CREATE AUTO_LOGIN KEYSTORE FROM
    KEYSTORE 'keystore_location' IDENTIFIED BY keystore_password;
    ```

How it works…

After you executed statement in step 2, in directory that holds password-based keystore, the `cwallet.sso` file was created. That file represents autologin keystore.

Encrypting tablespace

It is not possible to encrypt an existing tablespace using TDE tablespace encryption. In this recipe, you'll create a new encrypted tablespace.

Getting ready

It is assumed that a keystore is opened and a master key is created.

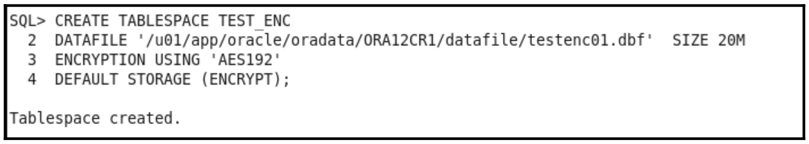
How to do it…

1. Connect to the database as a user who has a create tablespace privilege (for example, `zoran`):

    ```
    $ sqlplus zoran
    ```

2. Create encrypted tablespace (for example, `TEST_ENC`) using AES192 encryption algorithm:

```
SQL> CREATE TABLESPACE TEST_ENC
DATAFILE '/u01/app/oracle/oradata/ORA12CR1/datafile/testenc01.dbf'
SIZE 20M
ENCRYPTION USING 'AES192'
DEFAULT STORAGE (ENCRYPT);
```

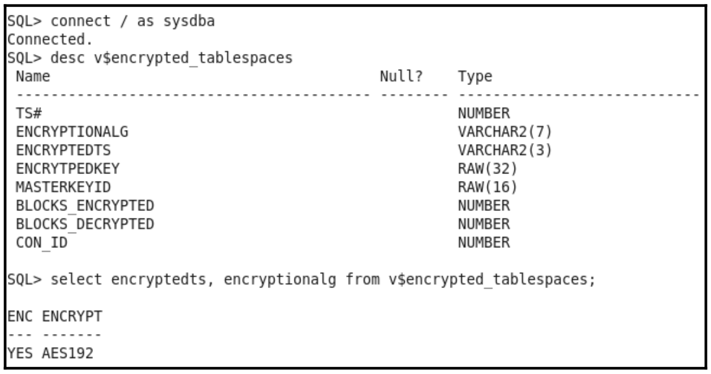


```
SQL> CREATE TABLESPACE TEST_ENC
  2  DATAFILE '/u01/app/oracle/oradata/ORA12CR1/datafile/testenc01.dbf'  SIZE 20M
  3  ENCRYPTION USING 'AES192'
  4  DEFAULT STORAGE (ENCRYPT);

Tablespace created.
```

Figure 22 – Encrypting tablespace

How it works…

In step 2, you create an encrypted tablespace `TEST_ENC`. To find information about encrypted tablespaces, you can query the `V$ENCRYPTED_TABLESPACES` view.



```
SQL> connect / as sysdba
Connected.
SQL> desc v$encrypted_tablespaces
 Name                                      Null?    Type
 ----------------------------------------- -------- ----------------------------
 TS#                                                NUMBER
 ENCRYPTIONALG                                      VARCHAR2(7)
 ENCRYPTEDTS                                        VARCHAR2(3)
 ENCRYTPEDKEY                                       RAW(32)
 MASTERKEYID                                        RAW(16)
 BLOCKS_ENCRYPTED                                   NUMBER
 BLOCKS_DECRYPTED                                   NUMBER
 CON_ID                                             NUMBER

SQL> select encryptedts, encryptionalg from v$encrypted_tablespaces;

ENC ENCRYPT
--- -------
YES AES192
```

Figure 23 – Finding information about encrypted tablespace

There's more…

You can import existing tables into encrypted tablespace using Oracle Data Pump. Another option is to use SQL statements, for example, **CTAS** (short for **CREATE TABLE AS**).

Rekeying

You can change (rekey) a master key and table keys. You cannot rekey tablespace keys.

Getting ready

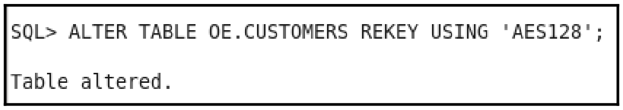
It is assumed that a keystore is opened and a master key is created.

How to do it…

1. Connect to the database as a user who has administer key privilege or `SYSKM` privilege (for example, `maja`):

   ```
   $ sqlplus maja
   ```

2. To rekey a table (for example, the `oe.customer`) using a different encryption algorithm (for example, AES128), execute the following statement:

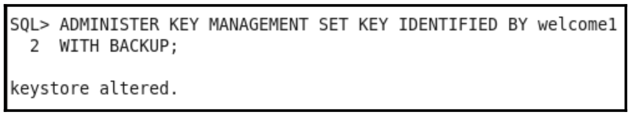


```
SQL> ALTER TABLE OE.CUSTOMERS REKEY USING 'AES128';

Table altered.
```

Figure 24 – Rekeying a table key

3. Change a master key by executing the following statement (in our example, `keystore_password` is `welcome1`):

```
SQL> ADMINISTER KEY MANAGEMENT SET KEY IDENTIFIED BY
keystore_password
WITH BACKUP;
```



```
SQL> ADMINISTER KEY MANAGEMENT SET KEY IDENTIFIED BY welcome1
  2  WITH BACKUP;

keystore altered.
```

Figure 25 – Rekeying a master key

How it works…

When you changed a table key, in step 2, all encrypted data in the oe.customers table were decrypted and then encrypted using the new table key and the new encryption algorithm. If you just want to change key and use the same algorithm as before, syntax for rekeying is:

```
ALTER TABLE table_name REKEY;
```

In step 3, you created a backup of the keystore and created a new master key in the keystore. Old master keys are held in the keystore.

It is extremely important to have backup of the keystore.

Backup and Recovery

RMAN supports three encryption modes:

- Transparent mode
- Password mode
- Dual mode

In this recipe, you're going to learn to create encrypted backups using RMAN.

How to do it…

1. Connect to the RMAN as user who has the `sysbackup` privilege:

   ```
   $ rman target '"zoran@orcl as sysbackup"'
   ```

2. Configure encryption on a database level:

   ```
   RMAN> CONFIGURE ENCRYPTION FOR DATABASE ON;
   ```

3. Backup a tablespace example in transparent mode:

   ```
   RMAN> BACKUP TABLESPACE EXAMPLE tag 'tran_mode';
   ```

4. Enable dual mode encryption and backup tablespace example in dual mode:

   ```
   RMAN> SET ENCRYPTION ON IDENTIFIED BY "password_1";
   RMAN> BACKUP TABLESPACE EXAMPLE tag 'dual_mode';
   ```

5. Enable password mode and backup tablespace example in password mode:

   ```
   RMAN> SET ENCRYPTION ON IDENTIFIED BY "password_2" ONLY;
   RMAN> BACKUP TABLESPACE EXAMPLE tag 'pass_mode';
   ```

There's more…

If a backup is created in transparent mode, it can be restored only by using a key that is used to create the backup (stored in the external keystore).

If the backup is created in password mode, it can be restored only by using a password that is provided during the backup.

If the backup is created in dual mode, it can be restored by either key that is stored in the external keystore or the password that is provided during the backup.

9 Database Vault

In this chapter, we will cover the following tasks:

- Registering Database Vault
- Preventing users from exercising system privileges on schema objects
- Securing roles
- Preventing users from executing a specific command on a specific object
- Creating a rule set
- Creating a secure application role
- Using Database Vault to implement that administrators cannot view data
- Running Oracle Database Vault reports
- Disabling Database Vault
- Re-enabling Database Vault

Introduction

Introduction of Oracle Database Vault in 2005 brought a major change in the way security is enforced. Today, 10 years after it was introduced, it remains the most significant tool to control data access and enforce separation of duties in Oracle Database.

From licensing viewpoint, it is only available as an option for Oracle Database Enterprise Edition.

You need to understand how, when, why, and which component of Database Vault you should implement in order to successfully protect your database. In this chapter, you are going to learn to create and appropriately use realms, rules, rule sets, command rules, factors, and secure application roles. Basic concepts are covered in this chapter, whereas doing everyday administration tasks in Database Vault environment, more advanced topics, and security in more complex environments are explained in `Chapter 11`, *Additional Topics*.

For all recipes in this chapter, we assume that database is up and running, and each user has at least a `create session` privilege. Also, you will use Oracle Enterprise Manager Cloud Control 12c.

A `SYS` user, because he is the most powerful user, will be used to test that security is correctly enforced (even for him).

Recipes are tested on Oracle Database 12.1.0.2 in multitenant environment.

Registering Database Vault

In Oracle Database 12c process of configuring and enabling Database Vault is different than in Oracle Database 11g. In this recipe, you will learn to register Oracle Database Vault in multitenant environment in two situations:

- When Oracle Database 12c is already installed
- During the installation of Oracle Database 12c

Getting ready

To complete this recipe, you'll need an existing common user who has a privilege to create users and grant `create session` and `set container` privileges (for example, `c##maja`).

How to do it…

To register Database Vault with Oracle Database 12c when the database is already installed, perform the following steps:

1. Connect to the root container as a user who has privileges to create users and grant `create session` and `set container` privileges (for example, `c##maja`):

   ```
   $ sqlplus c##maja
   ```

2. Create two users (for example, `c##dbv_owner` and `c##dbv_acctmgr`) and grant them `create session` and `set container` privileges:

   ```
   SQL> create user c##dbv_owner identified by oraDVO123 CONTAINER =
   ALL;
   SQL> grant create session, set container to c##dbv_owner CONTAINER =
   ALL;
   SQL> create user c##dbv_acctmgr identified by oraDVA123 CONTAINER =
   ALL;
   SQL> grant create session, set container to c##dbv_acctmgr CONTAINER
   = ALL;
   ```

3. Connect to the root as a `SYS` user:

   ```
   SQL> connect sys as sysdba
   ```

4. Configure the Database Vault users:

   ```
   SQL> begin
   DVSYS.CONFIGURE_DV (
   dvowner_uname => 'c##dbv_owner',
   dvacctmgr_uname => 'c##dbv_acctmgr');
   end;
   /
   ```

5. Execute the `utlrp.sql` script:

   ```
   SQL> @?/rdbms/admin/utlrp.sql
   ```

6. Connect to the root as the Database Vault Owner user that you just configured (for example, the `c##dbv_owner`):

   ```
   SQL> connect c##dbv_owner/oraDVO123
   ```

7. Enable Oracle Database Vault:

   ```
   SQL> exec DBMS_MACADM.ENABLE_DV
   ```

8. Connect as a `SYS` user:

   ```
   SQL> CONNECT / AS SYSDBA
   ```

9. Restart the database.

For each PDB, perform step 3 through step 8 and then close and reopen the pluggable database (for example, `PDB1`).

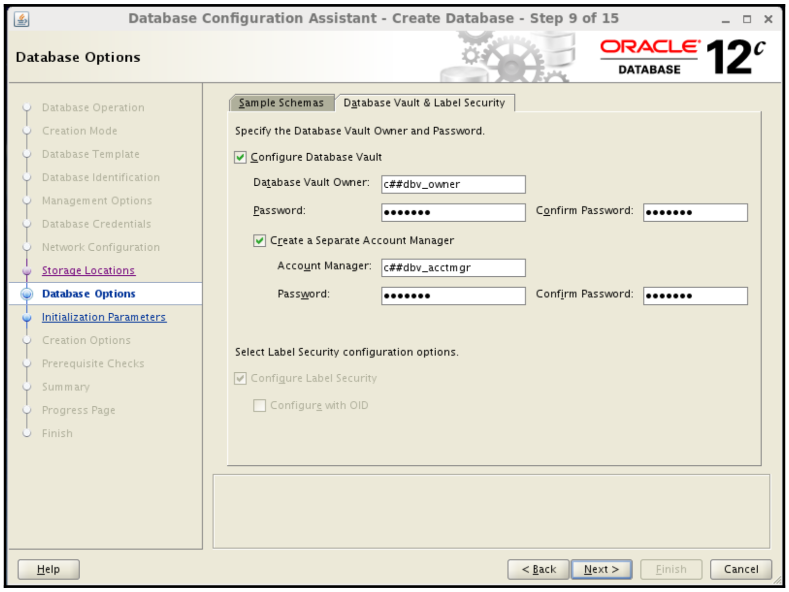
```
SQL> alter pluggable database pdb1 close immediate;

SQL> alter pluggable database pdb1 open;
```

How it works…

After you register Oracle Database Vault with Oracle Database 12c, there are number of changes in the Oracle Database. Some database parameters change values, separation of duties is enabled by revoking privileges from some roles and by creating new users.

There's more…

You use **Database Configuration Assistant** (**DBCA**) when you configure Database Vault during the database installation. When you get to step 9 (**Database Options**), click on tab **Database Vault & Label Security**. Select both available checkboxes and fill out text fields to create users: **Database Vault Owner** and **Account Manager** (see Figure 1). You should complete the rest of the installation in the same way you usually do.


Database Configuration Assistant - Create Database - Step 9 of 15

Database Options

Specify the Database Vault Owner and Password.

[✓] Configure Database Vault

Database Vault Owner: c##dbv_owner

Password: ••••••• Confirm Password: •••••••

[✓] Create a Separate Account Manager

Account Manager: c##dbv_acctmgr

Password: ••••••• Confirm Password: •••••••

Select Label Security configuration options.

[✓] Configure Label Security

[ ] Configure with OID

Figure 1 – Using DBCA to register Oracle Database Vault

See also

- *Disabling Database Vault*
- *Re-enabling Database Vault*

Preventing users from exercising system privileges on schema objects

In this recipe, to prevent users to exercise system privileges (such as `select any table`), you are going to first create a **realm** and then you are going to change it to a **mandatory realm**. The mandatory realm further restricts access to protected objects. Schema owners and users with object privileges cannot access mandatory realm-secured objects if they are not authorized in realm.

Getting ready

To complete this recipe, you'll need an existing common user who has a DBA role in the pluggable database PDB1 (for example, c##zoran).

How to do it…

1. Connect to a pluggable database (for example, pdb1) as a Database Vault account manager (for example, c##dbv_acctmgr):

   ```
   SQL> connect c##dbv_acctmgr@pdb1
   ```

2. Create a new local user in the pluggable database (for example, usr1):

   ```
   SQL> create user usr1 identified by oracle;
   ```

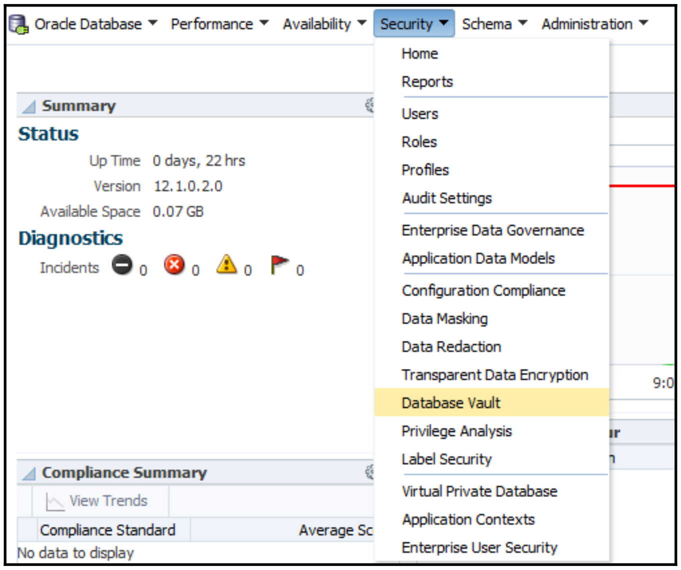
3. Connect to the pluggable database as a common user who has a DBA role in pdb1 (for example, c##zoran):

   ```
   SQL> connect c##zoran@pdb1
   ```

4. Grant the select privilege on the table HR.EMPLOYEES and the create session privilege to the user usr1:

   ```
   SQL> grant select on hr.employees to usr1;

   SQL> grant create session to usr1;
   ```

5. Connect to the Enterprise Manager Cloud Control 12c (EM) as a privileged user (SYSMAN or some other privileged user, for example, zoran). From **Security** drop-down menu, choose **Database Vault** (see Figure 2).



Status

Up Time	0 days, 22 hrs
Version	12.1.0.2.0
Available Space	0.07 GB

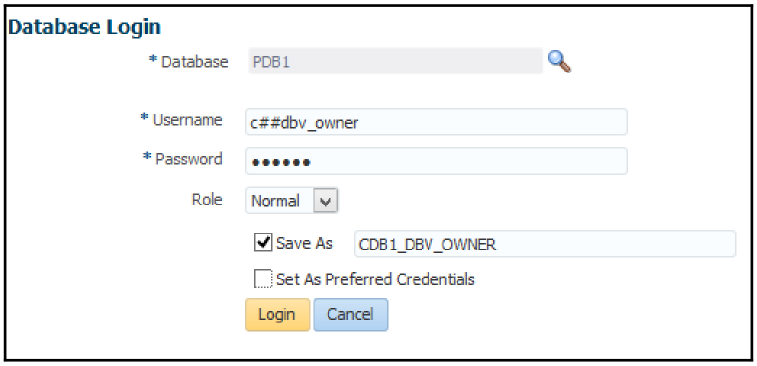
Diagnostics

Incidents ● 0 ✖ 0 ⚠ 0 ⚑ 0

No data to display

Figure 2 – Selecting Database Vault

6. Log in to the pluggable database `PDB1` as a user who is the Database Vault Owner (see Figure 3).



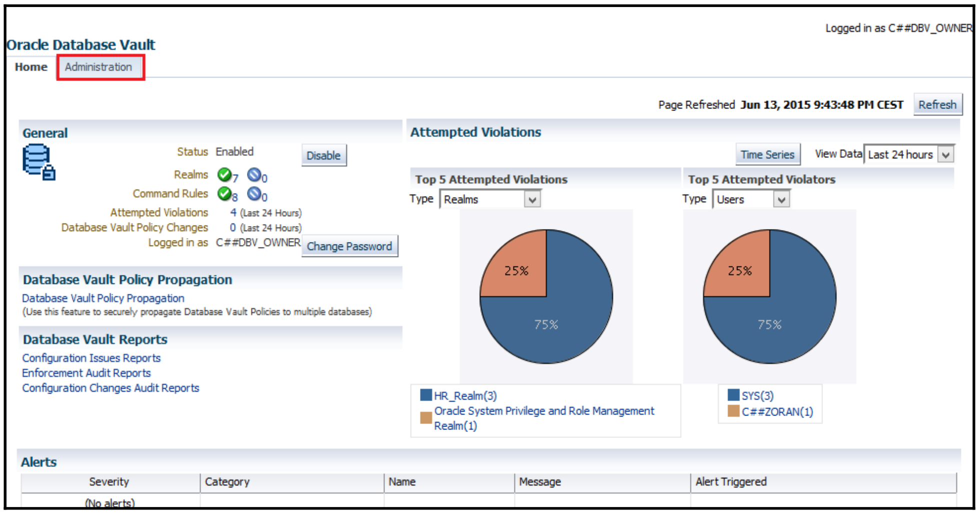
Database Login

* Database	PDB1
* Username	c##dbv_owner
* Password	••••••
Role	Normal

[✓] Save As CDB1_DBV_OWNER

[ ] Set As Preferred Credentials

7. On the next page, click on the **Administration** tab (see Figure 4).



Logged in as C##DBV_OWNER

Oracle Database Vault

Home | Administration

Page Refreshed **Jun 13, 2015 9:43:48 PM CEST** Refresh

General

Status Enabled (Disable)
Realms ✓ 7 ⊘ 0
Command Rules ✓ 8 ⊘ 0
Attempted Violations 4 (Last 24 Hours)
Database Vault Policy Changes 0 (Last 24 Hours)
Logged in as C##DBV_OWNER (Change Password)

Database Vault Policy Propagation

Database Vault Policy Propagation
(Use this feature to securely propagate Database Vault Policies to multiple databases)

Database Vault Reports

Configuration Issues Reports
Enforcement Audit Reports
Configuration Changes Audit Reports

Attempted Violations

Time Series | View Data Last 24 hours

Top 5 Attempted Violations — Type Realms: 25%, 75%
🟦 HR_Realm(3)
🟧 Oracle System Privilege and Role Management Realm(1)

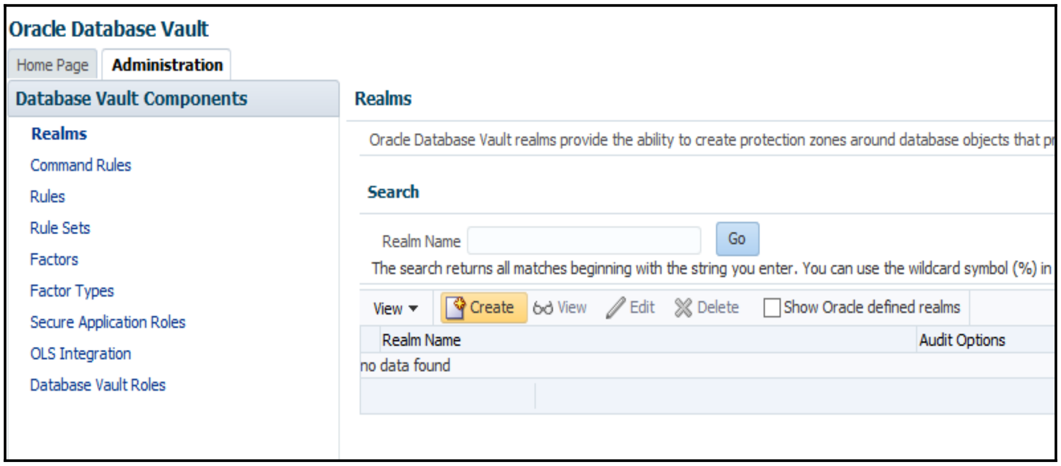
Top 5 Attempted Violators — Type Users: 25%, 75%
🟦 SYS(3)
🟧 C##ZORAN(1)

Alerts

Severity	Category	Name	Message	Alert Triggered
(No alerts)				

Figure 4 – Switching to the Administration tab

8. Create `HR_Realm`, as shown in the following figures (Figure 5 – 8). First, click on the **Create** button.



Oracle Database Vault

Home Page | **Administration**

Database Vault Components

Realms
Command Rules
Rules
Rule Sets
Factors
Factor Types
Secure Application Roles
OLS Integration
Database Vault Roles

Realms

Oracle Database Vault realms provide the ability to create protection zones around database objects that p

Search

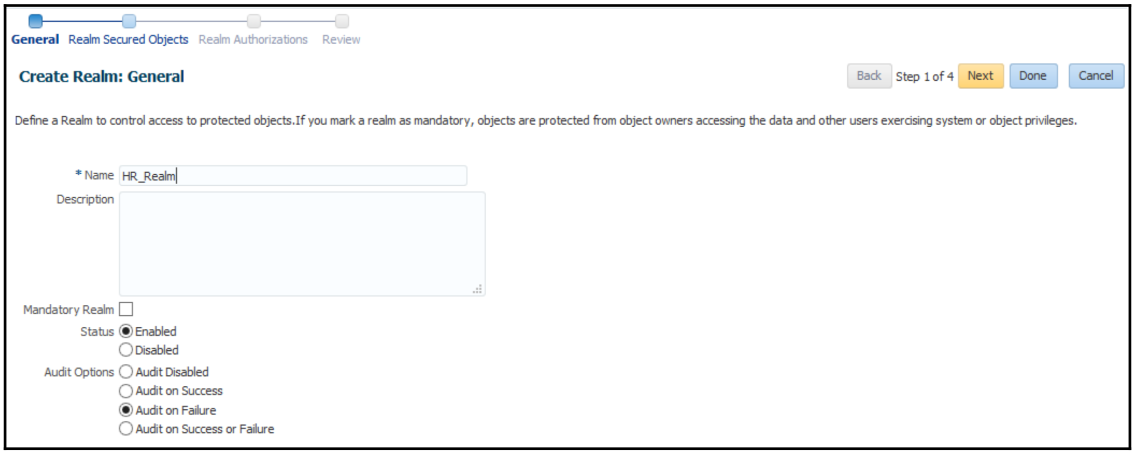
Realm Name [ ] Go

The search returns all matches beginning with the string you enter. You can use the wildcard symbol (%) in

View ▾ | Create | View | Edit | Delete | ☐ Show Oracle defined realms

Realm Name	Audit Options
no data found	

9. Name the realm (for example, `HR_Realm`) and leave default values for other parts of the form.

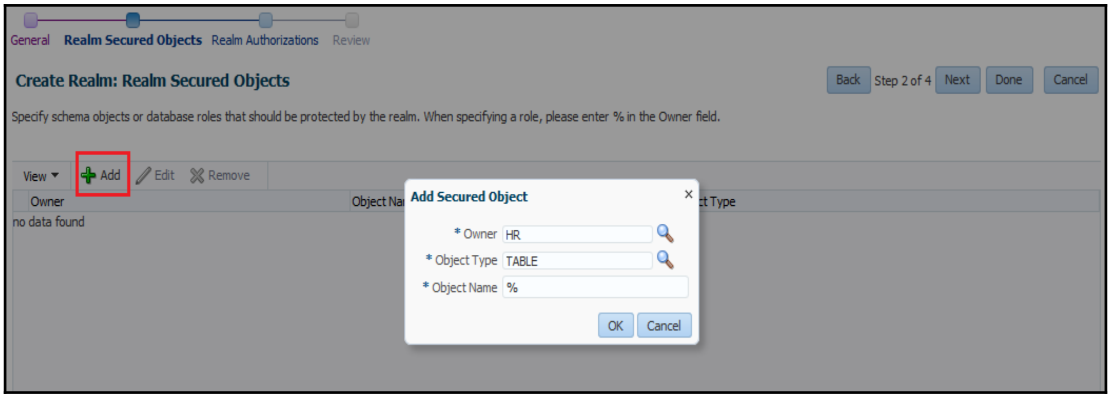


Create Realm: General

Define a Realm to control access to protected objects.If you mark a realm as mandatory, objects are protected from object owners accessing the data and other users exercising system or object privileges.

* Name: HR_Realm
Description:
Mandatory Realm: ☐
Status: [✓ Enabled] Disabled
Audit Options: Audit Disabled / Audit on Success / [✓ Audit on Failure] / Audit on Success or Failure

10. Securing all tables in `HR` schema.



Create Realm: Realm Secured Objects

Specify schema objects or database roles that should be protected by the realm. When specifying a role, please enter % in the Owner field.

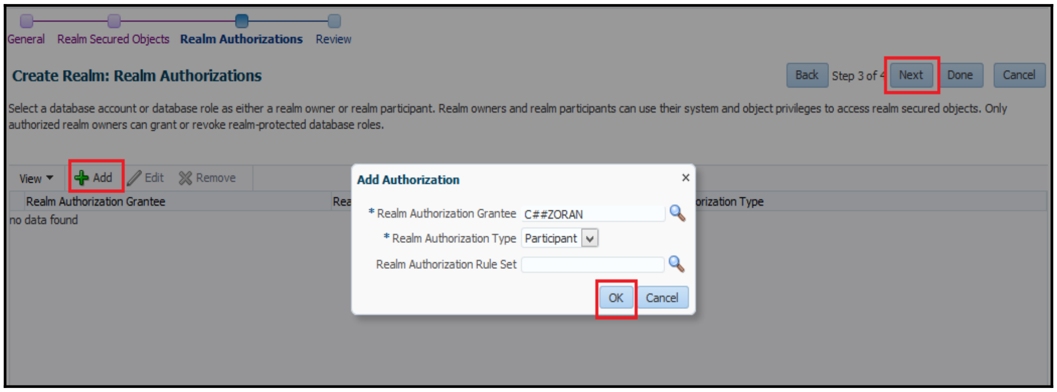
Owner	Object Na	ct Type
no data found		

Add Secured Object

* Owner: HR
* Object Type: TABLE
* Object Name: %

Figure 7 – Adding secured objects

11. Add realm participant (for example, `C##ZORAN`).



Create Realm: Realm Authorizations

Select a database account or database role as either a realm owner or realm participant. Realm owners and realm participants can use their system and object privileges to access realm secured objects. Only authorized realm owners can grant or revoke realm-protected database roles.

Realm Authorization Grantee	Rea...	...orization Type
no data found		

Add Authorization

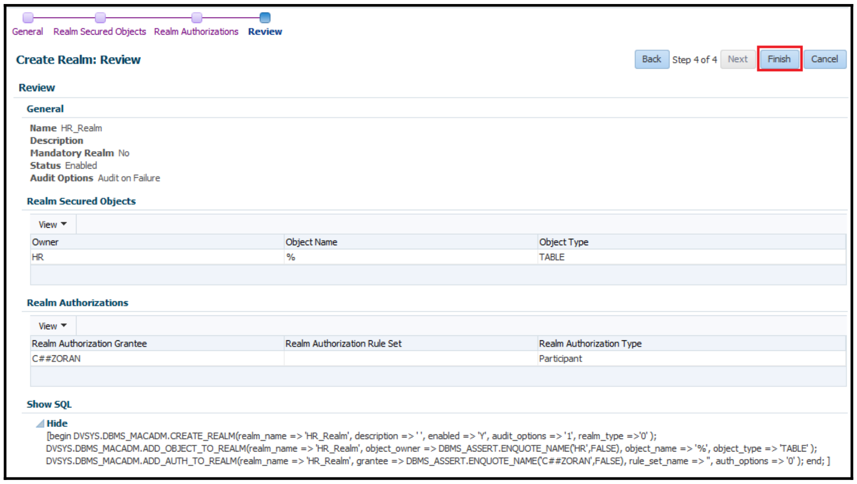
* Realm Authorization Grantee: C##ZORAN
* Realm Authorization Type: Participant

Realm Authorization Rule Set:

OK Cancel

Figure 8 – Adding authorized user(s)

12. After you make sure that you chose the options you wanted, click on the **Finish** button.



Create Realm: Review

Review

General

Name HR_Realm
Description
Mandatory Realm No
Status Enabled
Audit Options Audit on Failure

Realm Secured Objects

Owner	Object Name	Object Type
HR	%	TABLE

Realm Authorizations

Realm Authorization Grantee	Realm Authorization Rule Set	Realm Authorization Type
C##ZORAN		Participant

Show SQL

Hide

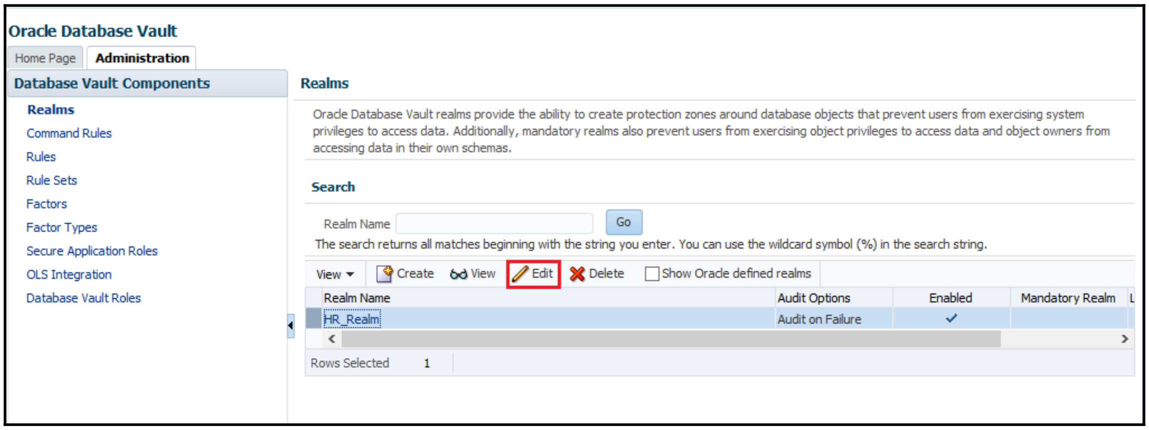
```
[begin DVSYS.DBMS_MACADM.CREATE_REALM(realm_name => 'HR_Realm', description => ' ', enabled => 'Y', audit_options => '1', realm_type =>'0' );
DVSYS.DBMS_MACADM.ADD_OBJECT_TO_REALM(realm_name => 'HR_Realm', object_owner => DBMS_ASSERT.ENQUOTE_NAME('HR',FALSE), object_name => '%', object_type => 'TABLE' );
DVSYS.DBMS_MACADM.ADD_AUTH_TO_REALM(realm_name => 'HR_Realm', grantee => DBMS_ASSERT.ENQUOTE_NAME('C##ZORAN',FALSE), rule_set_name => '', auth_options => '0' ); end; ]
```

Figure 9 – Reviewing and clicking on the Finish button

13. Verify that the `usr1` and `hr` users can view data in the `HR.EMPLOYEES` table:

```
SQL> connect usr1@pdb1

SQL> select count(*) from hr.employees;

  COUNT(*)
----------
       107

SQL> connect hr@pdb1

SQL> select count(*) from hr.employees;

  COUNT(*)
----------
       107
```

14. To provide better security, edit the realm `HR_Realm` and select the checkbox **Mandatory Realm** (see Figure 10 – Figure 12).



Oracle Database Vault realms provide the ability to create protection zones around database objects that prevent users from exercising system privileges to access data. Additionally, mandatory realms also prevent users from exercising object privileges to access data and object owners from accessing data in their own schemas.

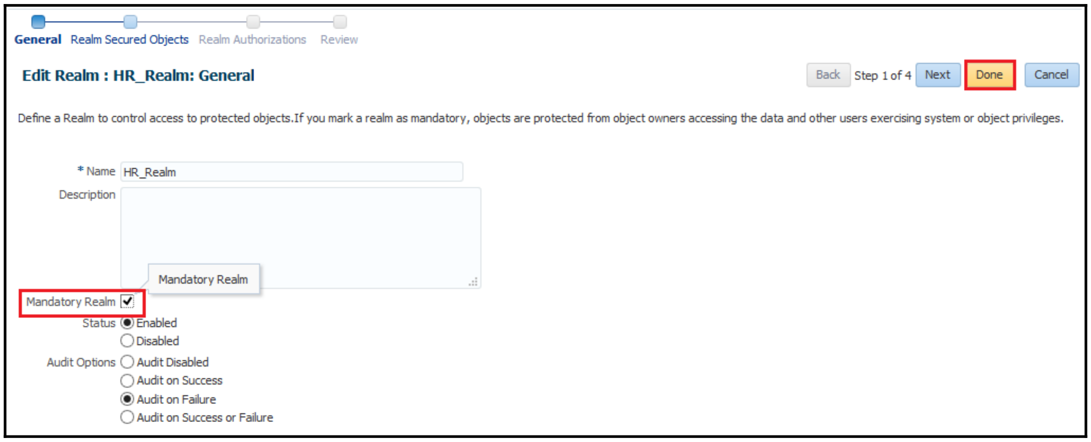
Realm Name

The search returns all matches beginning with the string you enter. You can use the wildcard symbol (%) in the search string.

Realm Name	Audit Options	Enabled	Mandatory Realm
HR_Realm	Audit on Failure	✓	

Rows Selected 1

Figure 10 – Editing HR_Realm



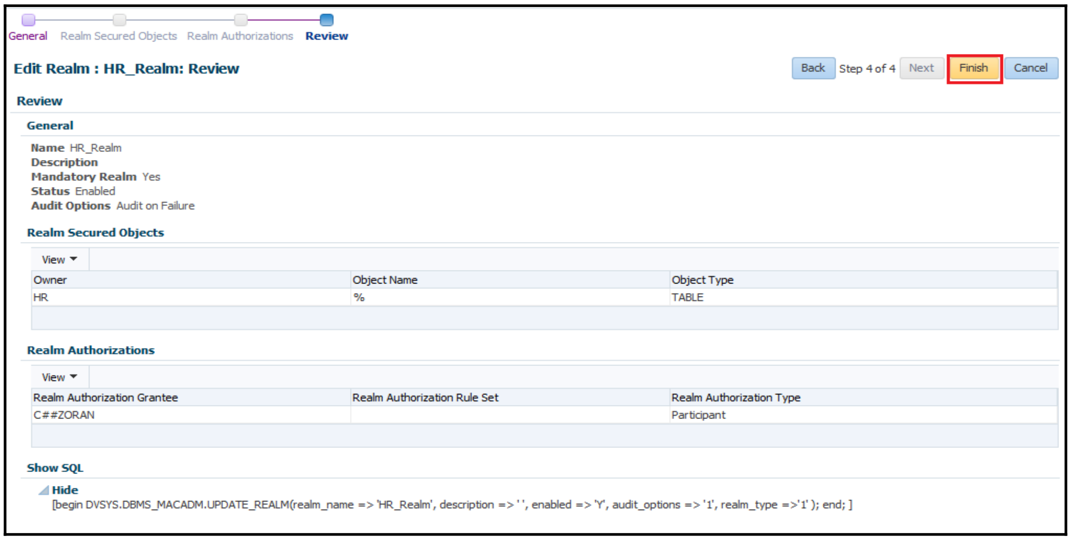
Edit Realm : HR_Realm: General

Define a Realm to control access to protected objects.If you mark a realm as mandatory, objects are protected from object owners accessing the data and other users exercising system or object privileges.

* Name: HR_Realm
Description:
Mandatory Realm: ✓
Status: [● Enabled] ○ Disabled
Audit Options: ○ Audit Disabled ○ Audit on Success [● Audit on Failure] ○ Audit on Success or Failure

Figure 11 – Mandatory Realm checkbox

15. Clicking on the **Finish** button.



Edit Realm : HR_Realm: Review

Review

General

Name HR_Realm
Description
Mandatory Realm Yes
Status Enabled
Audit Options Audit on Failure

Realm Secured Objects

Owner	Object Name	Object Type
HR	%	TABLE

Realm Authorizations

Realm Authorization Grantee	Realm Authorization Rule Set	Realm Authorization Type
C##ZORAN		Participant

Show SQL

```
[begin DVSYS.DBMS_MACADM.UPDATE_REALM(realm_name => 'HR_Realm', description => ' ', enabled => 'Y', audit_options => '1', realm_type =>'1' ); end; ]
```

Figure 12 – Leaving other settings as they were and clicking on the Finish button

There's more…

The difference between **participant** and **owner** of the realm is that a realm participant can only exercise system privileges on realm-secured objects, whereas an owner besides that can grant object privileges on realm-secured objects to other users and roles.

Verify that the SYS user can't create a user, after Database Vault is registered:

```
SQL> connect sys@pdb1 as sysdba

Enter password:
Connected.

SQL> create user usr1 identified by oracle;
create user usr1 identified by oracle
                                *

ERROR at line 1:
ORA-01031: insufficient privileges
```

Verify that after you created realm HR_Realm, the SYS user can't access data in the table HR.EMPLOYEES.

```
SQL> connect sys@pdb1 as sysdba

Enter password:
Connected.

SQL> select count(*) from hr.employees;

select count(*) from hr.employees
                           *
ERROR at line 1:
ORA-01031: insufficient privileges
```

This is the expected behavior because realm protects secured objects from users who try to use their system privileges. In our example, SYS tried to use SELECT ANY TABLE, and because he doesn't have direct object privilege (SELECT on HR.EMPLOYEES), he is restricted from selecting data in the table HR.EMPLOYEES.

```
SQL> conn c##zoran@pdb1

Enter password:
Connected.
```

```
SQL> select count(*) from hr.employees;

  COUNT(*)
----------
       107
```

After mandatory realm is created, the user `usr1` can't access data in the table `HR.EMPLOYEES` because he/she is not authorized in the realm.

```
SQL> connect usr1@pdb1

Enter password:
Connected.

usr1@CDB1> select count(*) from hr.employees;

select count(*) from hr.employees
                            *
ERROR at line 1:
ORA-01031: insufficient privileges
```

The same principle applies even to the schema owner (`HR`).

```
SQL> connect hr@pdb1

Enter password:
Connected.

SQL> select count(*) from hr.employees;

select count(*) from hr.employees
                            *
ERROR at line 1:
ORA-01031: insufficient privileges
```

See also

- *Securing roles*

Securing roles

In the recipe *Preventing users from exercising system privileges on schema objects*, you secured the table `HR.EMPLOYEES` by creating the `HR_Realm` realm, and afterwards, you edit it and made it mandatory. In this recipe, you'll learn to protect roles using a realm and a mandatory realm.

Getting ready

To complete this recipe, you'll need to use a `SYS` user.

How to do it…

1. Connect to the pluggable database `PDB1` as a `SYS` user:

   ```
   SQL> connect sys@pdb1 as sysdba
   ```

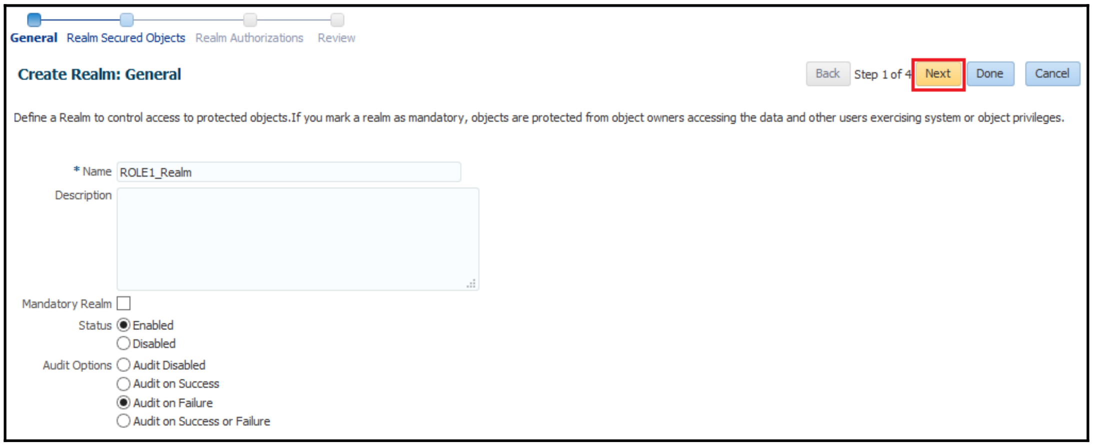
2. Create the role `role1`:

   ```
   SQL> create role role1;
   ```

3. Grant the `create session` and `select any table` privileges to the role:

   ```
   SQL> grant create session, select any table to role1;
   ```

4. Create realm `ROLE1_Realm` in Enterprise Manager Cloud Control 12c (see Figure 13).



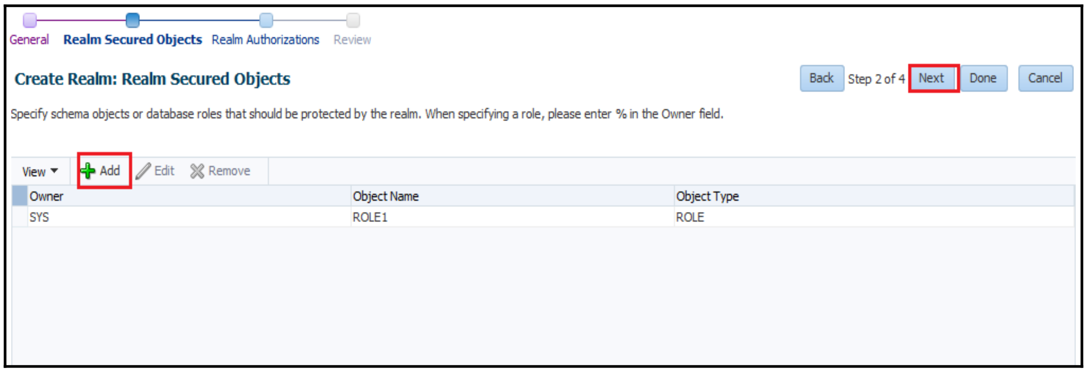
Create Realm: General

Define a Realm to control access to protected objects.If you mark a realm as mandatory, objects are protected from object owners accessing the data and other users exercising system or object privileges.

* Name	ROLE1_Realm
Description	
Mandatory Realm	☐
Status	[✓ Enabled] Disabled
Audit Options	Audit Disabled, Audit on Success, [✓ Audit on Failure], Audit on Success or Failure

Figure 13 – Creating ROLE1_Realm

5. Add realm-secured objects (see Figure 14).



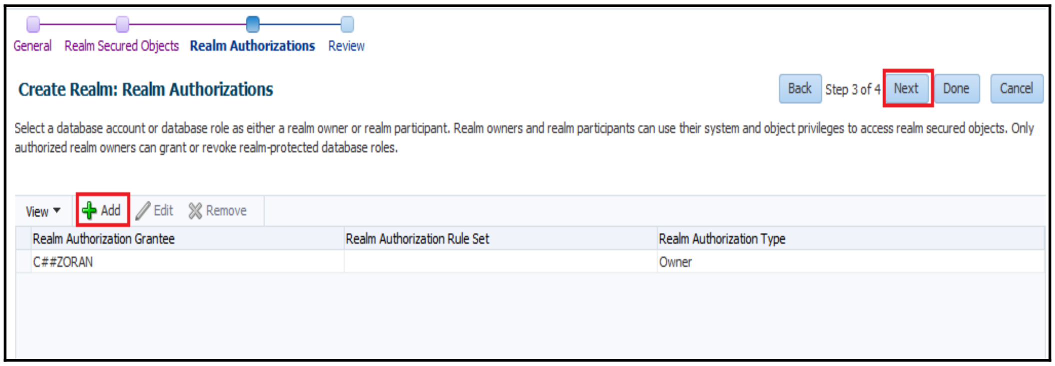
Create Realm: Realm Secured Objects

Specify schema objects or database roles that should be protected by the realm. When specifying a role, please enter % in the Owner field.

Owner	Object Name	Object Type
SYS	ROLE1	ROLE

Figure 14 – Adding secured objects

6. Add realm authorizations and click on the **Next** button (see Figure 15).



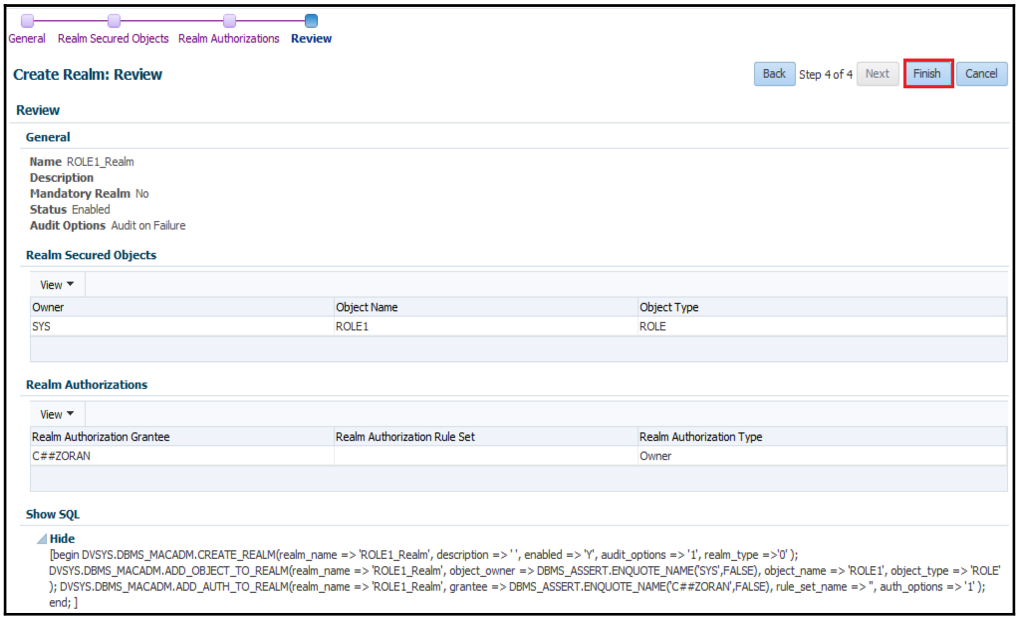
Create Realm: Realm Authorizations

Select a database account or database role as either a realm owner or realm participant. Realm owners and realm participants can use their system and object privileges to access realm secured objects. Only authorized realm owners can grant or revoke realm-protected database roles.

Realm Authorization Grantee	Realm Authorization Rule Set	Realm Authorization Type
C##ZORAN		Owner

Figure 15 – Realm authorizations

7. Review and click on the **Finish** button (see Figure 16).



Create Realm: Review

Review

General

Name ROLE1_Realm
Description
Mandatory Realm No
Status Enabled
Audit Options Audit on Failure

Realm Secured Objects

Owner	Object Name	Object Type
SYS	ROLE1	ROLE

Realm Authorizations

Realm Authorization Grantee	Realm Authorization Rule Set	Realm Authorization Type
C##ZORAN		Owner

```
[begin DVSYS.DBMS_MACADM.CREATE_REALM(realm_name => 'ROLE1_Realm', description => ' ', enabled => 'Y', audit_options => '1', realm_type =>'0' );
DVSYS.DBMS_MACADM.ADD_OBJECT_TO_REALM(realm_name => 'ROLE1_Realm', object_owner => DBMS_ASSERT.ENQUOTE_NAME('SYS',FALSE), object_name => 'ROLE1', object_type => 'ROLE'
); DVSYS.DBMS_MACADM.ADD_AUTH_TO_REALM(realm_name => 'ROLE1_Realm', grantee => DBMS_ASSERT.ENQUOTE_NAME('C##ZORAN',FALSE), rule_set_name => '', auth_options => '1' );
end; ]
```

Figure 16

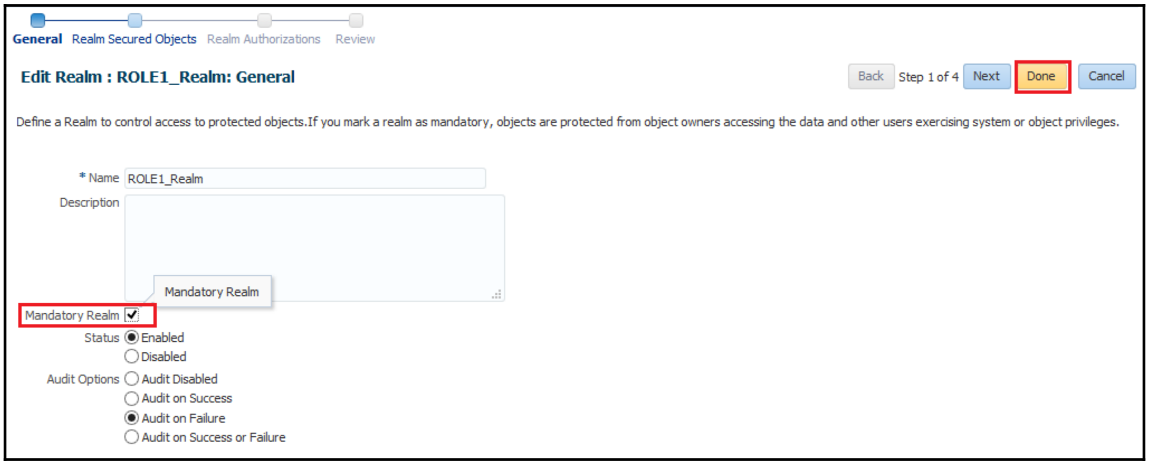
8. Connect to the pluggable database `PDB1` as a `SYS` user:

```
SQL> connect sys@pdb1 as sysdba
```

9. Verify that `SYS` still can revoke/grant privileges from/to role `role1`, even though `role1` is protected by the realm:

```
SQL> revoke select any table from role1;

SQL> grant drop any synonym to role1;
```

10. Edit the realm `ROLE1_Realm` and make it mandatory (select the **Mandatory Realm** checkbox).



Edit Realm : ROLE1_Realm: General

Define a Realm to control access to protected objects.If you mark a realm as mandatory, objects are protected from object owners accessing the data and other users exercising system or object privileges.

* Name: ROLE1_Realm

Description:

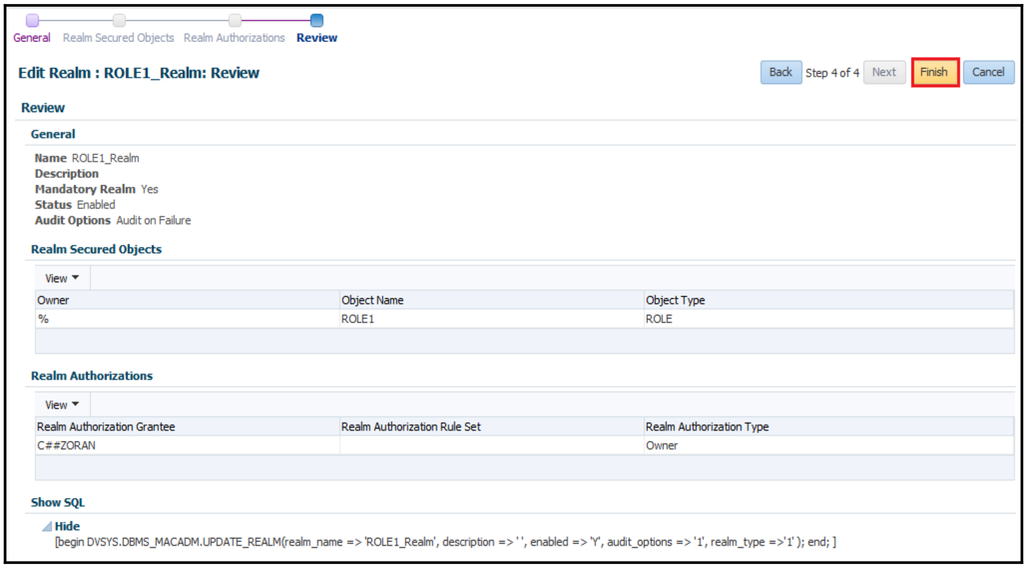
Mandatory Realm: ✓

Status: [✓ Enabled] Disabled

Audit Options: Audit Disabled, Audit on Success, [✓ Audit on Failure], Audit on Success or Failure

Figure 17 – Editing realm

11. Review and confirm the change of `ROLE1_Realm`.



Edit Realm : ROLE1_Realm: Review

Review

General

Name ROLE1_Realm
Description
Mandatory Realm Yes
Status Enabled
Audit Options Audit on Failure

Realm Secured Objects

View ▾

Owner	Object Name	Object Type
%	ROLE1	ROLE

Realm Authorizations

View ▾

Realm Authorization Grantee	Realm Authorization Rule Set	Realm Authorization Type
C##ZORAN		Owner

Show SQL

Hide

```
[begin DVSYS.DBMS_MACADM.UPDATE_REALM(realm_name => 'ROLE1_Realm', description => ' ', enabled => 'Y', audit_options => '1', realm_type =>'1' ); end; ]
```

Figure 18

There's more…

After we created a realm, the `SYS` user (or any user that is not authorized in realm) cannot grant the realm-protected role:

```
SQL> connect sys@pdb1 as sysdba

Enter password:
Connected.

SQL> grant role1 to usr1;

grant role1 to usr1
*
ERROR at line 1:
ORA-47410: Realm violation for GRANT on ROLE1
```

However, user `c##zoran` is authorized in realm as owner, so he can grant this role:

```
SQL> connect c##zoran@pdb1

Enter password:
Connected.

SQL> grant role1 to usr1;

Grant succeeded.
```

In step 9, we've seen that the `SYS` user can grant or revoke privileges from role even though the role is protected by realm. After we make the realm mandatory (steps 10 and 11), this is no longer possible:

```
SQL> connect sys@pdb1 as sysdba

Enter password:
Connected.

SQL> revoke drop any synonym from role1;

revoke drop any synonym from role1
*
ERROR at line 1:
ORA-47410: Realm violation for REVOKE on ROLE1

SQL> grant update any table to role1;

grant update any table to role1
*
ERROR at line 1:
ORA-47410: Realm violation for GRANT on ROLE1
```

See also

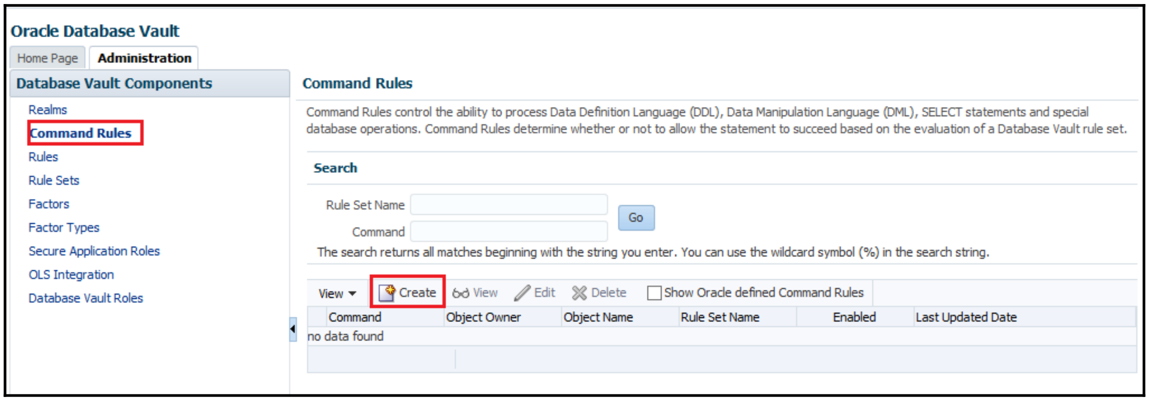
- *Preventing users from exercising system privileges on schema objects*

Preventing users from executing specific command on specific object

In this recipe, you'll learn to create command rules. A command rule defines a protected database operation on a specific database object (for example, `UPDATE` on all tables in `HR` schema). The evaluation of associated rule set determines if statement will be allowed (executed) or blocked.

How to do it…

Create a command rule by following these steps depicted in Figures 19 and 20.



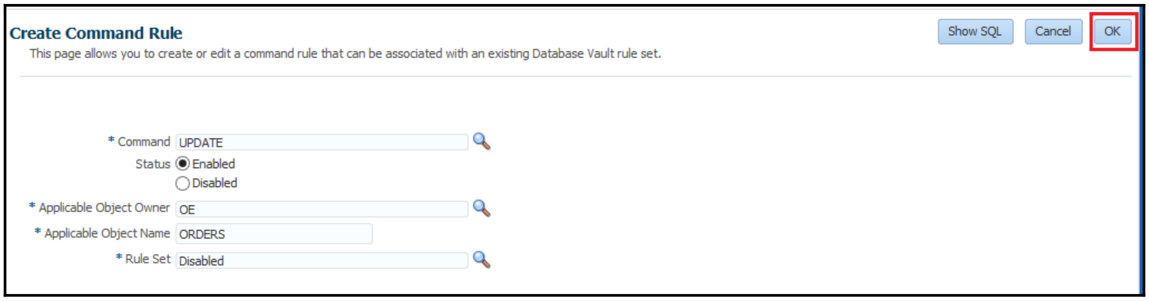
Command Rules control the ability to process Data Definition Language (DDL), Data Manipulation Language (DML), SELECT statements and special database operations. Command Rules determine whether or not to allow the statement to succeed based on the evaluation of a Database Vault rule set.

The search returns all matches beginning with the string you enter. You can use the wildcard symbol (%) in the search string.

Command	Object Owner	Object Name	Rule Set Name	Enabled	Last Updated Date
no data found					

Figure 19 – Creating a command rule

In the **Command** field, write `UPDATE`; in the **Applicable Object Owner** field, write `OE`; in the **Applicable Object Name** field, write `ORDERS`; and select **Disabled** for **Rule Set** (see Figure 20).



Create Command Rule

This page allows you to create or edit a command rule that can be associated with an existing Database Vault rule set.

* Command	UPDATE
Status	[✓ Enabled] Disabled
* Applicable Object Owner	OE
* Applicable Object Name	ORDERS
* Rule Set	Disabled

Figure 20 – A Command rule to secure the UPDATE operation on OE.Orders

How it works...

Command rules can be understood this way: In order to execute command *X* on object *Y* in schema *Z*, rule set with name *A* needs to evaluate `TRUE`.

In our case, it can be understood this way: In order to execute `UPDATE` on the table `ORDERS` in schema `OE`, rule set `Disabled` needs to evaluate `TRUE`. However, because rule set `DISABLED` will evaluate `FALSE` always, consequently, this command is disabled for all users in the database:

```
SQL> connect sys@pdb1 as sysdba

Enter password:
Connected.

SQL> UPDATE OE.ORDERS SET ORDER_MODE = 'TEST' WHERE ORDER_ID < 3000;

UPDATE OE.ORDERS SET ORDER_MODE = 'TEST' WHERE ORDER_ID < 3000
          *
ERROR at line 1:
ORA-01031: insufficient privileges
```

Creating a rule set

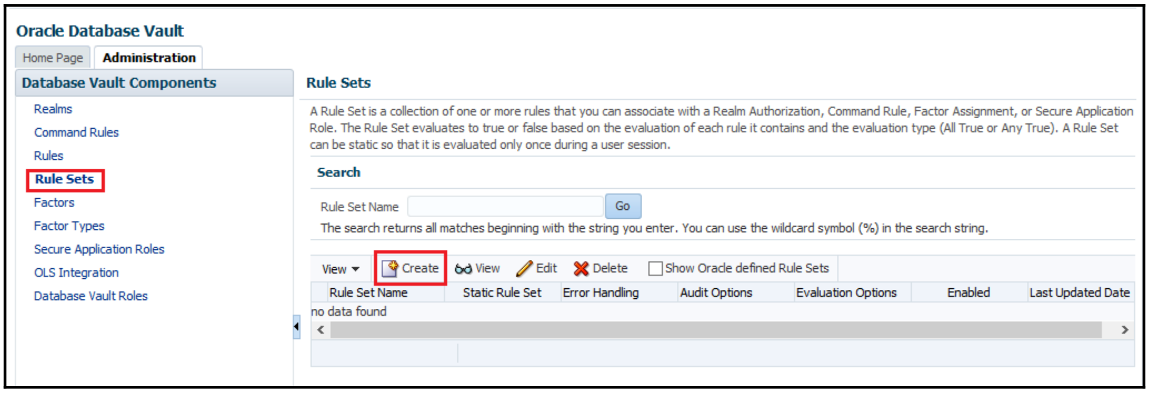
A rule set is a group of rules, which will be evaluated as a whole, using only `AND` or only `OR` operator. The Boolean result of logical evaluation is used in other Oracle Database Vault components to grant or deny certain actions (for example, deleting data from a table). In this recipe, you'll learn to create rules and rule sets.

Getting ready

In this recipe, you are going to use Enterprise Manager Cloud Control 12c.

How to do it…

1. Go to Rule Sets component and then click on **Create** (Figure 21).



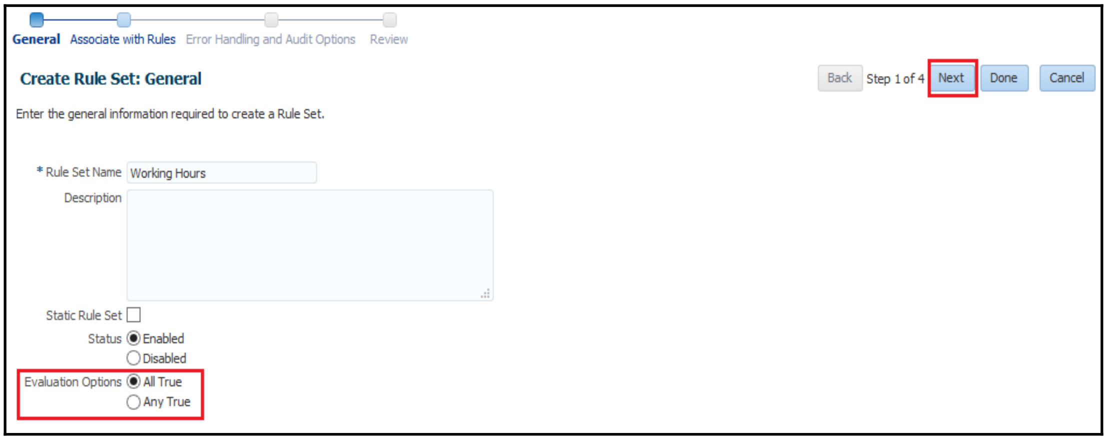
A Rule Set is a collection of one or more rules that you can associate with a Realm Authorization, Command Rule, Factor Assignment, or Secure Application Role. The Rule Set evaluates to true or false based on the evaluation of each rule it contains and the evaluation type (All True or Any True). A Rule Set can be static so that it is evaluated only once during a user session.

The search returns all matches beginning with the string you enter. You can use the wildcard symbol (%) in the search string.

Rule Set Name	Static Rule Set	Error Handling	Audit Options	Evaluation Options	Enabled	Last Updated Date
no data found						

Figure 21

2. As a name, enter `Working Hours` and click on **Next** (Figure 22). For **Evaluation Options**, choose **All True**.



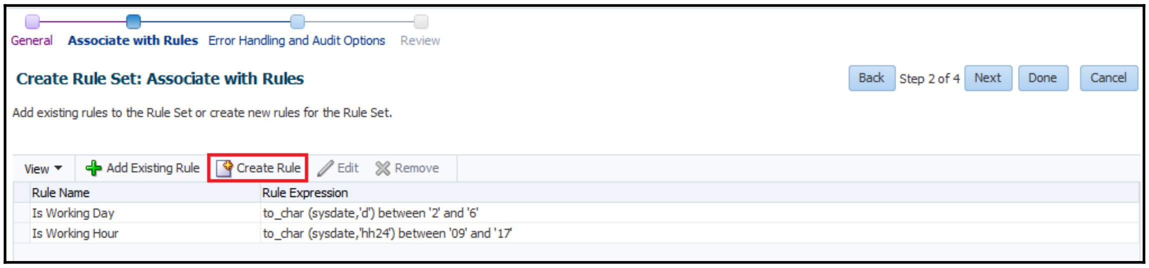
Create Rule Set: General

Enter the general information required to create a Rule Set.

* Rule Set Name	Working Hours
Description	
Static Rule Set	☐
Status	[✓ Enabled] Disabled
Evaluation Options	[✓ All True] Any True

Figure 22 – Our rule set "Working Hours"

3. Add two rules (`Is Working Day` and `Is Working Hour`) by clicking on **Create Rule** before adding each of them. Enter the details in **Rule Name** and `Rule Expression` as shown in Figure 23. After you added both rules, click on **Next**.



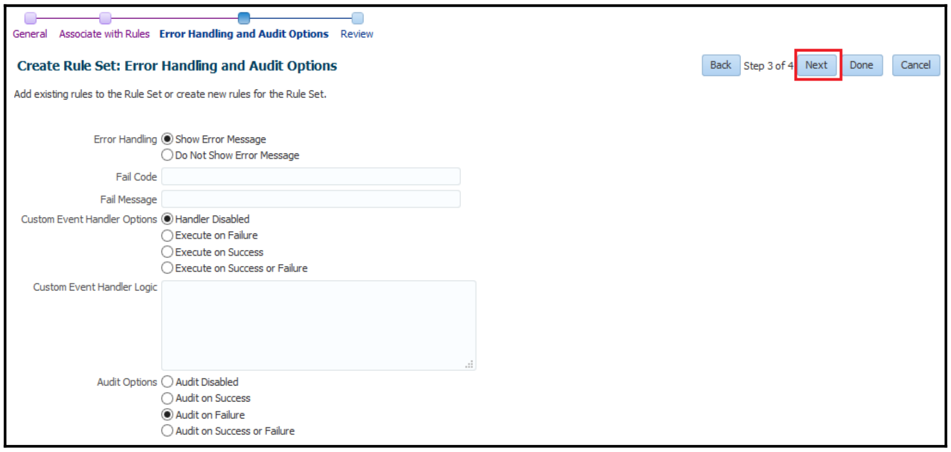
Create Rule Set: Associate with Rules

Add existing rules to the Rule Set or create new rules for the Rule Set.

Rule Name	Rule Expression
Is Working Day	to_char (sysdate,'d') between '2' and '6'
Is Working Hour	to_char (sysdate,'hh24') between '09' and '17'

Figure 23 – Create two rules

4. Leave all options on defaults and click on Next.



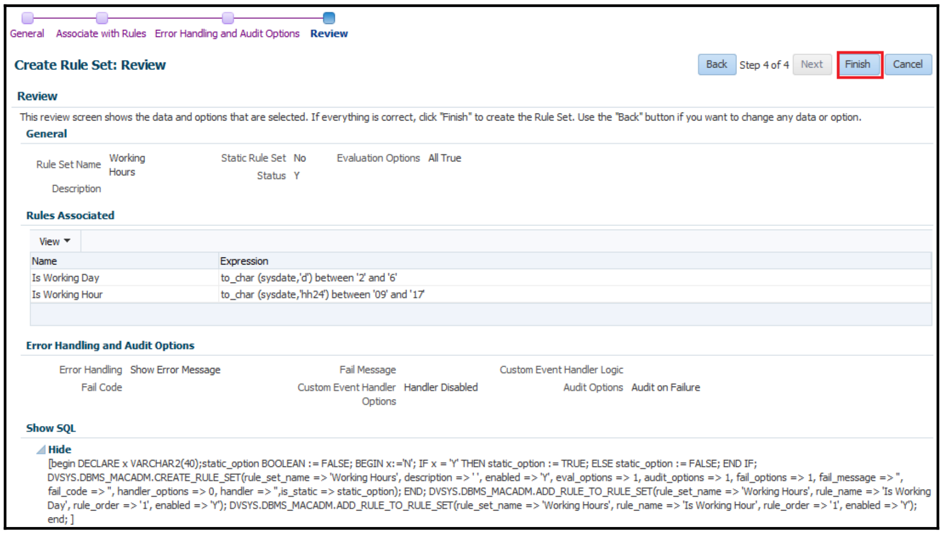
Create Rule Set: Error Handling and Audit Options

Add existing rules to the Rule Set or create new rules for the Rule Set.

Error Handling	[✓ Show Error Message] Do Not Show Error Message
Fail Code	
Fail Message	
Custom Event Handler Options	[✓ Handler Disabled] Execute on Failure / Execute on Success / Execute on Success or Failure
Custom Event Handler Logic	
Audit Options	Audit Disabled / Audit on Success / [✓ Audit on Failure] / Audit on Success or Failure

Figure 24 – Error handling and audit options

5. Click on `Finish`.



Create Rule Set: Review

Review

This review screen shows the data and options that are selected. If everything is correct, click "Finish" to create the Rule Set. Use the "Back" button if you want to change any data or option.

General

Rule Set Name	Working Hours	Static Rule Set	No	Evaluation Options	All True
Description		Status	Y		

Rules Associated

Name	Expression
Is Working Day	to_char (sysdate,'d') between '2' and '6'
Is Working Hour	to_char (sysdate,'hh24') between '09' and '17'

Error Handling and Audit Options

Error Handling	Show Error Message	Fail Message		Custom Event Handler Logic	
Fail Code		Custom Event Handler Options	Handler Disabled	Audit Options	Audit on Failure

Show SQL

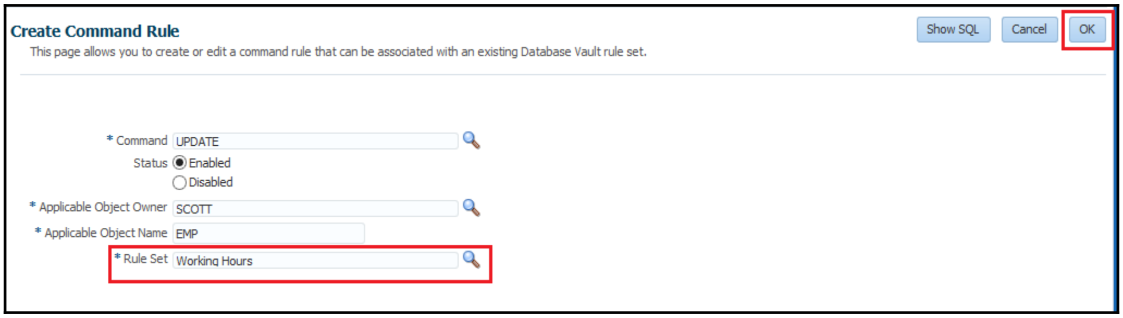
Hide

```
[begin DECLARE x VARCHAR2(40);static_option BOOLEAN := FALSE; BEGIN x:='N'; IF x = 'Y' THEN static_option := TRUE; ELSE static_option := FALSE; END IF;
DVSYS.DBMS_MACADM.CREATE_RULE_SET(rule_set_name => 'Working Hours', description => ' ', enabled => 'Y', eval_options => 1, audit_options => 1, fail_options => 1, fail_message => '',
fail_code => '', handler_options => 0, handler => '',is_static => static_option); END; DVSYS.DBMS_MACADM.ADD_RULE_TO_RULE_SET(rule_set_name => 'Working Hours', rule_name => 'Is Working
Day', rule_order => '1', enabled => 'Y'); DVSYS.DBMS_MACADM.ADD_RULE_TO_RULE_SET(rule_set_name => 'Working Hours', rule_name => 'Is Working Hour', rule_order => '1', enabled => 'Y');
end; ]
```

Figure 25 – Finish

There's more...

To use rule set you have created in this recipe, create command rule for `UPDATE` operation on schema `SCOTT`, table `EMP`, and choose that condition for evaluation whether update operation will be executed is defined by rule set `Working Hours`.



Create Command Rule

This page allows you to create or edit a command rule that can be associated with an existing Database Vault rule set.

* Command	UPDATE
Status	[✓ Enabled] Disabled
* Applicable Object Owner	SCOTT
* Applicable Object Name	EMP
* Rule Set	Working Hours

Figure 26 – Create command rule using your rule set

Check time and day (your result will be different). In this case, it's *NOT* a work day, so rule set will evaluate to `false`.

```
SQL> !date

Sun Jun 14 02:12:02 CEST 2015
```

Try to increase salary by `300` for the employee whose `empno` is `7902`.

```
SQL> UPDATE SCOTT.EMP SET SAL = SAL + 300 WHERE EMPNO = 7902;

UPDATE SCOTT.EMP SET SAL = SAL + 300 WHERE EMPNO = 7902
             *
ERROR at line 1:
ORA-01031: insufficient privileges
```

Check time and day (your result will be different). In this case, it is a work day and it is during working hours, so rule set will evaluate to `true`.

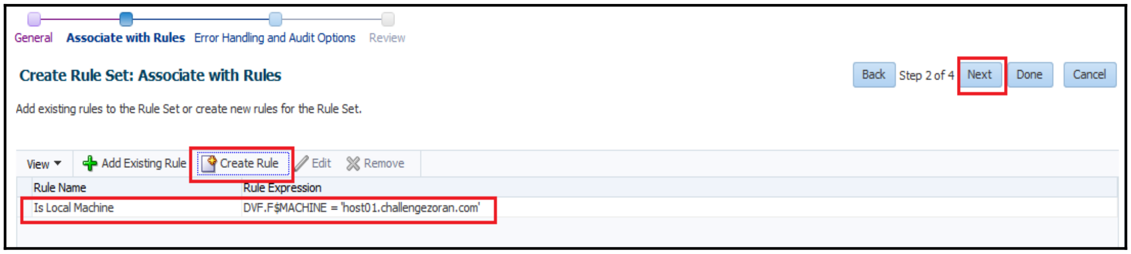
```
SQL> !date

Mon Jun 15 14:27:24 CEST 2015

SQL> UPDATE SCOTT.EMP SET SAL = SAL + 300 WHERE EMPNO = 7902;

1 row updated.
```

Creating a secure application role

A secure application role is a database role whose enablement depends on the evaluation of a specified condition. In this recipe, you'll learn to create secure application role using Oracle Database Vault. The condition that determines whether the role will be enabled is specified by rule set (you can use built-in rule set or create your own).

How to do it…

1. Create rule set with name `Can Access Customer Data` and with rule `DVF.F$MACHINE = <your host name>` (for example, name it: `Is Local Machine`). In our case, hostname is `host01.challengezoran.com` (see Figure 27). Refer to the recipe *Creating rule sets* for full explanation.



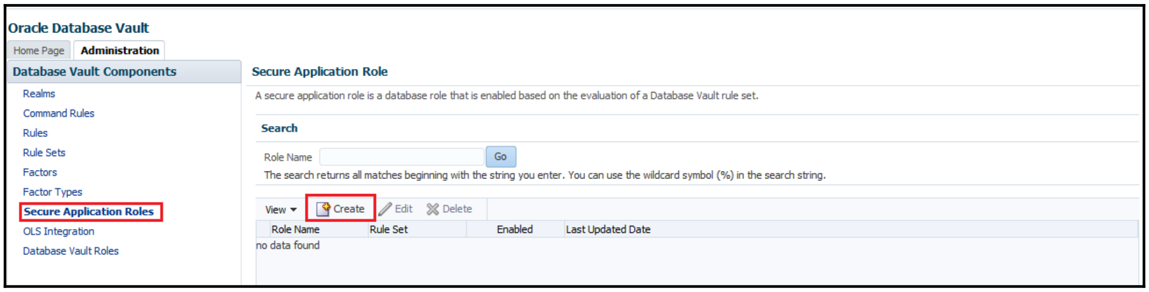
Create Rule Set: Associate with Rules

Add existing rules to the Rule Set or create new rules for the Rule Set.

Rule Name	Rule Expression
Is Local Machine	DVF.F$MACHINE = 'host01.challengezoran.com'

Figure 27 – Is a Local Machine rule

2. In the Database Vault Components panel, click on the **Secure Application Roles** link and then click on the **Create** button (see Figure 28).


Oracle Database Vault

Home Page | Administration

Database Vault Components: Realms, Command Rules, Rules, Rule Sets, Factors, Factor Types, Secure Application Roles, OLS Integration, Database Vault Roles

Secure Application Role

A secure application role is a database role that is enabled based on the evaluation of a Database Vault rule set.

Search

Role Name [ ] Go

The search returns all matches beginning with the string you enter. You can use the wildcard symbol (%) in the search string.

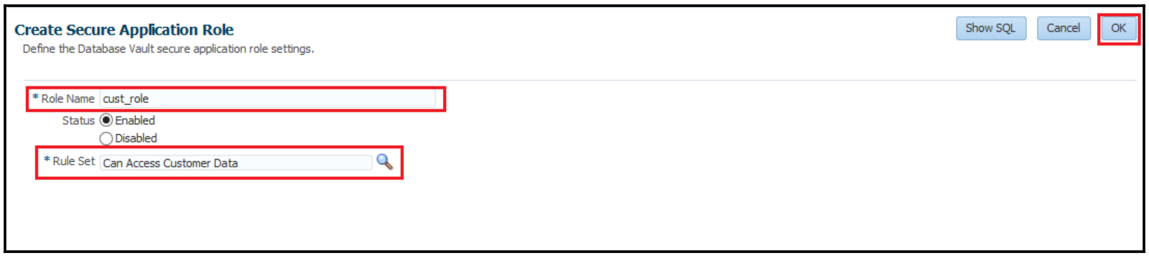
View ▾ | Create | Edit | Delete

Role Name	Rule Set	Enabled	Last Updated Date

no data found

Figure 28 – Create a secure application role

3. Define secure application role settings. In our case, we secure the role `cust_role` and condition for enablement is defined by the `Can Access Customer Data` rule set (see Figure 29).


Create Secure Application Role

Define the Database Vault secure application role settings.

Show SQL | Cancel | OK

* Role Name: cust_role

Status: (● Enabled) ○ Disabled

* Rule Set: Can Access Customer Data

Figure 29 – Define secure application role

There's more…

Now, you are going to test behavior of the secure application role.

Connect to pluggable database pdb1 as a user who has the Oracle Database Vault Account Manager role and create the user `usr2`.

```
SQL> connect c##dbv_acctmgr/oraDVA123@pdb1

Connected.

SQL> create user usr2 identified by oracle1;

User created.
```

Connect to the pluggable database `pdb1` as a `SYS` user and grant a `create session` privilege to `usr2` and select and update privileges to the role `cust_role`.

```
SQL> connect sys/oracle@pdb1 as sysdba

Connected.

SQL> grant create session to usr2.

Grant succeeded.

SQL> grant select on oe.customers to cust_role;

Grant succeeded.

SQL> grant update on oe.customers to cust_role;

Grant succeeded.
```

Connect to pluggable database `pdb1` as `usr2` and view information about machine you are accessing the database from. In this example, we are using a built-in factor to get that information. If you want to learn more about factors in Oracle Database Vault, see `Chapter 11`, *Additional Topics*.

```
SQL> connect usr2/oracle1@pdb1

SQL> select dvf.f$machine from dual;

F$MACHINE
------------------------------------------------
host01.challengezoran.com
```

Set `cust_role` by using the PL/SQL package `DBMS_MACSEC_ROLES`:

```
SQL> EXEC DBMS_MACSEC_ROLES.SET_ROLE('CUST_ROLE');

PL/SQL procedure successfully completed.
```

View number of rows in the table `OE.CUSTOMERS`:

```
SQL> select count(*) from oe.customers;

  COUNT(*)
----------
       319
```

When the same user tries to connect from another machine, he or she won't be able to set the role, which in turn means that he or she won't be able to view data in the table `OE.CUSTOMERS`:

```
SQL> connect usr2/oracle1@pdb1

Connected.

SQL> select dvf.f$machine from dual;

F$MACHINE
----------------------------------------------------
host02.challengezoran.com

SQL> EXEC DBMS_MACSEC_ROLES.SET_ROLE('CUST_ROLE');

BEGIN DBMS_MACSEC_ROLES.SET_ROLE('CUST_ROLE'); END;

*
ERROR at line 1:
ORA-47305: Rule Set violation on SET ROLE (CUST_ROLE)
ORA-06512: at "DVSYS.DBMS_MACUTL", line 49
ORA-06512: at "DVSYS.DBMS_MACUTL", line 398
ORA-06512: at "DVSYS.DBMS_MACSEC", line 306
ORA-06512: at "DVSYS.ROLE_IS_ENABLED", line 4
ORA-06512: at "DVSYS.DBMS_MACSEC_ROLES", line 55
ORA-06512: at line 1

SQL> select count(*) from oe.customers;

select count(*) from oe.customers
                        *
ERROR at line 1:
ORA-00942: table or view does not exist
```

See also

- `Chapter 11`, *Additional topics*

Using Database Vault to implement that administrators cannot view data

In this recipe, you will use multiple components (realms, command rules, and rule sets) to secure data in database from administrators.

How to do it…

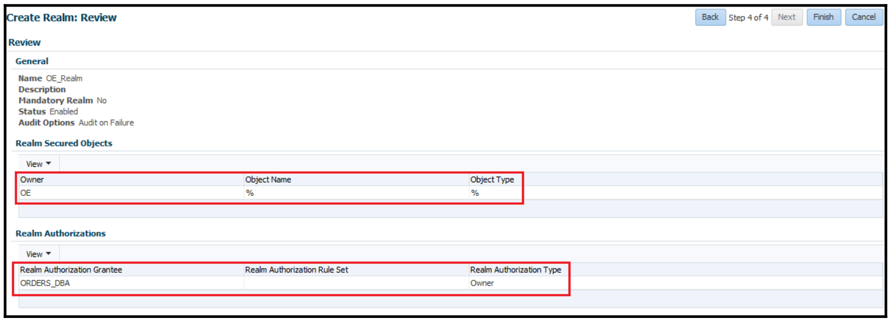
1. Connect to the pluggable database `PDB1` as the user `c##dbv_acctmgr`:

   ```
   SQL> connect c##dbv_acctmgr@pdb1
   SQL> create user orders_dba identified by oracle1;
   SQL> create user orders_user identified by oracle2;
   ```

2. Connect to the pluggable database `PDB1` as a `SYS` user and execute the following statements:

   ```
   SQL> connect sys@pdb1 as sysdba
   SQL> grant dba to orders_dba;
   SQL> grant create session to orders_user;
   SQL> grant select on oe.orders to orders_user;
   SQL> grant update on oe.orders to orders_user;
   SQL> create role ord_usr_role;
   SQL> grant ord_usr_role to orders_user;
   ```

3. Create a realm that protects all objects in `OE` schema and authorize user `orders_dba` as owner (for detailed explanation on creating realms, see recipe *Preventing users from exercising system privileges on schema objects*) – Figure 30.



Create Realm: Review

Back | Step 4 of 4 | Next | Finish | Cancel

Review

General

Name OE_Realm
Description
Mandatory Realm No
Status Enabled
Audit Options Audit on Failure

Realm Secured Objects

View ▾

Owner	Object Name	Object Type
OE	%	%

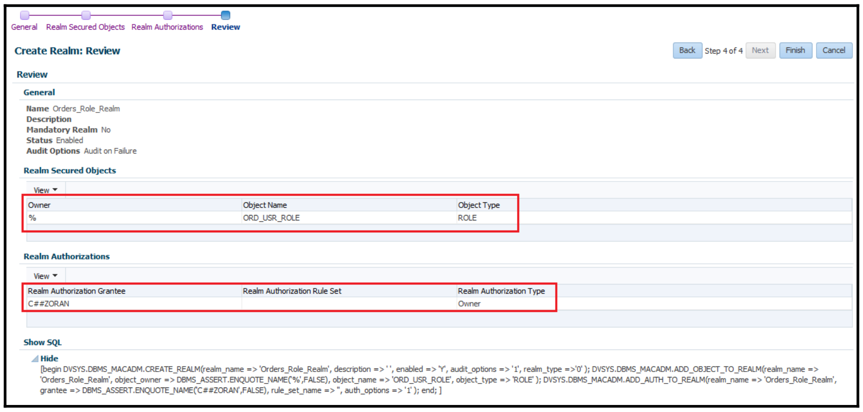
Realm Authorizations

View ▾

Realm Authorization Grantee	Realm Authorization Rule Set	Realm Authorization Type
ORDERS_DBA		Owner

Figure 30 – Create realm OE_Realm

4. Create realm that protects the `ORD_USR_ROLE` role and authorize the user `c##zoran` as owner (for detailed explanation on creating realms, see recipe Preventing users from exercising system privileges on schema objects) – Figure 31.



Create Realm: Review

Back | Step 4 of 4 | Next | Finish | Cancel

Review

General

Name Orders_Role_Realm
Description
Mandatory Realm No
Status Enabled
Audit Options Audit on Failure

Realm Secured Objects

View ▾

Owner	Object Name	Object Type
%	ORD_USR_ROLE	ROLE

Realm Authorizations

View ▾

Realm Authorization Grantee	Realm Authorization Rule Set	Realm Authorization Type
C##ZORAN		Owner

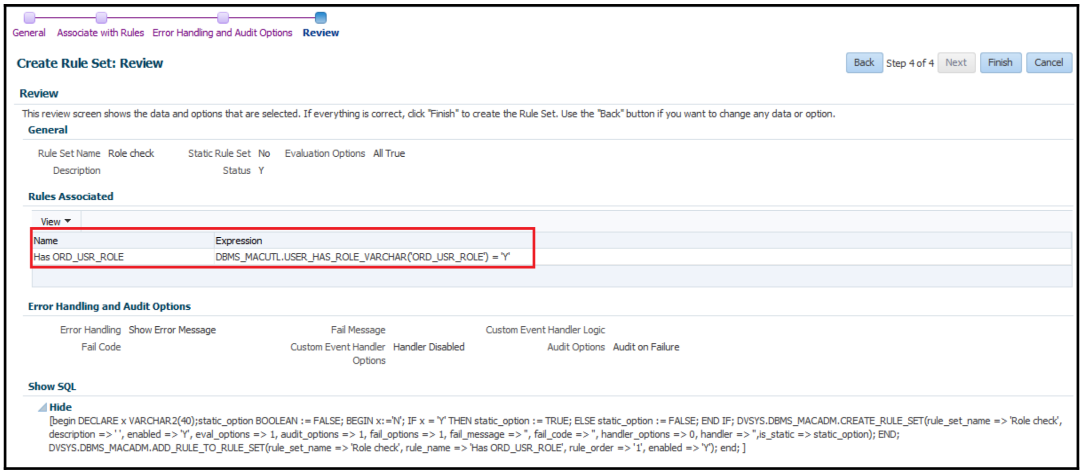
Show SQL

Hide

```
[begin DVSYS.DBMS_MACADM.CREATE_REALM(realm_name => 'Orders_Role_Realm', description => ' ', enabled => 'Y', audit_options => '1', realm_type =>'0' ); DVSYS.DBMS_MACADM.ADD_OBJECT_TO_REALM(realm_name =>
'Orders_Role_Realm', object_owner => DBMS_ASSERT.ENQUOTE_NAME('%',FALSE), object_name => 'ORD_USR_ROLE', object_type => 'ROLE' ); DVSYS.DBMS_MACADM.ADD_AUTH_TO_REALM(realm_name => 'Orders_Role_Realm',
grantee => DBMS_ASSERT.ENQUOTE_NAME('C##ZORAN',FALSE), rule_set_name => '', auth_options => '1' ); end; ]
```

Figure 31 – Create realm Orders_Role_Realm

5. Create rule set (exp. role check) that has one rule with name `Has ORD_USR_ROLE` and expression `DBMS_MACUTL.USER_HAS_ROLE_VARCHAR('ORD_USER_ROLE') = 'Y'` (for detailed explanation on how to create rule sets see the recipe *Creating a rule set*) – Figure 32.



Create Rule Set: Review

Review

This review screen shows the data and options that are selected. If everything is correct, click "Finish" to create the Rule Set. Use the "Back" button if you want to change any data or option.

General

Rule Set Name: Role check
Static Rule Set: No
Evaluation Options: All True
Description:
Status: Y

Rules Associated

Name	Expression
Has ORD_USR_ROLE	DBMS_MACUTL.USER_HAS_ROLE_VARCHAR('ORD_USR_ROLE') = 'Y'

Error Handling and Audit Options

Error Handling: Show Error Message
Fail Message:
Custom Event Handler Logic:
Fail Code:
Custom Event Handler Options: Handler Disabled
Audit Options: Audit on Failure

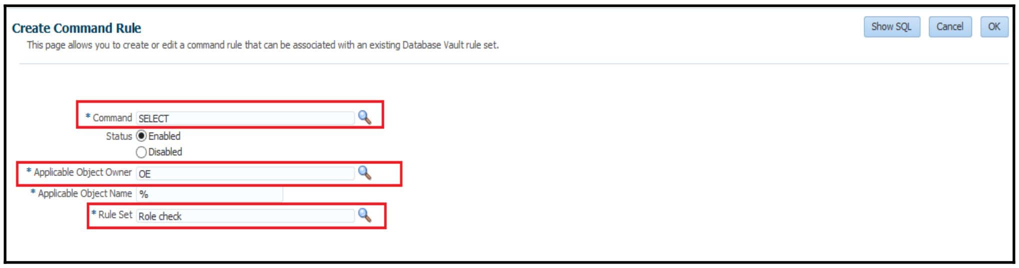
Show SQL

Hide

```
[begin DECLARE x VARCHAR2(40);static_option BOOLEAN := FALSE; BEGIN x:='N'; IF x = 'Y' THEN static_option := TRUE; ELSE static_option := FALSE; END IF; DVSYS.DBMS_MACADM.CREATE_RULE_SET(rule_set_name => 'Role check',
description => ' ', enabled => 'Y', eval_options => 1, audit_options => 1, fail_options => 1, fail_message => '', fail_code => '', handler_options => 0, handler => '',is_static => static_option); END;
DVSYS.DBMS_MACADM.ADD_RULE_TO_RULE_SET(rule_set_name => 'Role check', rule_name => 'Has ORD_USR_ROLE', rule_order => '1', enabled => 'Y'); end; ]
```

Figure 32 – Create Rule Set Role check

6. Create a command rule for `Select` on all objects in `OE` schema, and as rule set, select one that you created in previous step (exp role check) (for detailed explanation on how to create command rules, see recipe *Preventing users from executing a specific command on a specific object*) – Figure 33.



Create Command Rule

This page allows you to create or edit a command rule that can be associated with an existing Database Vault rule set.

* Command: SELECT
Status: [✓ Enabled] Disabled
* Applicable Object Owner: OE
* Applicable Object Name: %
* Rule Set: Role check

Figure 33 – Create a command rule

There's more…

We can show that the user `orders_dba` in fact can manage objects in `OE` schema (for instance, he can create and drop a table test) – this is because he is authorized in realm that protects `oe` schema:

```
SQL> connect orders_dba@pdb1

Enter password:
Connected.

SQL> create table oe.test(a int);

Table created.

SQL> drop table oe.test;

Table dropped.
```

However, the user `orders_dba` cannot view data that resides inside objects in `OE` schema – select on objects in this schema is restricted to users that have the role `ORD_USR_ROLE` using command rule:

```
SQL> select count(*) from oe.orders;

select count(*) from oe.orders
                        *
ERROR at line 1:
ORA-01031: insufficient privileges
```

The user `orders_user` has the role `ORD_USER_ROLE` and he or she can select data from table in `OE` schema:

```
SQL> connect orders_user@pdb1

Enter password:
Connected.

SQL> select count(*) from oe.orders;

  COUNT(*)
----------
       105
```

An example of adding a new user to the system and authorizing him to access the data:

Because separation of duties is implemented, there are several users that need to grant certain privileges.

Only account manager can create users in database:

```
SQL> connect c##dbv_acctmgr@pdb1

Enter password:
Connected.

SQL> create user orders_user2 identified by oracle3;

User created.
```

The `SYS` user is one of the few users who are authorized to grant a `create session` privilege (after Database Vault is implemented, users with the DBA role cannot grant the `create session` privilege, unless they are authorized in Database Vault)

```
SQL> connect sys@pdb1 as sysdba

Enter password:
Connected.

SQL> grant create session to orders_user2;

Grant succeeded.
```

Because `c##zoran` is the only authorized user in realm that protects the role `ORD_USR_ROLE`; he is the only user that can grant that role:

```
SQL> connect c##zoran@pdb1

Enter password:
Connected.

SQL> grant ord_usr_role to orders_user2;

Grant succeeded.
```

`Orders_dba` is the only user that is authorized in realm that protects `OE` schema, so he is the only user that can grant object privileges on objects in `OE` schema.

```
SQL> connect orders_dba@pdb1

Enter password:
Connected.

SQL> grant select on oe.orders to orders_user2;

Grant succeeded.

SQL> grant update on oe.orders to orders_user2;

Grant succeeded.
```

After a user is granted all necessary privileges, he or she is able to connect to the database and select data from table in secured schema.

```
SQL> connect orders_user2@pdb1

Enter password:
Connected.

SQL> select count(*) from oe.orders;

  COUNT(*)
 ---------
       105
```

Running Oracle Database Vault reports

In this recipe, you will intentionally violate some security controls in order to have data for reports.

How to do it...

Let's connect as user system and violate some restrictions. First, we are going to select from `hr` schema, which is going to violate `HR` realm, and second, we are going to update `sal` in the `scott.emp` table, which is going to violate the command rule (we are updating it outside of working hours).

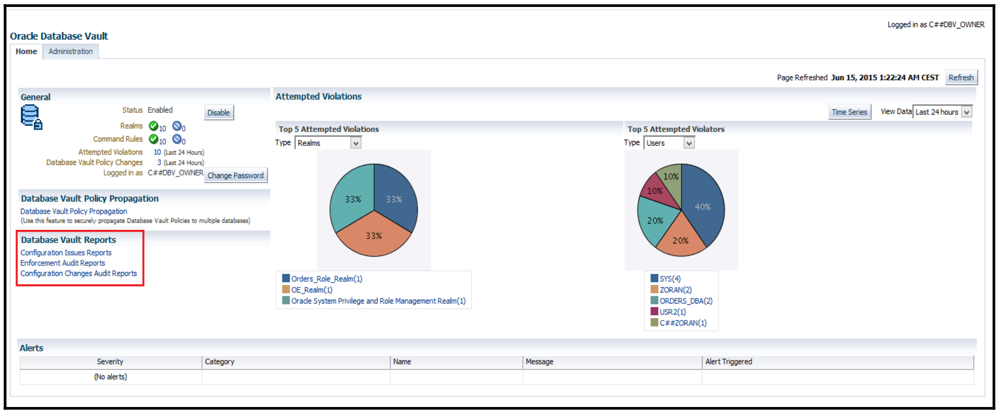
1. `SQL> connect system@pdb1`

2. `SQL> select count(*) from hr.employees;`

3. `SQL> update scott.emp set sal = sal*1.20 where empno = 7839;`

Let's see reports for these violations:

1. Go to Database Vault home page (See Figure 2).
2. Click on **Enforcement Audit Reports** (See Figure 34).



Page Refreshed **Jun 15, 2015 1:22:24 AM CEST**

General

Status Enabled
Realms ✓10 ⊘0
Command Rules ✓10 ⊘0
Attempted Violations 10 (Last 24 Hours)
Database Vault Policy Changes 3 (Last 24 Hours)
Logged in as C##DBV_OWNER

Database Vault Policy Propagation

Database Vault Policy Propagation
(Use this feature to securely propagate Database Vault Policies to multiple databases)

Database Vault Reports

Configuration Issues Reports
Enforcement Audit Reports
Configuration Changes Audit Reports

Attempted Violations

View Data Last 24 hours

Top 5 Attempted Violations

Type Realms

- 🟦 Orders_Role_Realm(1)
- 🟧 OE_Realm(1)
- 🟩 Oracle System Privilege and Role Management Realm(1)

Top 5 Attempted Violators

Type Users

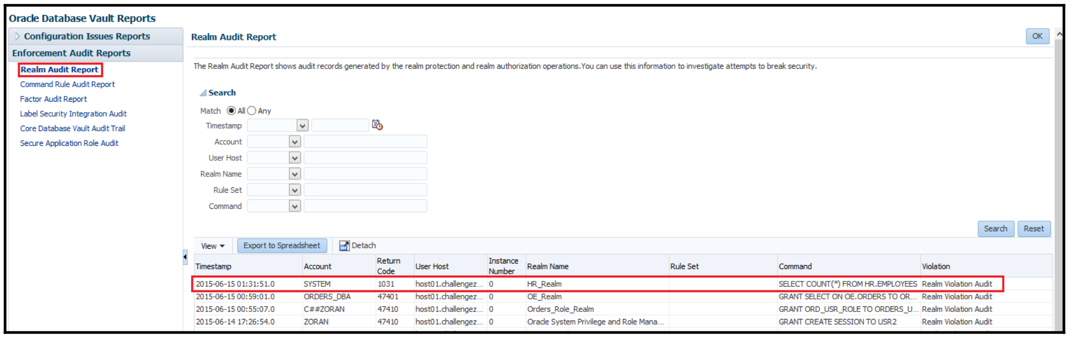
- 🟦 SYS(4)
- 🟧 ZORAN(2)
- 🟩 ORDERS_DBA(2)
- 🟥 USR2(1)
- 🟫 C##ZORAN(1)

Alerts

Severity	Category	Name	Message	Alert Triggered
(No alerts)				

Figure 34

3. Click on **Realm Audit Report** (see Figure 35). Observe the line marked in red (violation from step 2 is audited).


Oracle Database Vault Reports
Configuration Issues Reports
Enforcement Audit Reports
Realm Audit Report
Command Rule Audit Report
Factor Audit Report
Label Security Integration Audit
Core Database Vault Audit Trail
Secure Application Role Audit
OK
Search
Match All Any
Timestamp
Account
User Host
Realm Name
Rule Set
Command
Search
Reset
View
Export to Spreadsheet
Detach

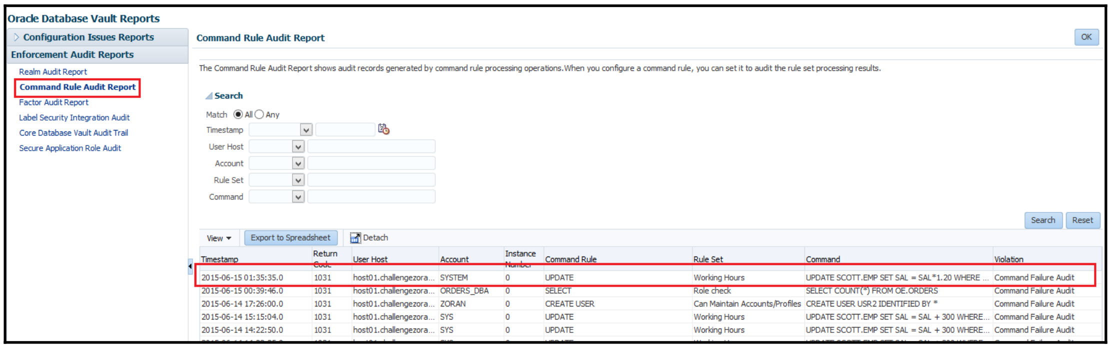
Realm Audit Report

The Realm Audit Report shows audit records generated by the realm protection and realm authorization operations.You can use this information to investigate attempts to break security.

Timestamp	Account	Return Code	User Host	Instance Number	Realm Name	Rule Set	Command	Violation
2015-06-15 01:31:51.0	SYSTEM	1031	host01.challengez...	0	HR_Realm		SELECT COUNT(*) FROM HR.EMPLOYEES	Realm Violation Audit
2015-06-15 00:59:01.0	ORDERS_DBA	47401	host01.challengez...	0	OE_Realm		GRANT SELECT ON OE.ORDERS TO OR...	Realm Violation Audit
2015-06-15 00:55:07.0	C##ZORAN	47410	host01.challengez...	0	Orders_Role_Realm		GRANT ORD_USR_ROLE TO ORDERS_U...	Realm Violation Audit
2015-06-14 17:26:54.0	ZORAN	47410	host01.challengez...	0	Oracle System Privilege and Role Mana...		GRANT CREATE SESSION TO USR2	Realm Violation Audit

Figure 35

4. Next, click on **Command Rule Audit Report** (see Figure 36). Observe the line marked in red (violation from step 3 is audited).


Oracle Database Vault Reports
Configuration Issues Reports
Enforcement Audit Reports
Realm Audit Report
Command Rule Audit Report
Factor Audit Report
Label Security Integration Audit
Core Database Vault Audit Trail
Secure Application Role Audit
OK
Search
Match All Any
Timestamp
User Host
Account
Rule Set
Command
Search
Reset
View
Export to Spreadsheet
Detach

Command Rule Audit Report

The Command Rule Audit Report shows audit records generated by command rule processing operations.When you configure a command rule, you can set it to audit the rule set processing results.

Timestamp	Return Code	User Host	Account	Instance Number	Command Rule	Rule Set	Command	Violation
2015-06-15 01:35:35.0	1031	host01.challengezora...	SYSTEM	0	UPDATE	Working Hours	UPDATE SCOTT.EMP SET SAL = SAL*1.20 WHERE ...	Command Failure Audit
2015-06-15 00:39:46.0	1031	host01.challengezora...	ORDERS_DBA	0	SELECT	Role check	SELECT COUNT(*) FROM OE.ORDERS	Command Failure Audit
2015-06-14 17:26:00.0	1031	host01.challengezora...	ZORAN	0	CREATE USER	Can Maintain Accounts/Profiles	CREATE USER USR2 IDENTIFIED BY *	Command Failure Audit
2015-06-14 15:15:04.0	1031	host01.challengezora...	SYS	0	UPDATE	Working Hours	UPDATE SCOTT.EMP SET SAL = SAL + 300 WHERE...	Command Failure Audit
2015-06-14 14:22:50.0	1031	host01.challengezora...	SYS	0	UPDATE	Working Hours	UPDATE SCOTT.EMP SET SAL = SAL + 300 WHERE...	Command Failure Audit

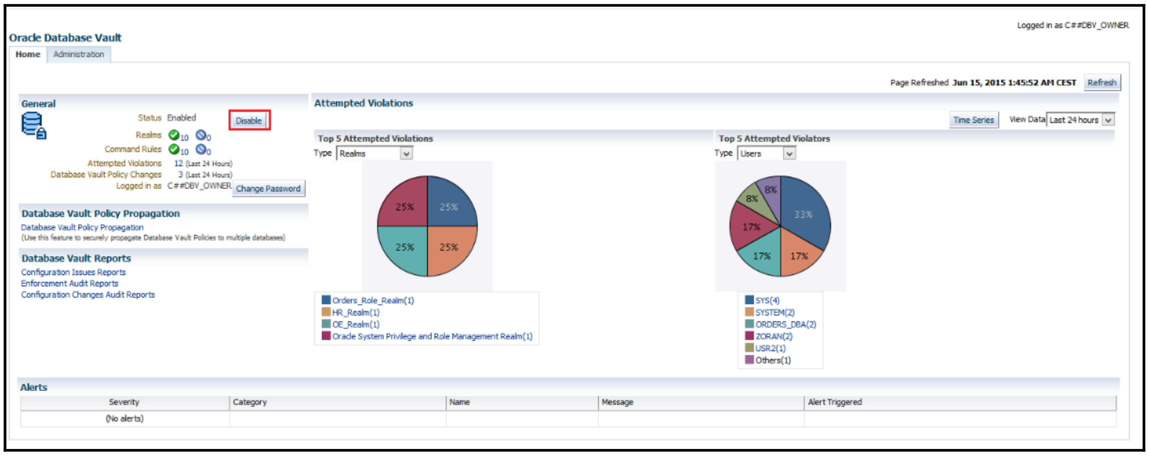
Figure 36

Disabling Database Vault

In this recipe, you will disable Database Vault in two ways: Using Enterprise Manager 12c Cloud Control and command line.

How to do it…

1. Go to Database Vault home page of your database or pluggable database and click on **Disable** (see Figure 37):



Oracle Database Vault

Logged in as C##DBV_OWNER

Page Refreshed **Jun 15, 2015 1:45:52 AM CEST**

General

Status	Enabled
Realms	✓ 10 ⊘ 0
Command Rules	✓ 10 ⊘ 0
Attempted Violations	12 (Last 24 Hours)
Database Vault Policy Changes	3 (Last 24 Hours)
Logged in as	C##DBV_OWNER

Database Vault Policy Propagation

Database Vault Policy Propagation
(Use this feature to securely propagate Database Vault Policies to multiple databases)

Database Vault Reports

Configuration Issues Reports
Enforcement Audit Reports
Configuration Changes Audit Reports

Attempted Violations

View Data: Last 24 hours

Top 5 Attempted Violations — Type: Realms

- Orders_Role_Realm(1)
- HR_Realm(1)
- OE_Realm(1)
- Oracle System Privilege and Role Management Realm(1)

Top 5 Attempted Violators — Type: Users

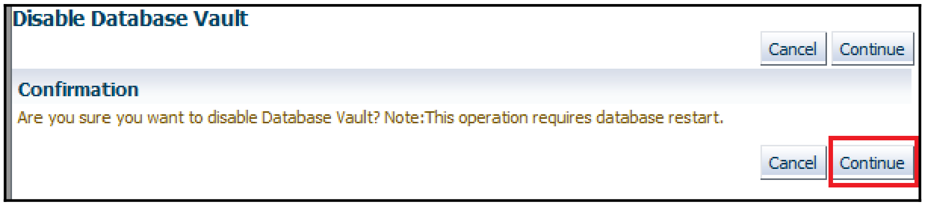
- SYS(4)
- SYSTEM(2)
- ORDERS_DBA(2)
- ZORAN(2)
- USR2(1)
- Others(1)

Alerts

Severity	Category	Name	Message	Alert Triggered
(No alerts)				

Figure 37

2. Click on continue in a small pop-up window (see Figure 38)



Disable Database Vault

Confirmation

Are you sure you want to disable Database Vault? Note:This operation requires database restart.

Figure 38

Or

Connect to the database as Database Vault owner and disable it through command line:

```
SQL> EXEC DBMS_MACADM.DISABLE_DV;
```

3. Connect to your database or pluggable database and restart it:

```
SQL> connect / as sysdba
SQL> alter pluggable database pdb1 close immediate;
SQL> alter pluggable database pdb1 open;
```

4. Confirm that Database Vault is disabled:

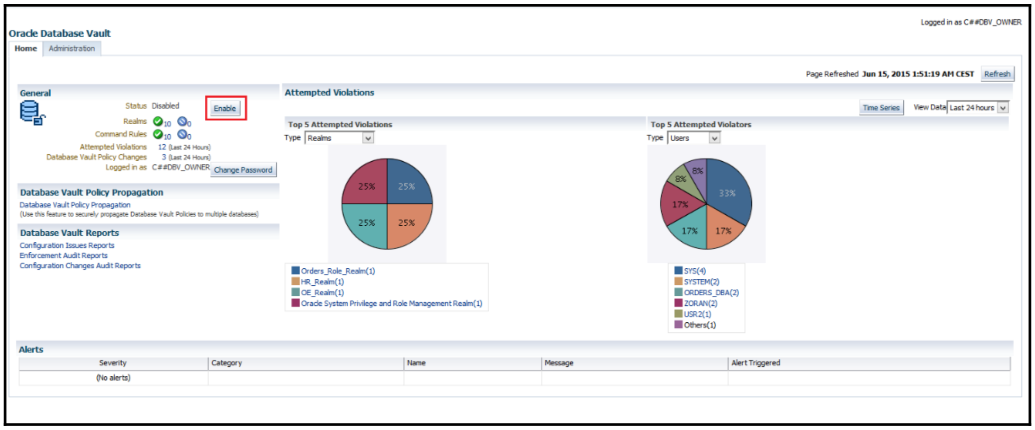
```
SQL> connect c##dbv_owner@pdb1
SQL> SELECT PARAMETER, VALUE FROM V$OPTION WHERE PARAMETER = 'Oracle
Database Vault';
PARAMETER                              VALUE
----------------------------           --------------
Oracle Database Vault                   FALSE
```

Re-enabling Database Vault

In this recipe, you will enable previously disabled Database Vault in two ways: Using Enterprise Manager 12c Cloud Control and command line.

How to do it…

1. Go to Database Vault home page of your database or pluggable database and click on **Enable**, then click on continue in a small pop-up window (see Figures 39, 40).



Oracle Database Vault

Logged in as C##DBV_OWNER

Page Refreshed **Jun 15, 2015 1:51:19 AM CEST**

General

Status Disabled

Realms ✓10 ⊘0

Command Rules ✓10 ⊘0

Attempted Violations 12 (Last 24 Hours)

Database Vault Policy Changes 3 (Last 24 Hours)

Logged in as C##DBV_OWNER

Database Vault Policy Propagation

Database Vault Policy Propagation
(Use this feature to securely propagate Database Vault Policies to multiple databases)

Database Vault Reports

Configuration Issues Reports
Enforcement Audit Reports
Configuration Changes Audit Reports

Attempted Violations

View Data Last 24 hours

Top 5 Attempted Violations

Type Realms

🟦 Orders_Role_Realm(1)
🟧 HR_Realm(1)
🟩 OE_Realm(1)
🟥 Oracle System Privilege and Role Management Realm(1)

Top 5 Attempted Violators

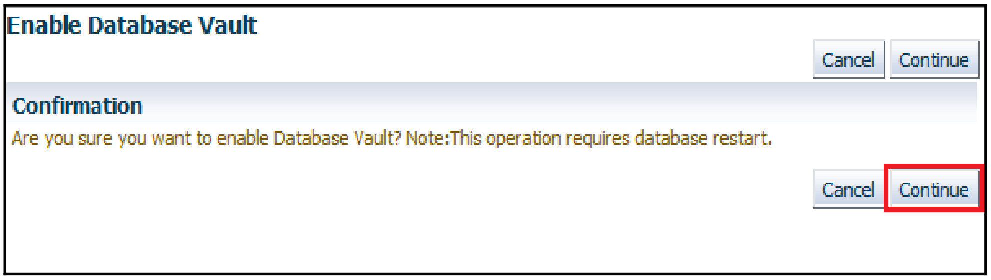
Type Users

🟦 SYS(4)
🟧 SYSTEM(2)
🟩 ORDERS_DBA(2)
🟥 ZORAN(2)
🟩 USR2(1)
🟪 Others(1)

Alerts

Severity	Category	Name	Message	Alert Triggered
(No alerts)				

Figure 39



Enable Database Vault

Confirmation

Are you sure you want to enable Database Vault? Note:This operation requires database restart.

Figure 40

Or

Connect to the database as Database Vault owner and enable it through command line:

```
SQL> EXEC DBMS_MACADM.ENABLE_DV;
```

2. Connect to your database or pluggable database and restart it:

```
SQL> connect / as sysdba

SQL> alter pluggable database pdb1 close immediate;

SQL> alter pluggable database pdb1 open;
```

3. Confirm that Database Vault is enabled:

```
SQL> connect c##dbv_owner@pdb1

SQL> SELECT PARAMETER, VALUE FROM V$OPTION WHERE PARAMETER = 'Oracle
Database Vault';
PARAMETER                        VALUE
----------------------------     --------------
Oracle Database Vault            TRUE
```

10
Unified Auditing

In this chapter, we will cover the following tasks:

- Enabling the Unified Auditing mode
- Configuring whether loss of audit data is acceptable
- Which roles do you need to have to be able to create audit policies and to view audit data?
- Auditing RMAN operations
- Auditing Data Pump operations
- Auditing Database Vault operations
- Creating audit policies to audit privileges, actions, and roles under specified conditions
- Enabling an audit policy
- Finding information about audit policies and audited data
- Auditing application contexts
- Purging audit trail
- Disabling and dropping audit policies

Introduction

Unified Auditing is a new feature in Oracle Database 12c, and it introduces new auditing architecture. Some of the characteristics of unified auditing are:

- A single audit trail
- Being based on a read-only table

- Extensible Audit Framework for additional columns
- The separation of audit administration with new roles
- Auditing performance is better, especially when used in the queued-write mode

Figure 1 depicts that in preunified auditing architecture, there were many audit trails. Now, there is one consolidated unified audit trail, which simplifies management, and auditors can more easily find audited data they are looking for.

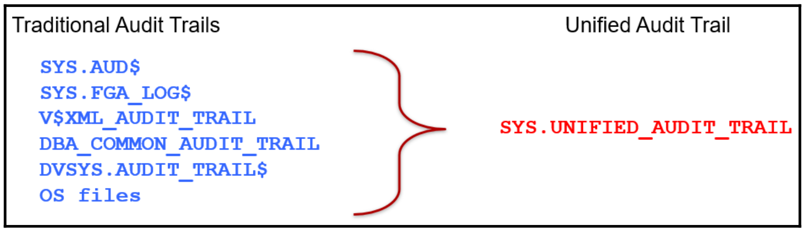


Figure 1

In Figure 2, a new architecture is shown:

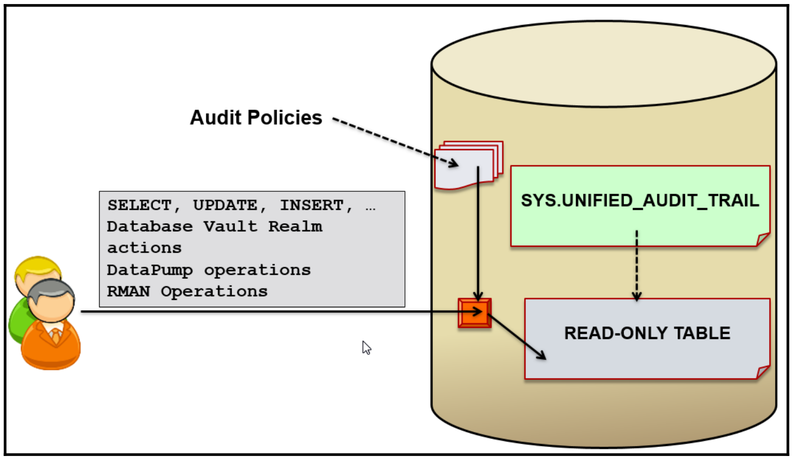


Figure 2 – Unified Auditing Architecture

Enabling Unified Auditing mode

In Oracle Database 12c, unified auditing is not enabled by default. The process of enabling it is simple and equivalent to enabling of other database options.

Getting ready

To complete this recipe, you'll need to shut down the database.

How to do it…

The process of enabling unified auditing is depicted in Figure 3.

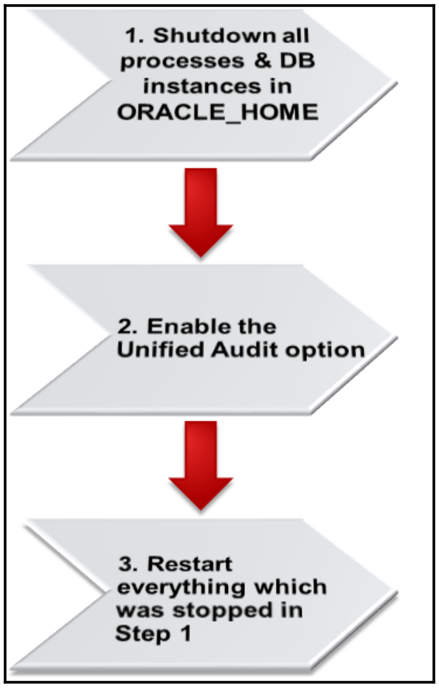

1. Shutdown all processes & DB instances in ORACLE_HOME
2. Enable the Unified Audit option
3. Restart everything which was stopped in Step 1

Figure 3

1. In our case, there is only one database instance. Connect to the instance as sysoper and shut it down. Also, stop the listener:

   ```
   $ sqlplus / as sysoper

   SQL> shutdown immediate
   SQL> exit
   $ lsnrctl stop
   ```

2. Relink Oracle binaries with the `uniaud_on` option:

   ```
   $ cd $ORACLE_HOME/rdbms/lib

   $ make -f ins_rdbms.mk uniaud_on ioracle
   ```

3. Start the listener and the database instance:

   ```
   $ lsnrctl start

   $ sqlplus / as sysoper
   SQL> startup
   ```

To verify that unified auditing is enabled, issue the following SQL statement:

```
SQL> SELECT PARAMETER, VALUE
  2  from v$option
  3  where PARAMETER = 'Unified Auditing';
```

You should see that value for `Unified Auditing` parameter is `true`:

```
    PARAMETER          VALUE
    ----------------  --------
    Unified Auditing   TRUE
```

How it works…

When database is upgraded to 12c, by default, it uses the traditional way of auditing (everything like it was in previous versions). However, when you directly install a new database 12c, default auditing is set to **mixed auditing mode**. In both cases, the procedure to enable the *unified auditing mode* is the same.

After you enable the unified auditing mode, traditional auditing doesn't work anymore. Old audit instance parameters (`AUDIT_TRAIL`, `AUDIT_FILE_DEST`, `AUDIT_SYSLOG_LEVEL`, and `AUDIT_SYS_OPERATIONS`) are disregarded. Also, using `syslog` and writing audit records to OS are not supported. Predefined unified audit policies that are enabled by default are:

- `ORA_SECURECONFIG` (database versions:12.1.0.1, 12.1.0.2)
- `ORA_LOGON_FAILURES` (Oracle Database 12.1.0.2)

Predefined unified audit policies

A **predefined unified audit policy** is a named set of commonly used and recommended audit settings, which already exists in Oracle Database 12c. In Oracle Database 12.1.0.1, there are five predefined unified audit policies, whereas there are eight predefined audit policies in Oracle Database 12.1.0.2. Table 1 lists predefined audit policies.

Predefined audit policy	**Oracle Database 12.1.0.1**	**Oracle Database 12.1.0.2**
`ORA_RAS_POLICY_MGMT`	Yes	Yes
`ORA_DATABASE_PARAMETER`	Yes	Yes
`ORA_RAS_SESSION_MGMT`	Yes	Yes
`ORA_ACCOUNT_MGMT`	Yes	Yes
`ORA_SECURECONFIG`	Yes	Yes
`ORA_LOGON_FAILURES`	No	Yes
`ORA_CIS_RECOMMENDATIONS`	No	Yes
`ORA_DV_AUDPOL`	No	Yes

Table 1 – The list of predefined unified audit policies

Even though predefined audit policies have the same name in different versions of Oracle Database, it doesn't necessarily mean that they are always identical.

If you execute the following statement in both 12.1.0.1 and 12.1.0.2 database versions, as a user who has the `audit_admin` or dba role:

```
SQL> select audit_option from audit_unified_policies
where policy_name='ORA_SECURECONFIG'
order by 1;
```

You will note that the `ORA_SECURECONFIG` predefined unified audit policy is slightly different (for example, `audit_options: LOGON, LOGOFF` that exist in 12.1.0.1 are removed from the policy in 12.1.0.2 and `LOGON` is part of `ORA_LOGON_FAILURES` policy; also some audit options are added in `ORA_SECURECONFIG` in 12.1.0.2 such as `ALTER PLUGGABLE DATABASE`).

There's more…

In Oracle Database 12cR1 **Standard Edition** (**SE**), when you enable unified auditing mode and query the v$option view to verify that it's enabled you may see the following:

```
PARAMETER          VALUE
----------------  --------
Unified Auditing   FALSE
```

This bug has been reported in My Oracle Support (17466854) and patch has been released.

See also

- *Finding information about audit policies and audited data*
- *Create audit policies to audit privileges, actions, and roles under specified conditions*
- *Enabling audit policy*

Configuring whether loss of audit data is acceptable

In this recipe, you'll learn to set whether audit data is queued in memory or is immediately written to audit trail.

Getting ready

To complete this recipe, you'll need an existing user who has the `audit_admin` role (for example, `jack`).

How to do it…

1. Connect to the database as user who has the `audit_admin` role (for example, `jack`):

   ```
   SQL> connect jack
   ```

2. If you want audit records to be immediately written to the unified audit trail set **immediate-write mode**:

   ```
   SQL> EXEC DBMS_AUDIT_MGMT.SET_AUDIT_TRAIL_PROPERTY
   (DBMS_AUDIT_MGMT.AUDIT_TRAIL_UNIFIED,DBMS_AUDIT_MGMT.
   AUDIT_TRAIL_WRITE_MODE,
   DBMS_AUDIT_MGMT.AUDIT_TRAIL_IMMEDIATE_WRITE);
   ```

3. Check that the mode is set to immediate-write:

   ```
   SQL> select * from dba_audit_mgmt_config_params
   where parameter_name='AUDIT WRITE MODE';
   ```

You should see that the value for the `AUDIT WRITE MODE` parameter is `IMMEDIATE WRITE MODE`:

```
PARAMETER_NAME       PARAMETER_VALUE       AUDIT_TRAIL
-----------------  --------------------  ------------------
AUDIT WRITE MODE   IMMEDIATE WRITE MODE  UNIFIED AUDIT TRAIL
```

If you want audit records to be queued in memory and at later time persisted, then set the **queued-write mode**. Instead of step 2, execute:

```
SQL> EXEC DBMS_AUDIT_MGMT.SET_AUDIT_TRAIL_PROPERTY
(DBMS_AUDIT_MGMT.AUDIT_TRAIL_UNIFIED,DBMS_AUDIT_MGMT.AUDIT_TRAIL_WRITE_MODE
, DBMS_AUDIT_MGMT.AUDIT_TRAIL_QUEUED_WRITE);
```

How it works…

The default value for a write mode is the queued-write mode. In this mode, audit data is stored in SGA queues and later automatically persisted in the read-only table in the `AUDSYS` schema in the `SYSAUX` tablespace. You can also manually flush content of memory queues to the disk:

```
SQL>EXEC SYS.DBMS_AUDIT_MGMT.FLUSH_UNIFIED_AUDIT_TRAIL;
```

You'll achieve better performance by using the queued-write mode, but in an event of instance crash, you may lose some audit records.

It is recommended that you use the queued-write mode in case that possibility of some audit data loss is acceptable.

Which roles do you need to have to be able to create audit policies and to view audit data?

In this recipe, you're going to create two users (for example, `jack` and `jill`). Jack's job is to implement auditing requirements and to make sure that auditing is functioning properly. Jill is an auditor and her job is to analyze audit data.

Getting ready

To complete this recipe, you'll need an existing user who has the DBA role (for example, `maja`).

How to do it…

1. Connect to the database as a user who has the dba role (for example, `maja`):

```
$ sqlplus maja
```

2. Create the user `jack` and grant him the `create session` privilege and the `audit_admin` role.

   ```
   SQL> create user jack identified by pQ3s7a4w2;

   SQL> grant create session, audit_admin to jack;
   ```

3. Create the user `jill` and grant her the `create session` privilege and the `audit_viewer` role.

   ```
   SQL> create user jill identified by t1m5_R2f3;

   SQL> grant create session, audit_viewer to jill;
   ```

How it works…

In Oracle Database 12c, there are two new roles: `AUDIT_ADMIN` and `AUDIT_VIEWER` (Figure 4).

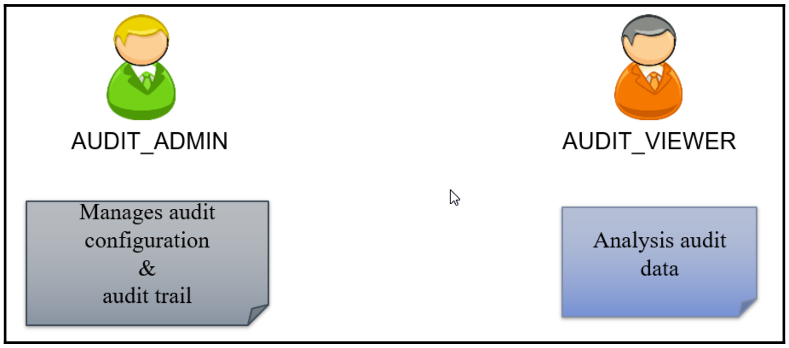


Figure 4

They enable the separation of duties in the auditing process. To configure auditing, you no longer need to have the dba role or connect as sysdba. From the security perspective, this is a significant improvement.

In step 2, you granted the AUDIT_ADMIN role to the newly created user jack because that role enables him to create, alter, enable, disable, and drop audit policies, view audit data, and manage the unified audit trail. In step 3, you granted the AUDIT_VIEWER role to the user jill because that role enables her to view audit data. You may wonder why the AUDIT_ADMIN role is designed in such a way that it enables a user to view audit data. One of the reasons could be that when you configure auditing (for example, create and enable audit policies), you have to be able to verify that audit records are generated in a way you have expected they would.

There's more…

To test what can and can't be done as a user who has the audit_viewer role, connect to the database as jill and try to create the unified audit policy jill_policy:

```
SQL> connect jill

SQL> create audit policy jill_policy
actions delete on oe.orders;
actions delete on oe.orders
*
ERROR at line 2:
ORA-00942: table or view does not exist
```

Even if you grant object privileges on the oe.orders table to jill, she won't be able to create unified audit policy because she doesn't have the audit_admin role or the AUDIT SYSTEM system privilege:

```
SQL> conn maja

SQL> grant select,delete on oe.orders to jill;

SQL> connect jill

SQL> create audit policy jill_policy
actions delete on oe.orders;
actions delete on oe.orders
*
ERROR at line 2:
ORA-01031: insufficient privileges
```

Revoke select and delete on the `oe.orders` table from Jill:

```
SQL> connect maja

SQL> revoke select,delete on oe.orders from jill;

Revoke succeeded.
```

Grant the `AUDIT SYSTEM` privilege to jill and again try to create the audit policy `jill_policy`:

```
SQL> grant audit system to jill;

SQL> connect jill

SQL> create audit policy jill_policy
actions delete on oe.orders;

Audit policy created.
```

Drop the unified audit policy `jill_policy` and revoke the `AUDIT SYSTEM` privilege from `jill`:

```
SQL> drop audit policy jill_policy;

Audit Policy dropped.

SQL> connect maja

SQL> revoke audit system from jill;
```

View audit data:

```
SQL> connect jill

SQL> select dbusername, action_name from unified_audit_trail
where unified_audit_policies='ORA_SECURECONFIG';
```

Also, a user who has the `audit_viewer` role can access information about defined and enabled unified audit policies.

Throughout this chapter, you'll use a user who has the `audit_admin` role (for example, `jack`), so only test you'll do right now is to enable the predefined audit policy `ORA_ACCOUNT_MGMT` and then to disable it:

```
SQL> connect jack

SQL> audit policy ora_account_mgmt;
Audit succeeded.
SQL> noaudit policy ora_account_mgmt;
Noaudit succeeded.
```

Auditing RMAN operations

In this recipe, you'll see that RMAN operations are audited by default.

Getting ready

In this recipe, we assume that database is in the `ARCHIVELOG` mode. To complete this recipe, you'll need an existing user who has the `SYSBACKUP` privilege (for example, `tom`) and an existing user who has the dba role (for example, `maja`).

How to do it…

1. Connect to the target database as a user who has the `SYSBACKUP` privilege (for example, `tom`).

   ```
   $ rman target '"tom@ora12cR1 AS SYSBACKUP"'
   ```

2. Backup the `EXAMPLE` tablespace and view information about backups:

   ```
   RMAN> backup tablespace EXAMPLE;

   RMAN> list backup;

   RMAN> exit
   ```

3. Connect to the database as a user who has the DBA role (for example, `maja`):

   ```
   $ sqlplus maja
   ```

4. Find the location of datafile for `EXAMPLE` tablespace:

   ```
   SQL> select file_name from dba_data_files where
   tablespace_name='EXAMPLE';
   FILE_NAME
   ----------------------------------------------------------
   /u01/app/oracle/oradata/ORA12CR1/datafile/
   o1_mf_example_9z79vpcj_.dbf
   ```

5. Remove the `EXAMPLE` tablespace datafile:

   ```
   SQL> !rm /u01/app/oracle/oradata/ORA12CR1/datafile/
   o1_mf_example_9z79vpcj_.dbf
   ```

6. Put the `EXAMPLE` tablespace offline:

   ```
   SQL> alter tablespace example offline immediate;

   SQL> exit
   ```

7. Restore the `EXAMPLE` tablespace datafile:

   ```
   $ rman target '"tom@ora12cR1 AS SYSBACKUP"'

   RMAN> restore tablespace EXAMPLE;
   ```

8. Recover the `EXAMPLE` tablespace datafile:

   ```
   RMAN> recover tablespace EXAMPLE;

   RMAN> exit
   ```

9. Put tablespace back online:

   ```
   $ sqlplus maja

   SQL> alter tablespace EXAMPLE online;
   ```

10. To verify that RMAN operations were successfully audited, execute the following statements:

    ```
    SQL> connect jack

    SQL> EXEC SYS.DBMS_AUDIT_MGMT.FLUSH_UNIFIED_AUDIT_TRAIL;

    SQL> select dbusername, rman_operation
    from unified_audit_trail
    where rman_operation is not null;
    ```

How it works…

When the mixed or unified auditing mode is enabled, RMAN operations are automatically audited. This means that you don't create audit policies, but you view and manage audit data in the same way as for other components.

In step 2, you performed the backup of the tablespace `EXAMPLE`. Then, in step 5, you intentionally caused a problem by removing the datafile. Afterwards, you performed restore and recover RMAN operations. The whole point of the example is to execute several RMAN operations. In the `unified_audit_trail` data dictionary view, there are several columns that contain data pertaining to the RMAN events. Their names start with RMAN, so it's easy to find them.

In step 10, you should get similar result to this one:

```
DBUSERNAME         RMAN_OPERATION
----------------- --------------------
TOM                   Backup
TOM                   List
TOM                   Restore
TOM                   Recover
```

See also

- *The sysbackup privilege – How, when, and why you should use it?* (`Chapter 1`, *Basic Database Security*)
- *Finding information about audit policies and audited data*

Auditing Data Pump operations

You can audit Data Pump export, import, or both export and import operations by creating audit policies.

Getting ready

To complete this recipe, you'll need an existing user who has the audit_admin role (for example, `jack`). Also, it is assumed that directory for export operations (for example, `my_dir`) is created and a user (for example, `maja`) who is going to perform the Data Pump export has read and write privileges on the directory.

```
SQL> CREATE DIRECTORY my_dir AS '/u01/app/oracle/oradata/export';

SQL> grant read, write ON DIRECTORY my_dir to maja;
```

How to do it…

1. Connect to the database as a user who has the `audit_admin` role (for example, `jack`):

   ```
   $ sqlplus jack
   ```

2. Create an audit policy to audit Data Pump export operations:

   ```
   SQL> CREATE AUDIT POLICY DP_POLICY ACTIONS
   COMPONENT=datapump export;
   ```

3. Enable the audit policy:

   ```
   SQL> AUDIT POLICY DP_POLICY;
   ```

4. Export the table `hr.departments`:

   ```
   $ expdp maja@ora12cR1 dumpfile=test tables=hr.departments
   DIRECTORY=my_dir
   ```

5. Verify that the export operation was successfully audited:

   ```
   SQL> connect jack
   SQL> select DP_TEXT_PARAMETERS1,DP_BOOLEAN_PARAMETERS1
   from unified_audit_trail
   where audit_type='Datapump' and dbusername='MAJA';
   ```

See also

- *Enabling audit policy*
- *Finding information about audit policies and audited data*

Auditing Database Vault operations

In this recipe, you'll learn to audit Oracle Database Vault events.

Getting ready

To complete this recipe, you'll need to use Oracle Database 12c, which has Oracle Database Vault enabled and at least some of the components configured (for example, the realm `HR` realm and rule set `Working Hours`). Also, you'll need an existing user who has the `audit_admin` role (for example, `jack`).

How to do it…

1. Connect to the database as a user who has the `audit_admin` role (for example, `jack)`:

   ```
   $ connect jack
   ```

2. Create the audit policy `dbv_policy`:

   ```
   SQL> CREATE AUDIT POLICY dbv_policy
   ACTIONS COMPONENT = DV Rule Set Failure on "Working Hours",realm
   violation on "HR Realm";
   ```

3. Enable the audit policy `dbv_policy`:

   ```
   SQL> audit policy dbv_policy;
   ```

4. Execute several statements that will cause generation of audit records:

   ```
   SQL> select * from oe.orders;

   SQL> update hr.employees set salary=30000 where salary=24000;
   ```

How it works…

To create an audit policy that captures Oracle Database Vault events, specify `ACTIONS COMPONENT = DV <action> ON <object>`. In step 2, you defined the audit policy `dbv_policy` that encapsulates the rules: audit records should be generated when somebody tries to access protected objects during nonworking hours or when unauthorized person tries to access objects secured by HR Realm.

In the unified audit trail, Oracle Database Vault-specific audit data is stored in the columns whose name starts with `DV_`.

There's more…

When you are using Oracle Database Vault, you can also additionally secure your auditing infrastructure by creating a realm around the `AUDIT_ADMIN` and `AUDIT_VIEWER` roles. This allows you to control who can grant those roles.

See also

- *Re-enabling Database Vault* (`Chapter 9`, *Database Vault*)
- *Creating a rule set* (`Chapter 9`, *Database Vault*)

Creating audit policies to audit privileges, actions and roles under specified conditions

In this recipe, you will create several unified audit policies.

Getting ready

To complete this recipe, you'll need two existing users:

- A user who has the `audit_admin` role (for example, `jack`)
- A user who has the `create session` privilege (for example, `john`)

Also, you should create the roles `hr_role` and `oe_role` as stated here and grant `hr_role` to the user `john`.

```
SQL> create role hr_role;
SQL> grant select any table, create table to hr_role;
SQL> grant insert on hr.departments to hr_role;
SQL> create role oe_role;
SQL> grant drop any table to oe_role;
SQL> grant select, update on oe.orders to oe_role;
SQL> grant oe_role to hr_role;
SQL> grant hr_role to john;
```

How to do it…

1. Connect to the database as a user who has the `audit_admin` role (for example, `jack`):

   ```
   $ sqlplus jack
   ```

2. Create audit policy `my_policy1`:

   ```
   SQL> CREATE AUDIT POLICY MY_POLICY1
   PRIVILEGES SELECT ANY TABLE
   ACTIONS CREATE TABLE, DROP TABLE;
   ```

3. Create the audit policy `role_con_policy`:

    ```
    SQL> CREATE AUDIT POLICY ROLE_CON_POLICY
    ROLES HR_ROLE
    WHEN 'SYS_CONTEXT(''USERENV'',''HOST'')=''dbhost.orapassion.com'''
    EVALUATE PER SESSION;
    ```

4. Create the audit policy `hr_policy`:

    ```
    SQL> CREATE AUDIT POLICY HR_POLICY
    ACTIONS SELECT,INSERT,UPDATE,DELETE ON HR.DEPARTMENTS;
    ```

5. Create the audit policy `oe_policy`:

    ```
    SQL> CREATE AUDIT POLICY OE_POLICY
    ACTIONS ALL ON OE.ORDERS;
    ```

How it works…

When you create a unified audit policy, it is stored in the first-class object owned by `SYS` schema (According to the official Oracle documentation, Oracle Database Security Guide 12c, E48135-09, p.22-4).

Audit records generation, as defined in a unified audit policy, starts after you *enable* the policy.

In step 2, you created the audit policy `my_policy1`.

In step 3, you created the audit policy `role_con_policy`, which defines that audit records will be generated when a user is connected to the database from the specified host (`dbhost.orapassion.com`) and *system privileges* that are *directly granted* to `HR_ROLE` are used. The Role `HR_ROLE` has to exist at the time audit policy `role_con_policy` is created because if it doesn't exist you will get an error message:

```
ERROR at line 2:
ORA-01919: role 'HR_ROLE' does not exist
```

In step 4, you created the audit policy `hr_policy`, the way it is written, audit records will be generated for `select`, `insert`, and `update` operations on all objects and for `delete` operations on `hr.departments`.

A common pitfall: People often define object-wise audit policies, the way you did in step 4 (`<object_action_1>`, `<object_action_2>`, …,`<object_action_n> ON <object>`). However, in most cases, the behavior they really want to get should be defined by writing `<object_action_1> ON <object>`, `<object_action_2> ON <object>`,…,`<object_action_n> ON <object>`.

In step 5, you created the audit policy `oe_policy`, which will be used in order to audit all actions on table orders in oe schema. In Oracle Database 12.1.0.1 due to the bug, audit records for this policy are not generated (16714031- Audit policy using `actions all` does not record audit trails (MOS)). Workaround is to specify one by one actions instead of using keyword `ALL`. The bug is fixed in Oracle Database 12.1.0.2.

See also

- *Enabling audit policy*

Enabling audit policy

In this recipe, you will learn to use different options to enable unified audit policies.

Getting ready

To complete this recipe, you'll need an existing user who has the `audit_admin` role (for example, `jack`) and several other existing users (for example, `john`, `maja`, and `zoran`).

How to do it…

1. Connect to the database as a user who has `audit_admin` role (for example, `jack`)

   ```
   SQL> connect jack
   ```

2. Enable audit policy `oe_policy` in such way that it applies only to user `JOHN`

   ```
   SQL> audit policy OE_POLICY BY JOHN;
   ```

3. Enable audit policy `hr_policy` to capture only successful events.

   ```
   SQL> AUDIT POLICY HR_POLICY WHENEVER SUCCESSFUL;
   ```

4. Enable policy `my_policy1` to audit unsuccessful events for all users except `maja` and `zoran`.

   ```
   SQL> audit policy my_policy1 EXCEPT MAJA, ZORAN WHENEVER NOT
   SUCCESSFUL;
   ```

5. Enable audit policy `role_con_policy` using default options.

   ```
   SQL> audit policy role_con_policy;
   ```

How it works…

In step 2, you defined `BY` list, which means that only user(s) listed on that list will be affected by the policy.

In step 3, you defined that audit policy `hr_policy` is applied to all users, but only successful operations will generate audit records.

In step 4, you defined `EXCEPT` list, which means that listed users will not be affected by audit policy. Also, audit records will be generated only for the failed operations.

In step 5, you enabled audit policy using default options, which means that `role_con_policy` will affect all users for both successful and unsuccessful events.

You can't use both `BY` and `EXCEPT` lists for the same policy statement.

Finding information about audit policies and audited data

In this recipe, you will view audited data and find information about unified audit policies.

Getting ready

To complete this recipe, you'll need three existing users:

- A user who has `audit_admin` role (for example, `jack`)
- A user who has `hr_role` and `oe_role` (for example, `john`), created in recipe *Creating audit policies to audit privileges, actions and roles under specified conditions*
- A user who has `admin_viewer` role (for example, `jill`)

Also, you'll need to connect to the database as `SYS` user.

How to do it…

1. Connect to the database as a user who has the `audit_admin` role (for example, `jack`):

   ```
   $ connect jack
   ```

2. Find which unified audit policies are defined (exist in the database):

   ```
   SQL> select distinct policy_name
   from audit_unified_policies;
   SQL> desc audit_unified_policies
   ```

3. View which unified audit policies are enabled:

   ```
   SQL> select * from audit_unified_enabled_policies;
   ```

4. Connect to the database as the user `john`:

   ```
   SQL> connect john
   ```

5. Execute several statements on the tables `HR.EMPLOYEES`, `HR.DEPARTMENTS`, and `OE.ORDERS`:

   ```
   SQL> create table t(a number(10));
   SQL> select count(*) from oe.orders;
   SQL> select first_name from hr.employees;
   SQL> drop table t;
   SQL> connect sys / as sysdba
   SQL> create table hr.my_table(b varchar2(10));
   SQL> connect john
   SQL> drop table hr.my_table;
   ```

6. Connect to the database as a user who has the `audit_viewer` role (for example, `jill`):

   ```
   SQL> connect jill
   ```

7. View audit records:

   ```
   SQL> set linesize 250
   SQL> col event_timestamp format a30
   SQL> col action_name format a20
   SQL> col unified_audit_policies format a20
   SQL> col sql_text format a80
   SQL> select event_timestamp,
   action_name,unified_audit_policies, sql_text  from
   unified_audit_trail where DBUSERNAME = 'SYS'and
   ACTION_NAME NOT IN ('LOGON','LOGOFF')
   ORDER BY EVENT_TIMESTAMP  DESC;
   SQL> select event_timestamp,
   action_name, unified_audit_policies, sql_text
   from unified_audit_trail where DBUSERNAME = 'JONH'and
   ACTION_NAME NOT IN ('LOGON','LOGOFF') ORDER BY EVENT_TIMESTAMP
   DESC;
   ```

Auditing application contexts

In this recipe, you will configure auditing of information contained in an application context.

Getting ready

To complete this recipe, you'll need an existing (or predefined) application context and a user who has the `audit_admin` role (for example, `jack`).

How to do it…

1. Connect to the database as a user who has the `audit_admin` role (for example, `jack`):

```
$ sqlplus jack
```

2. Configure application context auditing:

```
SQL> AUDIT CONTEXT NAMESPACE USERENV
ATTRIBUTES SESSION_USER, SERVICE_NAME;

Audit succeeded.

SQL> AUDIT CONTEXT NAMESPACE USERENV
ATTRIBUTES HOST BY jill;
Audit succeeded.
```

3. View for which application contexts audit data is going to be captured:

```
SQL> set linesize 180
SQL> column namespace format A30
SQL> column attribute format A30
SQL> column user_name format A30

SQL> select * from audit_unified_contexts;
```

4. Connect user `jill` as follows:

```
SQL> connect jill
```

5. View audit records:

```
SQL> SELECT APPLICATION_CONTEXTS FROM UNIFIED_AUDIT_TRAIL
WHERE APPLICATION_CONTEXTS IS NOT NULL;
```

How it works…

The result of the statements in step3:

```
NAMESPACE      ATTRIBUTE       USER_NAME
----------    ------------    -------------
 USERENV      HOST             JILL
 USERENV      SERVICE_NAME     ALL USERS
 USERENV      SESSION_USER     ALL USERS
```

You can audit custom application contexts (for example, the ones you created) in the same way.

If needed, execute the following statement as the user `jack`:

```
SQL>EXEC SYS.DBMS_AUDIT_MGMT.FLUSH_UNIFIED_AUDIT_TRAIL;
```

Result after step 5:

```
APPLICATION_CONTEXTS
--------------------------------------------------------------
(USERENV,SERVICE_NAME=SYS$USERS); (USERENV,SESSION_USER=JACK)
(USERENV,SERVICE_NAME=SYS$USERS); (USERENV,SESSION_USER=JILL);
(USERENV,HOST= dbhost.orapassion.com)
```

There's more…

To disable auditing of application contexts, you should use the `NOAUDIT` command:

```
SQL> connect jack

SQL> NOAUDIT CONTEXT NAMESPACE USERENV
ATTRIBUTES HOST BY jill;
```

See also

- `Chapter 12`, *Appendix – Application Contexts*

Purging audit trail

You can clean up audit data manually or by scheduling clean up job.

Getting ready

To complete this recipe, you'll need a user who has the `audit_admin` role (for example, `jack`).

How to do it…

1. Connect to the database as a user who has the `audit_admin` role (for example, `jack`):

   ```
   $ sqlplus jack
   ```

2. View number of audit records in the unified audit trail before the cleanup:

   ```
   SQL> select count (*) from unified_audit_trail;
   ```

   - To perform the manual cleanup, execute:

     ```
     SQL> exec DBMS_AUDIT_MGMT.CLEAN_AUDIT_TRAIL(
     AUDIT_TRAIL_TYPE => DBMS_AUDIT_MGMT.AUDIT_TRAIL_UNIFIED)
     ```

   - To create a purge job:

     ```
     SQL> exec DBMS_AUDIT_MGMT.CREATE_PURGE_JOB
     (AUDIT_TRAIL_TYPE => DBMS_AUDIT_MGMT.AUDIT_TRAIL_UNIFIED,
     AUDIT_TRAIL_PURGE_INTERVAL => 24,
     AUDIT_TRAIL_PURGE_NAME => 'My_Job',
     USE_LAST_ARCH_TIMESTAMP => TRUE)
     ```

3. View number of audit records in the unified audit trail after the cleanup:

```
SQL> select count (*) from unified_audit_trail;
```

How it works…

By default, `USE_LAST_ARCH_TIMESTAMP` is set to `TRUE`. It means that only records created before that time will be deleted. If you set that parameter to `FALSE`, all records will be deleted. It is recommended to use the default value.

There's more…

In multitenant environment, use `CONTAINER` clause as well (`CONTAINER => DBMS_AUDIT_MGMT.CONTAINER_CURRENT` or `DBMS_AUDIT_MGMT.CONTAINER_ALL`).

Disabling and dropping audit policies

In this recipe, you will learn to disable and drop audit policies.

Getting ready

To complete this recipe, you'll need an enabled unified audit policy (for example, `oe_policy`) and a user who has the `audit_admin` role (for example, `jack`).

How to do it…

1. Connect to the database as a user who has the `audit_admin` role (for example, `jack`):

```
$ sqlplus jack
```

2. Verify that the policy is enabled:

```
SQL> SELECT POLICY_NAME, ENABLED_OPT, USER_NAME,
SUCCESS, FAILURE
FROM AUDIT_UNIFIED_ENABLED_POLICIES;
```

3. Disable the policy `oe_policy`:

```
SQL> NOAUDIT policy oe_policy BY JOHN;
```

4. Verify that `oe_policy` is disabled:

```
SQL> select * from AUDIT_UNIFIED_ENABLED_POLICIES;
```

5. Drop the policy `oe_policy`:

```
SQL> drop audit policy oe_policy;
```

How it works…

In step 2, you checked that the audit policy `oe_policy` is enabled. In step 3, you disabled it.

When you disable audit policy, make sure that in the `NOAUDIT` statement, a list of users (`BY` or `EXCEPT`) is the same as it was in the `AUDIT` statement. If in step 3, you omit `BY JOHN`, audit records will continue to be generated.

To be able to drop audit policy, you have to disable it first. In step 5, you dropped the audit policy `oe_policy`.

See also

- *Enabling audit policy*

11
Additional Topics

In this chapter, we will cover the following tasks:

- Exporting data using Oracle Data Pump in the Oracle Database Vault environment
- Creating factors in Oracle Database Vault
- Using TDE in a multitenant environment

Introduction

An Oracle Database Vault component **factor** is a named variable, which can have one or more values, assigned in several ways. The actual value of factor is named **identity**. Each factor has a **factor type**. A factor type is used only for classification purposes. Factors are building blocks for configuring security policies. They can be used in rules/rule sets. You can configure factors by using Oracle Enterprise Manager or the Database Vault API.

Exporting data using Oracle Data Pump in Oracle Database Vault environment

In Oracle Database 12c, it is possible to perform Oracle Data Pump regular and transportable export and import operations in the Oracle Database Vault environment.

The process of exporting and importing data in Oracle Database 12c is a bit different than in Oracle Database 11g. The default rule set *Allow Oracle Data Pump Operation* is deprecated.

In this recipe, you'll export data that resides in a schema that is protected by a realm.

Getting ready

It is assumed that:

- You are using Oracle Database 12.1.0.2 (the traditional architecture) on Linux
- Sample schemas are installed (you'll use HR schema in this recipe)
- Database Vault is enabled and configured (a Database Vault *owner* is user `dbv_owner`, *account manager* is user `dbv_acctmgr`, and realm that protects `HR` schema is created). This is one way how you can create `HR` realm:

```
SQL> connect dbv_owner
SQL> BEGIN
 DBMS_MACADM.CREATE_REALM(
  realm_name    => 'HR Realm',
  description   => 'Protects HR schema',
  enabled       => DBMS_MACUTL.G_YES,
  audit_options => DBMS_MACUTL.G_REALM_AUDIT_OFF,
  realm_type    => 0);
END;
/

PL/SQL procedure successfully completed.
```

The parameter `realm_type` specifies whether realm is a mandatory realm or not. Allowed values, for the parameter, are (realm) and `1` (mandatory realm).

```
SQL> BEGIN
 DBMS_MACADM.ADD_OBJECT_TO_REALM(
  realm_name   => 'HR Realm',
  object_owner => 'HR',
  object_name  => '%',
  object_type  => '%');
END;
/

PL/SQL procedure successfully completed.
```

- A directory for export operations (for example, `dp_dir`) is created and a user (for example, `piter`) who is going to perform Data Pump export has read and write privileges on the directory. Also, the `DATAPUMP_EXP_FULL_DATABASE` role and the `CREATE TABLE` and `UNLIMITED TABLESPACE` privileges have been granted to the user:

```
SQL> connect system
SQL> CREATE DIRECTORY dp_dir AS '/u01/app/oracle/oradata/dp_exp';
SQL> connect dbv_acctmgr
SQL> create user piter identified by T2abc_4z1;
SQL> grant create session to piter;
SQL> connect / as sysdba
SQL> grant create table, unlimited tablespace to piter;
SQL> grant read, write ON DIRECTORY dp_dir to piter;
SQL> grant DATAPUMP_EXP_FULL_DATABASE to piter;
```

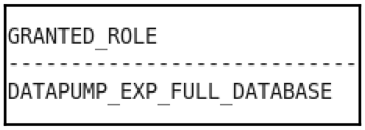
How to do it…

1. Connect to the database as a user who has the `DV_OWNER` or `DV_ADMIN` role (for example, `dbv_owner`):

```
$ sqlplus dbv_owner
```

2. Verify that the user `piter` has the `DATAPUMP_EXP_FULL_DATABASE` role:

```
SQL> SELECT GRANTED_ROLE FROM DBA_ROLE_PRIVS WHERE
GRANTED_ROLE LIKE '%FULL%' AND GRANTEE='PITER';
```



```
GRANTED_ROLE
------------------------------
DATAPUMP_EXP_FULL_DATABASE
```

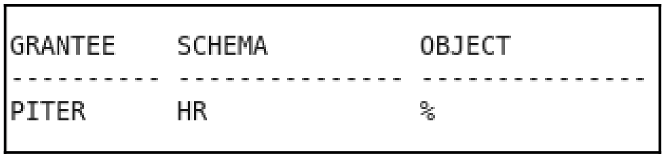
Figure 1 – Prerequisite role

3. Authorize the user `piter` to perform Data Pump operations on `HR` schema (execute the `DBMS_MACADM.AUTHORIZE_DATAPUMP_USER` procedure):

```
SQL> EXEC DBMS_MACADM.AUTHORIZE_DATAPUMP_USER ('PITER', 'HR');

PL/SQL procedure successfully completed.
```

4. Query the `DVSYS.DBA_DV_DATAPUMP_AUTH` view to confirm that the user `piter` is authorized to perform export and import operations only on `HR` schema:

```
SQL> column grantee format A10
SQL> column schema format A15
SQL> column object format A15
SQL> SELECT * FROM DVSYS.DBA_DV_DATAPUMP_AUTH WHERE GRANTEE =
'PITER';
```

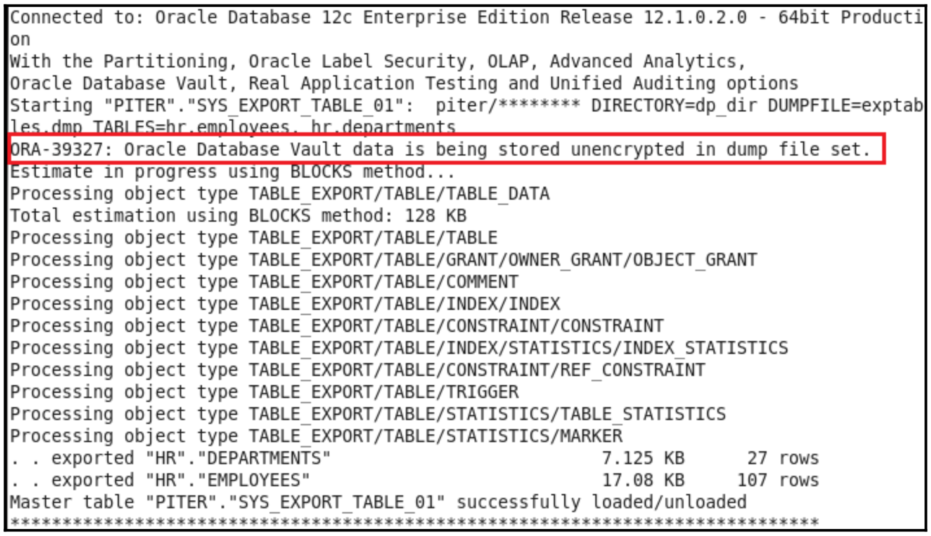


```
GRANTEE    SCHEMA          OBJECT
---------- --------------- ---------------
PITER      HR              %
```

Figure 2 – Authorized for all database object in schema HR

5. Export the `HR.EMPLOYEES` and `HR.DEPARTMENTS` tables:

```
$ expdp piter DIRECTORY=dp_dir DUMPFILE= exptables.dmp TABLES=
hr.employees, hr.departments
```



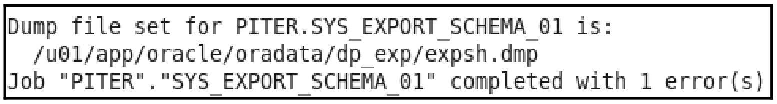
```
Connected to: Oracle Database 12c Enterprise Edition Release 12.1.0.2.0 - 64bit Producti
on
With the Partitioning, Oracle Label Security, OLAP, Advanced Analytics,
Oracle Database Vault, Real Application Testing and Unified Auditing options
Starting "PITER"."SYS_EXPORT_TABLE_01":  piter/******** DIRECTORY=dp_dir DUMPFILE=exptab
les.dmp TABLES=hr.employees, hr.departments
ORA-39327: Oracle Database Vault data is being stored unencrypted in dump file set.
Estimate in progress using BLOCKS method...
Processing object type TABLE_EXPORT/TABLE/TABLE_DATA
Total estimation using BLOCKS method: 128 KB
Processing object type TABLE_EXPORT/TABLE/TABLE
Processing object type TABLE_EXPORT/TABLE/GRANT/OWNER_GRANT/OBJECT_GRANT
Processing object type TABLE_EXPORT/TABLE/COMMENT
Processing object type TABLE_EXPORT/TABLE/INDEX/INDEX
Processing object type TABLE_EXPORT/TABLE/CONSTRAINT/CONSTRAINT
Processing object type TABLE_EXPORT/TABLE/INDEX/STATISTICS/INDEX_STATISTICS
Processing object type TABLE_EXPORT/TABLE/CONSTRAINT/REF_CONSTRAINT
Processing object type TABLE_EXPORT/TABLE/TRIGGER
Processing object type TABLE_EXPORT/TABLE/STATISTICS/TABLE_STATISTICS
Processing object type TABLE_EXPORT/TABLE/STATISTICS/MARKER
. . exported "HR"."DEPARTMENTS"                          7.125 KB      27 rows
. . exported "HR"."EMPLOYEES"                            17.08 KB     107 rows
Master table "PITER"."SYS_EXPORT_TABLE_01" successfully loaded/unloaded
******************************************************************************
```

Figure 3 – The warning message

6. Export `HR` schema in an unencrypted format:

```
$ expdp piter DIRECTORY=dp_dir DUMPFILE=expsh.dmp SCHEMAS=hr
ENCRYPTION=NONE
```

You'll receive the same message as in the previous step (ORA-39327), even though you explicitly stated that you don't want to encrypt export. At the end of the job, you'll see that it completed with one error (Figure 4) meaning that one warning:



```
Dump file set for PITER.SYS_EXPORT_SCHEMA_01 is:
  /u01/app/oracle/oradata/dp_exp/expsh.dmp
Job "PITER"."SYS_EXPORT_SCHEMA_01" completed with 1 error(s)
```

Figure 4 – Successful export with warning

How it works…

To be able to export data that is protected by Database Vault mechanisms, user has to be authorized (besides having appropriate privileges to perform Data Pump operations, for example, the role). You can authorize a user to perform export and import operations:

- On specific database object in a schema, such as table. For example, it authorizes the user `amy` to export the table `HR.EMPLOYEES`:

  ```
  SQL> EXEC DBMS_MACADM.AUTHORIZE_DATAPUMP_USER ('AMY', 'HR',
  'EMPLOYEES');
  ```

- On specific schema (you authorized the user `piter` to perform export and import operations on `HR` schema in step 3).
- For entire database. For example, it authorizes the user `kim` to export and import database object for the entire database:

  ```
  SQL> EXEC DBMS_MACADM.AUTHORIZE_DATAPUMP_USER ('KIM');

  SQL> grant DV_OWNER to kim;
  ```

There's more…

According to *Oracle Database Licensing Information, 12c Release 1 (12.1)*,If you want to encrypt Oracle Data Pump export, using its encryption features, Oracle Advanced Security option has to be enabled.

To encrypt export, specify appropriate value for `ENCRYPTION` parameter (instead of `NONE` which was shown in step 6 in the *How to do it* section). These are allowed values for the parameter:

```
ENCRYPTION=[ALL|DATA_ONLY|ENCRYPTED_COLUMNS_ONLY|METADATA_ONLY|NONE]
```

Also, before starting an export operation, make sure that the keystore is open.

See also

- A good reference to learn about Oracle Data Pump is official Oracle documentation – *Oracle Database Utilities, 12c Release 1 (12.1.0.2), Part I.*

Creating factors in Oracle Database Vault

In this recipe, you'll create three factors (`Day`, `Holiday`, and `NonWorkingDay`). The factor `Day` will return name of the day based on `sysdate`. The factor `Holiday` will return `TRUE` if it is a company nonworking holiday (for example, `1-JAN`, `4-JUL`, and `15-NOV`) and `FALSE` otherwise. The factor `NonWorkingDay` will return whether it's a nonworking day (`NO`, `WEEKEND`, and `COMPANY_HOLIDAY`). We'll assume that a day is a nonworking day if it is a weekend or a company nonworking holiday (in case it is both weekend and holiday, it should resolve it to `COMPANY_HOLIDAY`).

Getting ready

It is assumed that:

- You are using Oracle Database 12.1.0.2 (the traditional architecture) on Linux and Oracle Enterprise Manager Cloud Control 12c
- Database Vault is enabled and configured (the Database Vault *owner* is the user `dbv_owner` and *account manager* is the user `dbv_acctmgr`).

- The user `dbv_owner` has been granted the `SELECT ANY DICTIONARY` privilege
- The user `piter` exists, the function `piter.get_function` has been created, and `DVSYS` has been granted the `EXECUTE` privilege on the function:

```
SQL> connect system
SQL> create or replace function piter.get_holiday
  2  return varchar2
  3  IS
  4  holiday varchar2(10);
  5  begin
  6  IF (RTRIM(TO_CHAR(SYSDATE,'DD-MON')) IN ('1-JAN', '4-JUL',
  '15-NOV')) THEN
  7  holiday := 'TRUE';
  8  ELSE
  9  holiday := 'FALSE';
  10  END IF;
  11  RETURN holiday;
  12  end;
  13  /
Function created.
SQL> grant execute on piter.get_holiday to dvsys;
Grant succeeded.
```

- Results in this recipe are shown for the situation that, at the same time, it is `SUNDAY` and it is a holiday.

How to do it…

1. Log in to EM12c as a `SYSMAN` or some other privileged user. Select your database. Then, from **Security** drop-down menu, choose **Database Vault** (Figure 5).

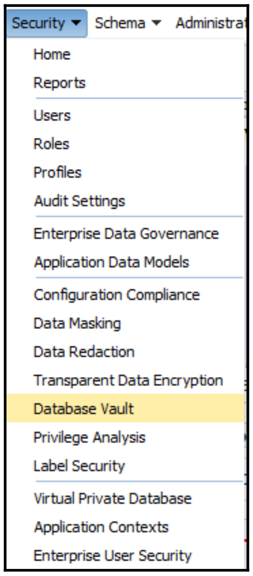
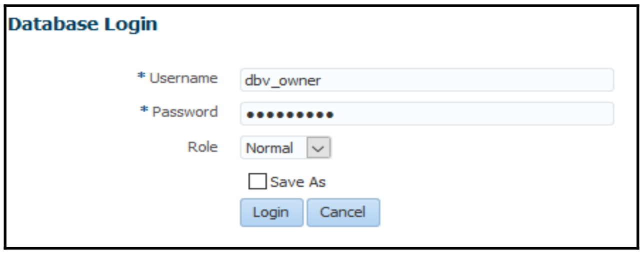


Figure 5

2. Log in as the `dbv_owner` user (Figure 6).



Database Login

* Username	dbv_owner
* Password	•••••••••
Role	Normal
	☐ Save As

Figure 6

3. Choose the **Administration** tab and click on the **Factors** link (Figure 7).

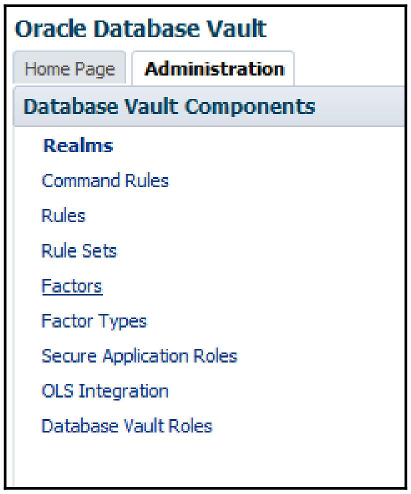
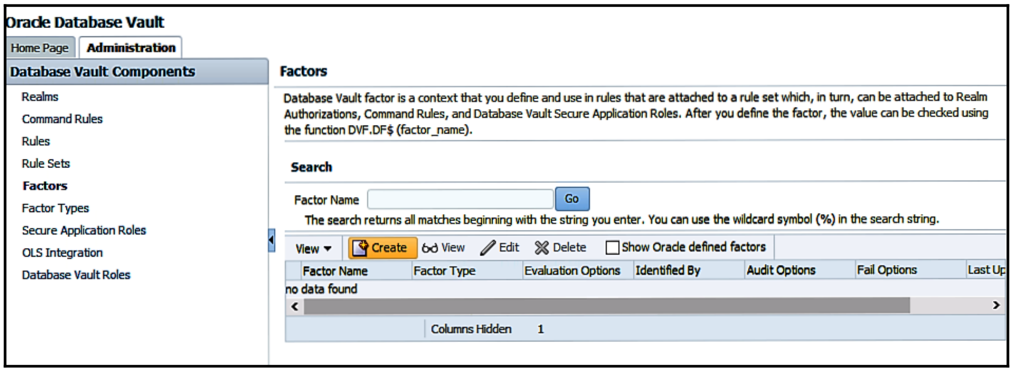


Figure 7

4. Click on the **Create** button to create your first custom factor (see Figure 8).


Oracle Database Vault

Home Page | Administration

Database Vault Components

Realms
Command Rules
Rules
Rule Sets
Factors
Factor Types
Secure Application Roles
OLS Integration
Database Vault Roles

Factors

Database Vault factor is a context that you define and use in rules that are attached to a rule set which, in turn, can be attached to Realm Authorizations, Command Rules, and Database Vault Secure Application Roles. After you define the factor, the value can be checked using the function DVF.DF$ (factor_name).

Search

Factor Name [ ] Go

The search returns all matches beginning with the string you enter. You can use the wildcard symbol (%) in the search string.

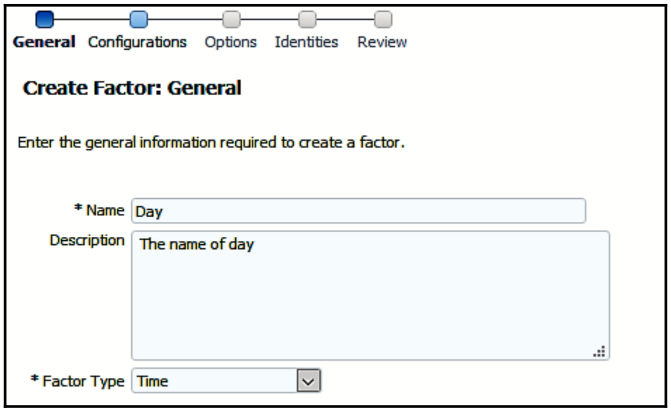
View ▾ | Create | View | Edit | Delete | ☐ Show Oracle defined factors

Factor Name	Factor Type	Evaluation Options	Identified By	Audit Options	Fail Options	Last Up
no data found						

Columns Hidden 1

Figure 8

5. The name of the factor will be `Day`, the description will be `The name of day`, and **Factor Type** will be **Time** (shown in Figure 9). After you enter that information, click on the button **Next**.



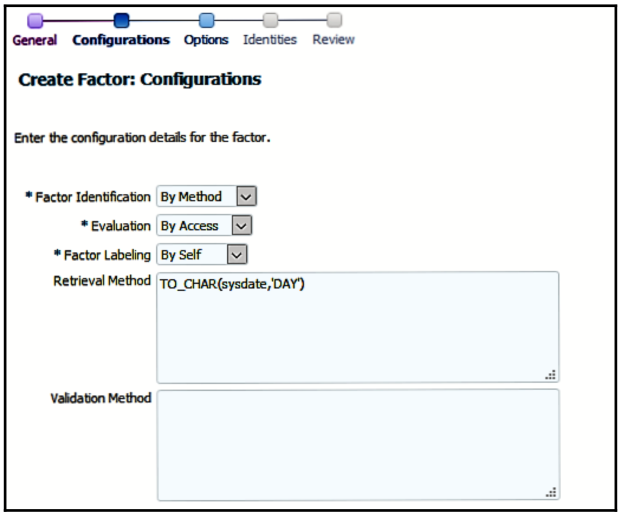
Create Factor: General

Enter the general information required to create a factor.

* Name	Day
Description	The name of day
* Factor Type	Time

Figure 9

6. Enter these configuration details for the factor and click on the button **Next.** It will appear as shown in this figure :



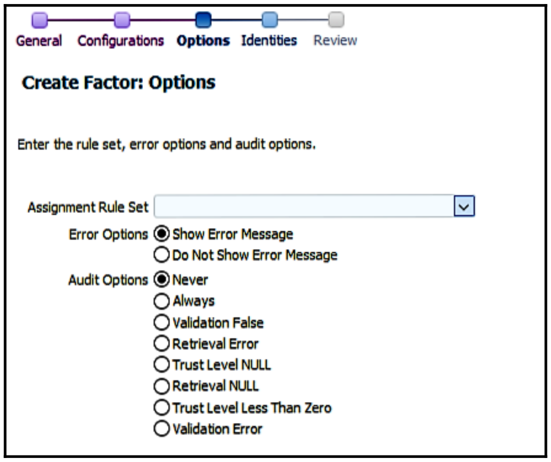
Create Factor: Configurations

Enter the configuration details for the factor.

* Factor Identification	By Method
* Evaluation	By Access
* Factor Labeling	By Self
Retrieval Method	TO_CHAR(sysdate,'DAY')
Validation Method	

Figure 10

7. For **Audit Options**, choose **Never**. Leave other default values and click the button **Next** (see Figure 11).



General Configurations **Options** Identities Review

Create Factor: Options

Enter the rule set, error options and audit options.

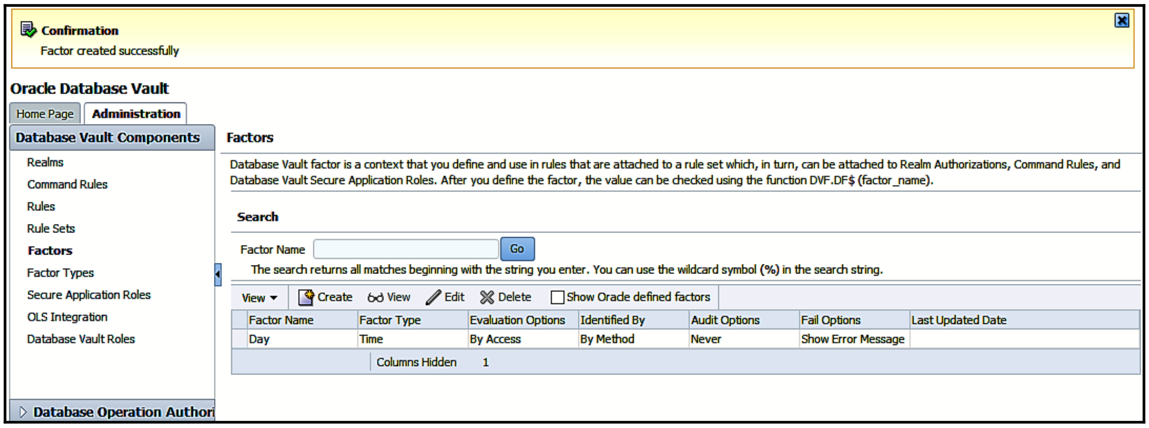
Assignment Rule Set

Error Options [✓ Show Error Message] Do Not Show Error Message

Audit Options [✓ Never] Always Validation False Retrieval Error Trust Level NULL Retrieval NULL Trust Level Less Than Zero Validation Error

Figure 11

8. You won't create new identities at this moment, so just click on the button **Next**. After you finish reviewing the configuration, click on the **Finish** button . You should receive a confirmation message and see the newly created factor `Day` (result is shown in Figure 12).



Confirmation
Factor created successfully

Oracle Database Vault

Home Page | **Administration**

Database Vault Components
- Realms
- Command Rules
- Rules
- Rule Sets
- **Factors**
- Factor Types
- Secure Application Roles
- OLS Integration
- Database Vault Roles

Database Operation Authori

Factors

Database Vault factor is a context that you define and use in rules that are attached to a rule set which, in turn, can be attached to Realm Authorizations, Command Rules, and Database Vault Secure Application Roles. After you define the factor, the value can be checked using the function DVF.DF$ (factor_name).

Search

Factor Name [Go]

The search returns all matches beginning with the string you enter. You can use the wildcard symbol (%) in the search string.

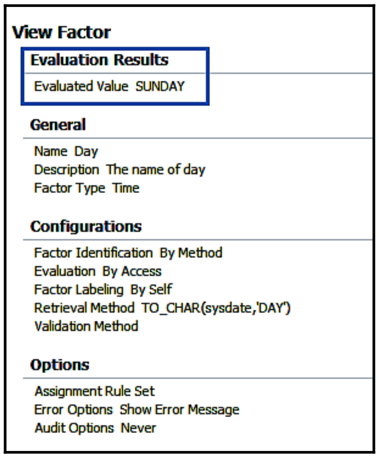
View | Create | View | Edit | Delete | Show Oracle defined factors

Factor Name	Factor Type	Evaluation Options	Identified By	Audit Options	Fail Options	Last Updated Date
Day	Time	By Access	By Method	Never	Show Error Message	

Columns Hidden 1

Figure 12

9. Click on **Link Day** (in the column **Factor Name**, as shown in Figure 12). You will see that factor `Day` will get value `SUNDAY` (see figure 13). Click on the **OK** button.



View Factor

Evaluation Results

Evaluated Value SUNDAY

General

Name Day
Description The name of day
Factor Type Time

Configurations

Factor Identification By Method
Evaluation By Access
Factor Labeling By Self
Retrieval Method TO_CHAR(sysdate,'DAY')
Validation Method

Options

Assignment Rule Set
Error Options Show Error Message
Audit Options Never

Figure 13

Now create the new factor `NonWorkingDay` (**Factor Type**: `Time`) which will, for the beginning, be based only on the factor `Day` and test it. After you create the factor `Holiday`, you'll edit the factor `NonWorkingDay` in such a way that it is based on both factors (`Day` and `Holiday`).

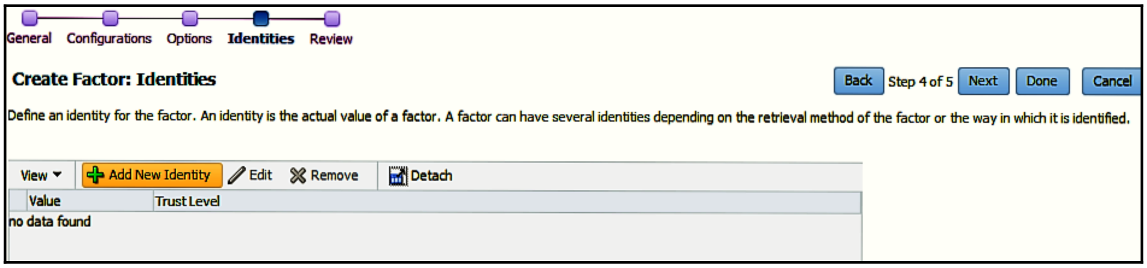
10. Repeat steps 4 and 5.

11. Enter these configuration details for the factor and click on the button **Next**:

Factor Identification:	**By Factors**
Evaluation:	**By Access**
Factor Labeling:	**By Self**

12. Leave the default values and click on the **Next** button.

13. Click on the green plus button – **Add New Identity** (see Figure 14).



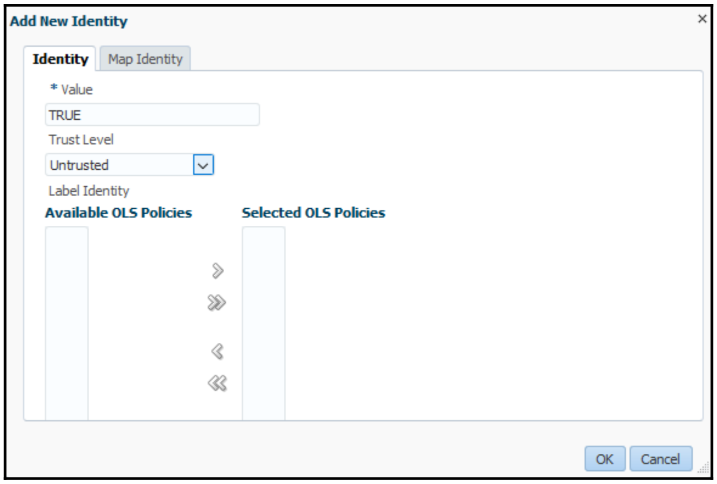
Create Factor: Identities

Define an identity for the factor. An identity is the actual value of a factor. A factor can have several identities depending on the retrieval method of the factor or the way in which it is identified.

Value	Trust Level
no data found	

Figure 14

14. On the tab Identity, enter **Value** as `TRUE` and select **Untrusted** for **Trust Level** (see Figure 15).



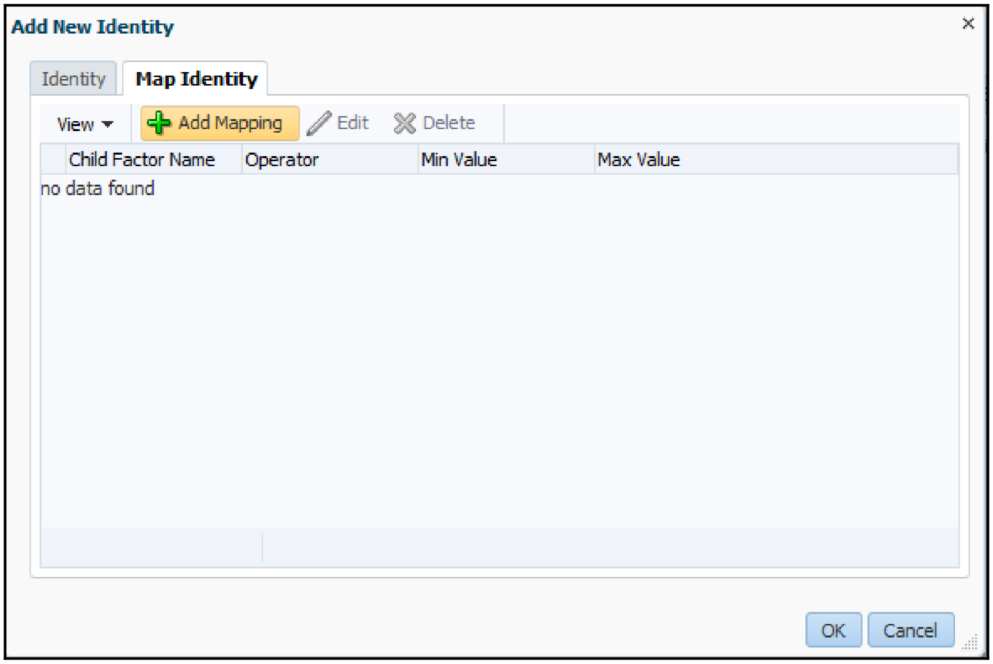
* Value: TRUE

Trust Level: Untrusted

Label Identity

Figure 15

15. Click on the **Map Identity** tab . Click on the green plus button – **Add Mapping** (see Figure 16).



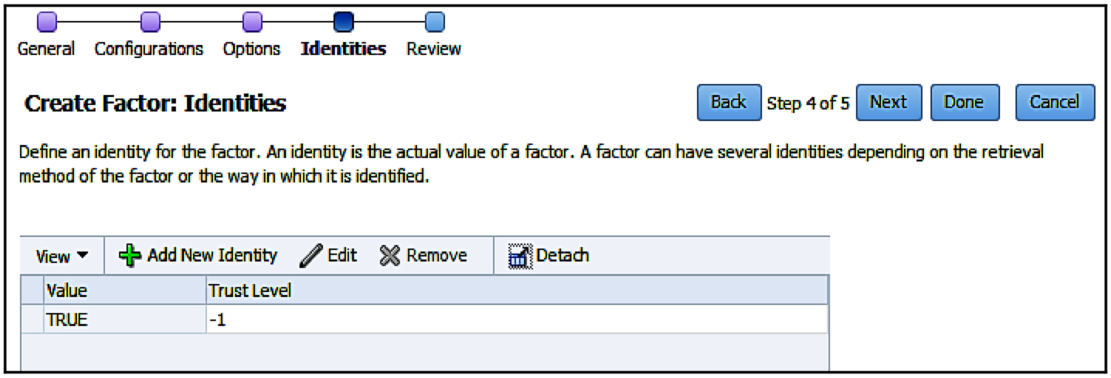
Child Factor Name	Operator	Min Value	Max Value
no data found			

Figure 16

16. Select the following values and click on the **OK** button:

Child Factor Name	`Day`
Operator	`Like`
Min Value	`S%`

17. You should see that identity is added (Figure 17).



Create Factor: Identities

Define an identity for the factor. An identity is the actual value of a factor. A factor can have several identities depending on the retrieval method of the factor or the way in which it is identified.

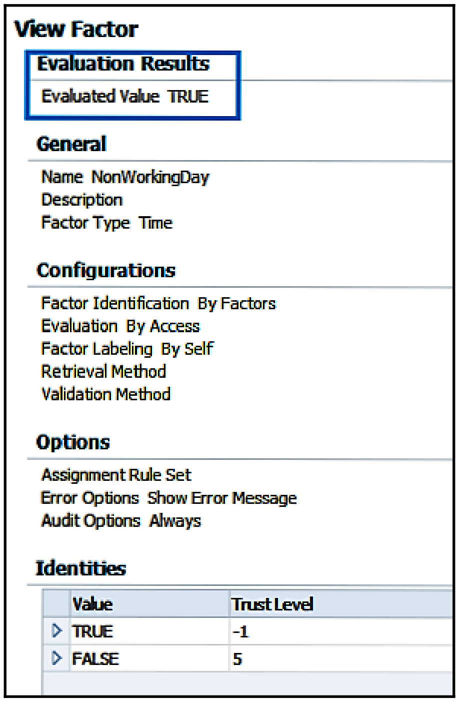
Value	Trust Level
TRUE	-1

Figure 17

18. Add the new identity `FALSE`. Repeat steps from 13 to 16 with appropriate values (for example, the value `FALSE`, **Trust Level** as **Somewhat trusted**; instead of the **Like** operator, choose **Not Like**).

19. Click on the **Next** button. Review the configuration and click on the **Finish** button. You should see confirmation message.

20. Click on the link `NonWorkingDay` (in the column **Factor Name**). You will see that the factor `NonWorkingDay` will get value `TRUE` (see Figure 18). Click on the **OK** button.



View Factor

Evaluation Results

Evaluated Value TRUE

General

Name NonWorkingDay
Description
Factor Type Time

Configurations

Factor Identification By Factors
Evaluation By Access
Factor Labeling By Self
Retrieval Method
Validation Method

Options

Assignment Rule Set
Error Options Show Error Message
Audit Options Always

Identities

Value	Trust Level
TRUE	-1
FALSE	5

Figure 18

21. On the **Factors** page (see Figure 12), in the table select row in which `Day` factor is displayed and click on the **Edit** button (pencil icon). Click on the **Next** button.

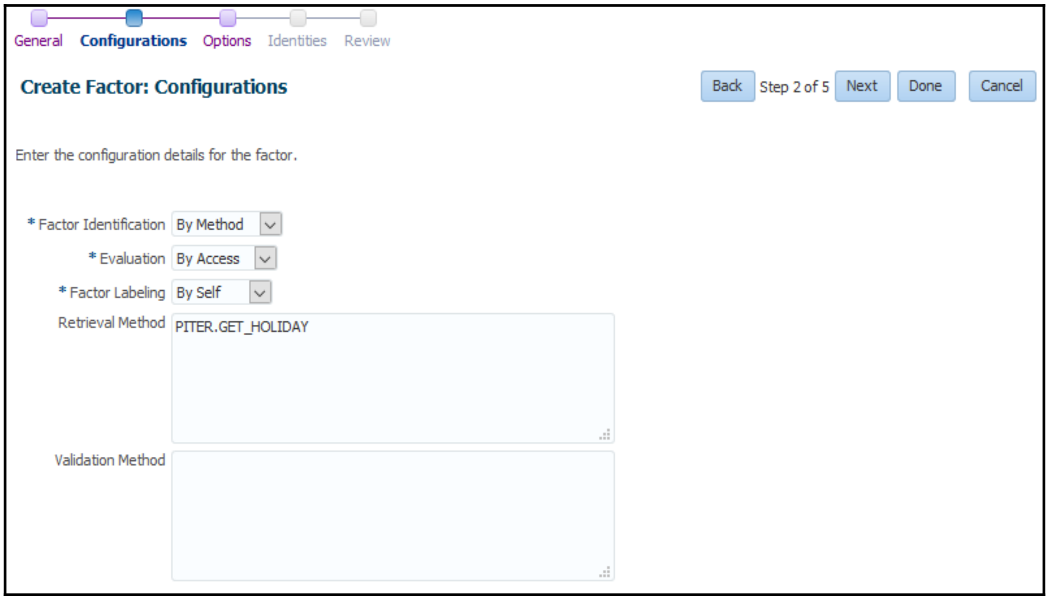
22. Change **Retrieval Method** to `RTRIM(TO_CHAR(sysdate, 'DAY'))` and click on the **Done** button.

23. Create the new factor `Holiday` (**Factor Type**: `Time`).

24. Enter these configuration details for the factor and click on the **Done** button:

Factor Identification:	**By Method**
Evaluation:	**By Access**
Factor Labeling:	**By Self**
Retrieval Method:	`PITER.GET_HOLIDAY`

It will appear as shown in this figure :



Create Factor: Configurations

Enter the configuration details for the factor.

* Factor Identification: By Method
* Evaluation: By Access
* Factor Labeling: By Self

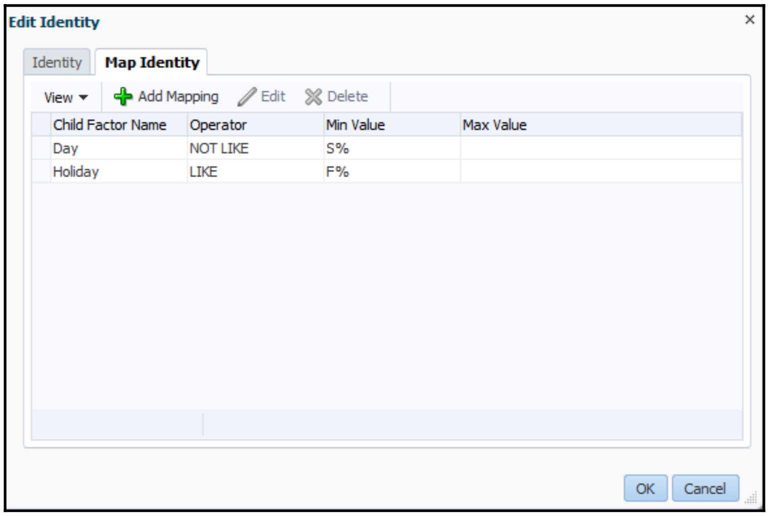
Retrieval Method: PITER.GET_HOLIDAY

Validation Method:

Figure 19

25. Edit the factor `NonWorkingDay` so that it has three identities (`NO`, `WEEKEND`, and `COMPANY_HOLIDAY`) and click on **OK**.

26. a. Edit the `FALSE` identity (change value to **NO**, add mapping in the **Map Identity – Child Factor Name**: `Holiday`, **Operator**: `Like`, **Min Value**: `F%`). Click on the **OK** button.



Child Factor Name	Operator	Min Value	Max Value
Day	NOT LIKE	S%	
Holiday	LIKE	F%	

Figure 20

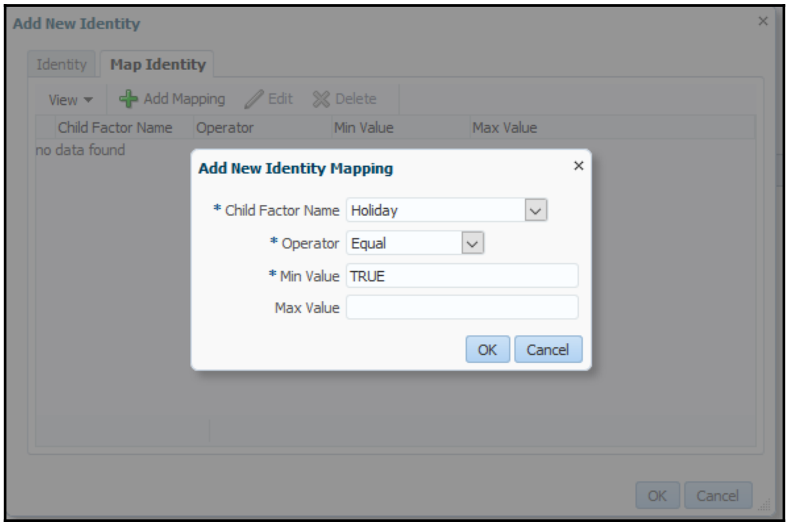
26. b. Edit the `TRUE` identity and click on the **OK** button (change value to `WEEKEND`, change mapping to have two rows:

Child Factor Name	**Operator**	**Min Value**	**Max Value**
`Day`	`Equal`	`SATURDAY`	
`Day`	`Equal`	`SUNDAY`	

26. c. Add the new `COMPANY_HOLIDAY` identity (**Trust Level**: **Untrusted**). On the **Map Identity** tab, click on **Add Mapping**. Set the following values and click on **OK**:

Child Factor Name	**Operator**	**Min Value**	**Max Value**
`Holiday`	`Equal`	`TRUE`	

This will appear as shown in this figure:

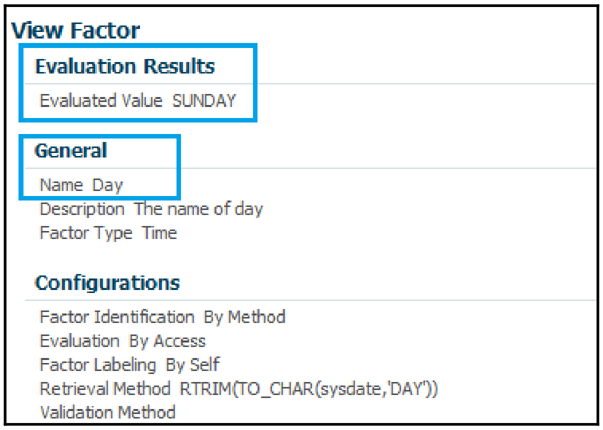


Add New Identity Mapping

* Child Factor Name	Holiday
* Operator	Equal
* Min Value	TRUE
Max Value	

Figure 21

27. View evaluated value for factor `Day` (repeat step 9). The result is shown in Figure 22.



View Factor

Evaluation Results

Evaluated Value SUNDAY

General

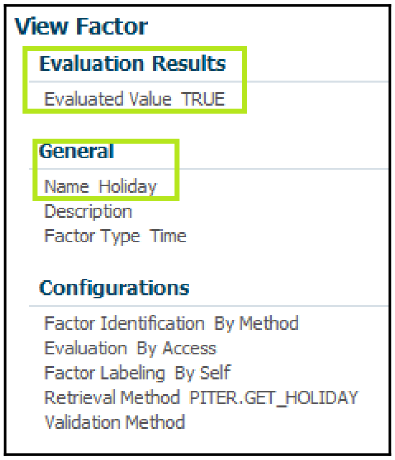
Name Day
Description The name of day
Factor Type Time

Configurations

Factor Identification By Method
Evaluation By Access
Factor Labeling By Self
Retrieval Method RTRIM(TO_CHAR(sysdate,'DAY'))
Validation Method

Figure 22

28. View evaluated value for factor `Holiday`. The result is shown in figure.



View Factor

Evaluation Results

Evaluated Value TRUE

General

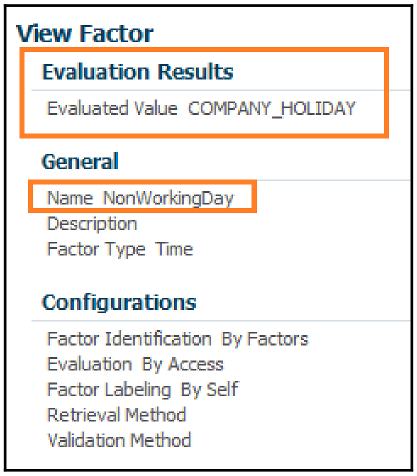
Name Holiday
Description
Factor Type Time

Configurations

Factor Identification By Method
Evaluation By Access
Factor Labeling By Self
Retrieval Method PITER.GET_HOLIDAY
Validation Method

Figure 23

29. View an evaluated value for factor `NonWorkingDay`. The result is shown in Figure 24.



View Factor

Evaluation Results

Evaluated Value COMPANY_HOLIDAY

General

Name NonWorkingDay
Description
Factor Type Time

Configurations

Factor Identification By Factors
Evaluation By Access
Factor Labeling By Self
Retrieval Method
Validation Method

Figure 24

How it works…

The identity of a factor can be assigned by:

- Method
- Constant
- Factors

The process of assigning identity to a factor is named factor identification.

In this recipe, you created two factors (`Day` and `Holiday`) whose identities were assigned by methods and one factor (`NonWorkingDay`) whose identity was assigned by factors.

Factors can be evaluated when database session is created (`By Session`), each time factor is accessed (`By Access`), and when a database session starts (`On Startup`). Because you created factors that can change during a session, you chose evaluation by access.

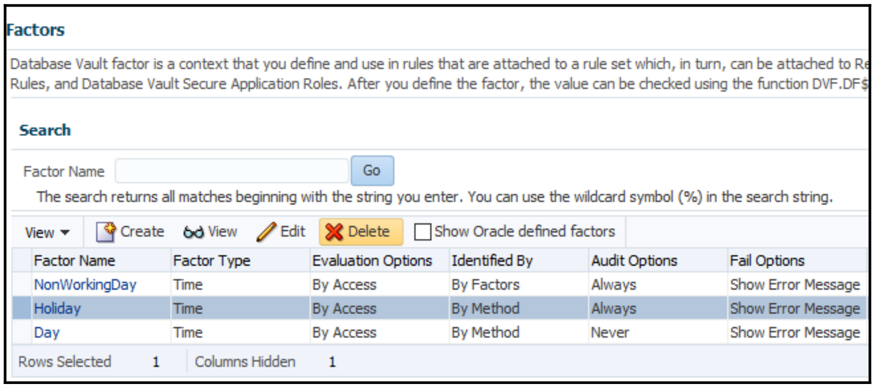
Factor labeling is relevant for integration with Oracle Label Security.

In step 28, you verified that the factor `NonWorkingDay` got the value `COMPANY_HOLIDAY` (in case when it is `SUNDAY` and a holiday at the same time). That happened because factors that are based on other factors get actual value by evaluating identities in the order of their sorted ASCII identity values and first one that matches is assigned (evaluation stops). In our case, `COMPANY_HOLIDAY` was matched, so `WEEKEND` wasn't evaluated. in general, it is better to try to avoid overlapping conditions (if possible) because maintenance is easier and the risk of making a mistake is smaller.

There's more…

From **Factors** page in EM12c verify that you can't delete the factor `Holiday` because you use it to resolve identities for the factor `NonWorkingDay` (error ORA-47030: Factor `Holiday` is referred by one or more factor links).

1. Select the factor `Holiday` and click on the **Delete** button (see Figure 25).



Factors

Database Vault factor is a context that you define and use in rules that are attached to a rule set which, in turn, can be attached to Re
Rules, and Database Vault Secure Application Roles. After you define the factor, the value can be checked using the function DVF.DF$

Search

Factor Name

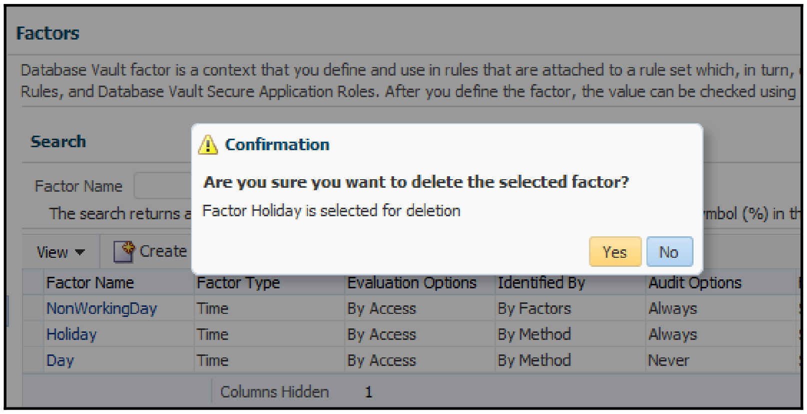
The search returns all matches beginning with the string you enter. You can use the wildcard symbol (%) in the search string.

Factor Name	Factor Type	Evaluation Options	Identified By	Audit Options	Fail Options
NonWorkingDay	Time	By Access	By Factors	Always	Show Error Message
Holiday	Time	By Access	By Method	Always	Show Error Message
Day	Time	By Access	By Method	Never	Show Error Message

Rows Selected 1 Columns Hidden 1

Figure 25

2. Click on the button **Yes** (see Figure 26).



Factors

Database Vault factor is a context that you define and use in rules that are attached to a rule set which, in turn,
Rules, and Database Vault Secure Application Roles. After you define the factor, the value can be checked using

Search

Factor Name

The search returns a

Confirmation

Are you sure you want to delete the selected factor?

Factor Holiday is selected for deletion

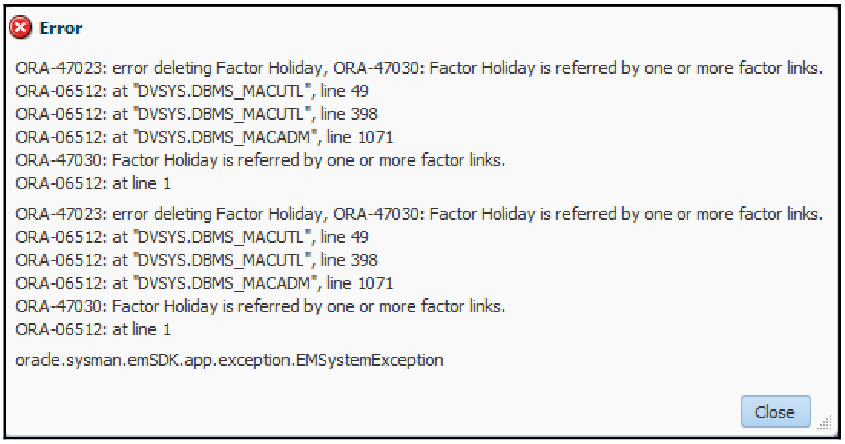
mbol (%) in th

Factor Name	Factor Type	Evaluation Options	Identified By	Audit Options
NonWorkingDay	Time	By Access	By Factors	Always
Holiday	Time	By Access	By Method	Always
Day	Time	By Access	By Method	Never

Columns Hidden 1

Figure 26

3. You will receive an error message (see Figure 27).



```
ORA-47023: error deleting Factor Holiday, ORA-47030: Factor Holiday is referred by one or more factor links.
ORA-06512: at "DVSYS.DBMS_MACUTL", line 49
ORA-06512: at "DVSYS.DBMS_MACUTL", line 398
ORA-06512: at "DVSYS.DBMS_MACADM", line 1071
ORA-47030: Factor Holiday is referred by one or more factor links.
ORA-06512: at line 1
ORA-47023: error deleting Factor Holiday, ORA-47030: Factor Holiday is referred by one or more factor links.
ORA-06512: at "DVSYS.DBMS_MACUTL", line 49
ORA-06512: at "DVSYS.DBMS_MACUTL", line 398
ORA-06512: at "DVSYS.DBMS_MACADM", line 1071
ORA-47030: Factor Holiday is referred by one or more factor links.
ORA-06512: at line 1
oracle.sysman.emSDK.app.exception.EMSystemException
```

Figure 27

When you create the factor PL/SQL, a function is created in schema `DVF` with the name `F$<factor_name>`.

See also

- An Oracle official guide *Database Vault Administrator's Guide* - Chapters: 8, 16, and 19.

Using TDE in a multitenant environment

In this recipe, you will perform different operations using Transparent Data Encryption in a multitenant environment.

Getting ready

It is assumed that:

- You have two container databases (the multitenant architecture), version 12.1.0.2 in the same host.
- You have at least one pluggable database in each container database
- You have sample schemes installed.

How to do it…

1. Enter the following text into your `sqlnet.ora` file located in a `network/admin` directory of your oracle home (for example, `/u01/app/oracle/product/12.1.0/dbhome_1`)

```
ENCRYPTION_WALLET_LOCATION=
  (SOURCE=
    (METHOD=FILE)
      (METHOD_DATA=
     (DIRECTORY=/u01/app/oracle/admin/$ORACLE_SID/wallet)))
```

2. Change your environment to the first container database (for example, `cdb1`):

```
[oracle@host01 ~]$ . oraenv
ORACLE_SID = [oracle] ? cdb1
```

3. Connect as a user with the DBA role (for example, `system`), create a new user (for example, `c##tdedba`) to manage key management administration, and grant him appropriate privileges:

```
$ sqlplus system
SQL> create user c##tdedba identified by oracle123 container=all;

SQL> grant administer key management to c##tdedba container=all;

SQL> grant create session to c##tdedba container=all;

SQL> grant select any dictionary to c##tdedba container=all;

SQL> grant set container to c##tdedba container=all;
```

4. Connect as a user `c##tdedba` and create a keystore:

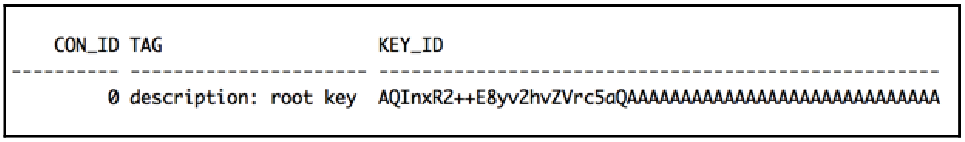
```
SQL> connect c##tdedba/oracle123
SQL> ADMINISTER KEY MANAGEMENT CREATE KEYSTORE
'/u01/app/oracle/admin/cdb1/wallet' identified by oracle1;
```

5. See information about the previously created keystore and open it:

```
SQL> select wallet_type,wrl_type,status from v$encryption_wallet;

WALLET_TYPE    WRL_TYPE     STATUS
-------------- ------------ -------------------
UNKNOWN        FILE         CLOSED

SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY
oracle1;
SQL> select wallet_type,wrl_type,status from v$encryption_wallet;

WALLET_TYPE     WRL_TYPE     STATUS
--------------- ------------ -------------------
PASSWORD        FILE         OPEN_NO_MASTER_KEY

SQL> select con_id, tag, key_id from v$encryption_keys;

no rows selected
```

6. Create a new master key for root container:

```
SQL> ADMINISTER KEY MANAGEMENT SET KEY USING TAG 'description:
root key' IDENTIFIED BY oracle1 WITH BACKUP;

SQL> select con_id, tag, key_id from v$encryption_keys;
```



```
    CON_ID TAG                    KEY_ID
---------- ---------------------- ------------------------------------------------------
         0 description: root key  AQInxR2++E8yv2hvZVrc5aQAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
```

Figure 28

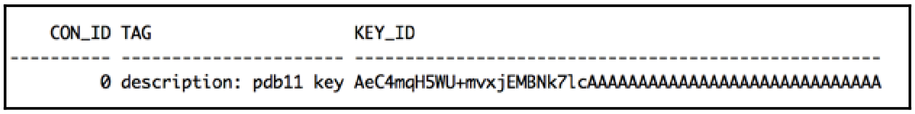
```
SQL> select wallet_type,wrl_type,status from v$encryption_wallet;

WALLET_TYPE    WRL_TYPE     STATUS
-------------- ------------ -------------------
PASSWORD       FILE         OPEN
```

7. Connect to a pluggable database (for example, `pdb11`) inside the first container database and check availability of a keystore:

```
SQL> alter session set container=pdb11;

SQL> select wallet_type,wrl_type,status from v$encryption_wallet;

WALLET_TYPE    WRL_TYPE   STATUS
-------------- ---------- -------------------
UNKNOWN        FILE       CLOSED
```

8. Open a keystore, check availability of a master key, and create one:

```
SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED
BY oracle1;
SQL> select wallet_type,wrl_type,status from v$encryption_wallet;

WALLET_TYPE    WRL_TYPE      STATUS
-------------- ------------- -------------------
PASSWORD       FILE          OPEN_NO_MASTER_KEY

SQL> select con_id, tag, key_id from v$encryption_keys;
no rows selected

SQL> ADMINISTER KEY MANAGEMENT SET KEY USING TAG 'description:
pdb11 key' IDENTIFIED BY oracle1 WITH BACKUP;

SQL> select con_id, tag, key_id from v$encryption_keys;
```



```
    CON_ID TAG                    KEY_ID
---------- ---------------------- ----------------------------------------------------
         0 description: pdb11 key AeC4mqH5WU+mvxjEMBNk7lcAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
```

Figure 29

```
SQL> select wallet_type,wrl_type,status from v$encryption_wallet;

WALLET_TYPE     WRL_TYPE      STATUS
-------------- ------------- -------------------
PASSWORD       FILE          OPEN
```

9. Change environment for the second container database (for example, `cdb2`):

```
[oracle@host01 ~]$ . oraenv
ORACLE_SID = [cdb1] ? cdb2
```

10. Connect as a user with the `sysdba` privileges, create a new user (for example, `c##tdedba`), and grant him appropriate privileges:

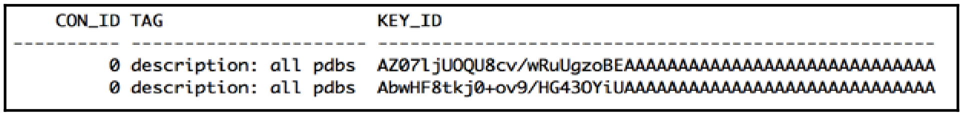
```
$ sqlplus / as sysdba
SQL> create user c##tdedba identified by oracle321 container=all;
SQL> grant syskm to c##tdedba container=all;
```

11. Connect as a user `c##tdedba` (as `syskm`), create a keystore, and open it for all pluggable databases:

```
 SQL> ADMINISTER KEY MANAGEMENT CREATE KEYSTORE
'/u01/app/oracle/admin/cdb2/wallet' identified by oracle2;

SQL> select wallet_type,wrl_type,status from v$encryption_wallet;

WALLET_TYPE   WRL_TYPE      STATUS
---------------- -------------- -------------------
UNKNOWN             FILE               CLOSED

SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY
oracle2 container=all;

SQL> select wallet_type,wrl_type,status from v$encryption_wallet;

WALLET_TYPE      WRL_TYPE      STATUS
---------------- ------------- -------------------
PASSWORD         FILE          OPEN_NO_MASTER_KEY
```

12. Create new master keys for all pdbs:

```
SQL> ADMINISTER KEY MANAGEMENT SET KEY USING TAG 'description:
all pdbs' IDENTIFIED BY oracle2 WITH BACKUP container=all;
SQL> select con_id, tag, key_id from v$encryption_keys;
```

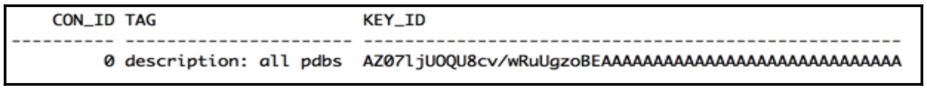


```
    CON_ID TAG                    KEY_ID
---------- ---------------------- ----------------------------------------------------
         0 description: all pdbs  AZ07ljUOQU8cv/wRuUgzoBEAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
         0 description: all pdbs  AbwHF8tkj0+ov9/HG43OYiUAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
```

Figure 30

13. Connect to a pluggable database as a `SYS` user and check keystore and masterkey:

```
SQL> connect / as sysdba

SQL> alter session set container=pdb21;

SQL> select wallet_type,wrl_type,status from v$encryption_wallet;

WALLET_TYPE      WRL_TYPE       STATUS
---------------- -------------- -------------------
PASSWORD         FILE           OPEN

SQL> select con_id, tag, key_id from v$encryption_keys;
```



```
    CON_ID TAG                    KEY_ID
---------- ---------------------- ----------------------------------------------------
         0 description: all pdbs  AZ07ljUOQU8cv/wRuUgzoBEAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
```

Figure 31

14. Change your environment to the first container database (for example, `cdb1`):

```
[oracle@host01 ~]$ . oraenv
ORACLE_SID = [cdb2] ? cdb1
```

15. Connect to the pluggable database as a user who has the DBA role (for example, `c##zoran`), create a test table with one encrypted column, and insert some data:

```
$ sqlplus c##zoran@pdb11
SQL> create table hr.enc_tbl(a int, b varchar2(20) encrypt);
SQL> insert into hr.enc_tbl values (1, 'value1');
SQL> insert into hr.enc_tbl values (2, 'value2');
SQL> commit;
SQL> select * from hr.enc_tbl;

     A          B
---------- ------------
     1       value1
     2       value2
```

16. Export a master key:

```
SQL> ADMINISTER KEY MANAGEMENT EXPORT KEYS WITH SECRET "secret1"
to '/home/oracle/keys.exp' IDENTIFIED BY oracle1;
```

17. Close the pluggable database pdb11 and unplug it:

```
SQL> alter pluggable database pdb11 close immediate;
SQL> alter pluggable database pdb11 unplug into
'/home/oracle/pdb11.xml';
SQL> drop pluggable database pdb11 keep datafiles;
```

18. Change your environment to the second container database (for example, `cdb2`):

```
[oracle@host01 ~]$ . oraenv
ORACLE_SID = [cdb1] ? cdb2
```

19. Connect to the second container database (for example, `cdb2`) as a sys user and plug the previously unplugged database (`pdb11`):

```
$ sqlplus / as sysdba
SQL> create pluggable database pdb11 using '/home/oracle/pdb11.xml';
```

20. Open the pluggable database:

```
SQL> alter pluggable database pdb11 open;

Warning: PDB altered with errors.

SQL> show pdbs

   CON_ID   CON_NAME        OPEN MODE   RESTRICTED
---------- --------------- ----------- -----------
         2   PDB$SEED        READ ONLY   NO
         3   PDB21           READ WRITE  NO
         4   PDB11           READ WRITE  YES
```

21. Connect to `pdb11`, as a `SYS` user, open the keystore, and try to select from table with encrypted column:

    ```
    SQL> alter session set container=pdb11;
    SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY
    oracle2;
    SQL> select * from hr.enc_tbl;
    select * from hr.enc_tbl
                     *
    ERROR at line 1:
    ORA-28362: master key not found
    ```

22. Import the master key for this pluggable database and restart it:

    ```
    SQL> ADMINISTER KEY MANAGEMENT IMPORT ENCRYPTION KEYS WITH SECRET
    "secret1" FROM '/home/oracle/keys.exp' IDENTIFIED BY oracle2 WITH
    BACKUP;
    SQL> alter pluggable database pdb11 close immediate;

    SQL> alter pluggable database pdb11 open;

    SQL> show pdbs

        CON_ID   CON_NAME     OPEN MODE   RESTRICTED
    ---------- -------------- ----------- -----------
             2  PDB$SEED       READ ONLY    NO
             3  PDB21          READ WRITE   NO
             4  PDB11          READ WRITE   NO
    ```

23. Connect to the pluggable database (`pdb11`), open the keystore, and select from table with encrypted column:

    ```
    SQL> alter session set container=pdb11;

    SQL> ADMINISTER KEY MANAGEMENT SET KEYSTORE OPEN IDENTIFIED BY
    oracle2;

    SQL> select * from hr.enc_tbl;

     A          B
    ---------- --------------------
     1           value1
     2           value2
    ```

How it works…

In steps 1-6, the creation of keystore and master key in root container is shown. In step 7-8, the opening and creation of master key in the pluggable database is shown. There is only one keystore per entire container database, but that keystore contains multiple master keys (root container has its own master key, as well as every pluggable database in which transparent data encryption is used). In steps 9-13, another way of creation of the keystore and master key is shown (in the second container database). The user with the `SYSKM` system privilege is used, and opening of keystore as well as the creation of master keys are done by using `container=all` clause. This way, we are opening a keystore and creating master keys in all pluggable databases.

Because there is only one keystore per container database but multiple master keys, if database needs to be unplugged and plugged into another container database, a master key needs to be exported and imported into the target database also. In steps 16 and 17, we are exporting a master key and unplugging the database. In steps 18-20, we are plugging this database into another container database (`cdb2`). When we try to open the pluggable database in step 20, we get an error (because the master key is missing). The pluggable database is opened but in restricted mode. We can ignore this error for now and connect to that pluggable database as `SYS` user, but if we try to select from table that has encrypted columns, we get an error because the master key is missing. In step 22, we are importing a master key (that we exported in step 16). After importing a master key, we are restarting that pluggable database (now we can see that it can be opened without errors). And when we try to select from table that has encrypted columns, everything works perfectly.

See also

- `Chapter 8`, *Transparent Data Encryption* (in this book) and official Oracle documentation *Oracle Advanced Security Guide*.

12
Appendix – Application Contexts

In this chapter, we will cover the following tasks:

- Exploring and using built-in contexts
- Creating an application context
- Setting application context attributes
- Using an application context

Introduction

An **application context** is a memory container that holds a set of key-value pairs. You can think of an application context as an array of attributes where every attribute has a name (key) and value. Also, an application context is a namespace because in different application contexts, attributes that have the same name can exist (and there is no correlation between those attributes; they can store the same or different value).

To implement a local application context, you should complete steps shown in Figure 1 (the order of steps 1 and 2 is not important).

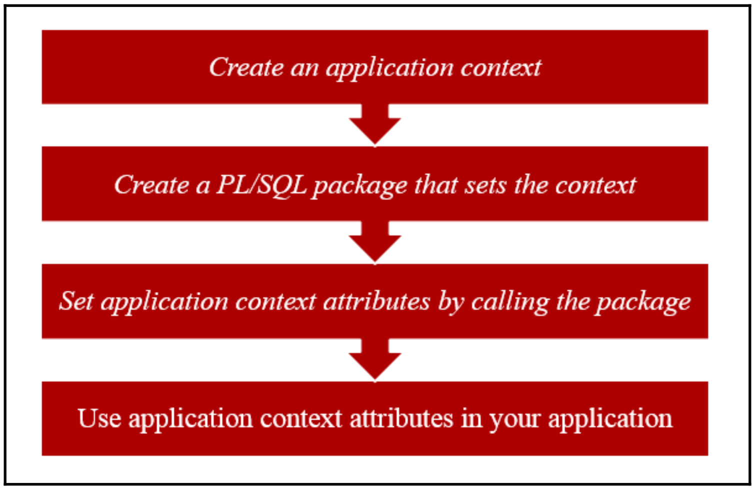

Create an application context
Create a PL/SQL package that sets the context
Set application context attributes by calling the package
Use application context attributes in your application

Figure 1 – The steps to implement a local application context

Exploring and using built-in contexts

The `USERENV` application context is a built-in context that contains information about the current session. In this recipe, you'll learn to retrieve values from built-in contexts.

Getting ready

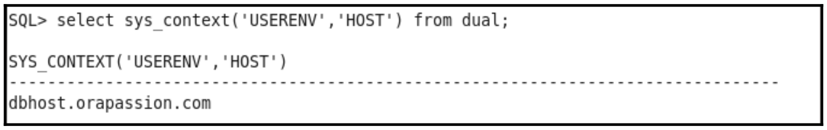
To complete this recipe, you'll need an existing user who can get values from built-in namespaces by using the `SYS_CONTEXT` function (for example, user `maja`).

How to do it…

1. Connect to the database as a user who has appropriate privileges (for example, user `maja`):

   ```
   $ sqlplus maja
   ```

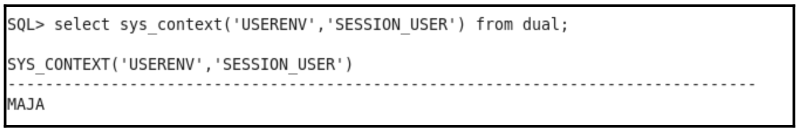
2. Find the name of host machine from which the client has connected to the database.



```
SQL> select sys_context('USERENV','HOST') from dual;

SYS_CONTEXT('USERENV','HOST')
--------------------------------------------------------------------------------
dbhost.orapassion.com
```

Figure 2 – The name of the client host machine

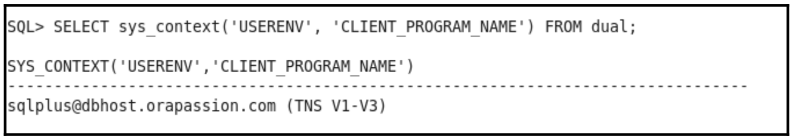
3. Find the name of the user who logged on to the database.



```
SQL> select sys_context('USERENV','SESSION_USER') from dual;

SYS_CONTEXT('USERENV','SESSION_USER')
--------------------------------------------------------------------------------
MAJA
```

Figure 3 – The name of the session user

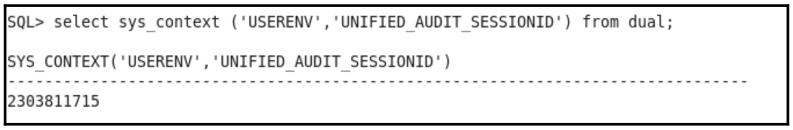
4. Find the name of the program used for the database session.



```
SQL> SELECT sys_context('USERENV', 'CLIENT_PROGRAM_NAME') FROM dual;

SYS_CONTEXT('USERENV','CLIENT_PROGRAM_NAME')
--------------------------------------------------------------------------------
sqlplus@dbhost.orapassion.com (TNS V1-V3)
```

Figure 4 – The name of the client program

5. Find unified audit session ID.



```
SQL> select sys_context ('USERENV','UNIFIED_AUDIT_SESSIONID') from dual;

SYS_CONTEXT('USERENV','UNIFIED_AUDIT_SESSIONID')
--------------------------------------------------------------------------------
2303811715
```

Figure 5 – A unified audit session ID

How it works…

In steps 2-5, you used the `SYS_CONTEXT` function to get values of several parameters from the `USERENV` context. You can use that function in both SQL and PL/SQL statements. It is expected that your results will differ from those shown in Figures 2-5, because they are system-specific.

The `UNIFIED_AUDIT_SESSIONID` attribute (parameter) is introduced in Oracle Database 12.1.0.2. The value of that parameter is `unified audit session ID` if the database uses unified auditing mode or mixed auditing mode, and `NULL` if the database uses traditional auditing (see Figure 6).

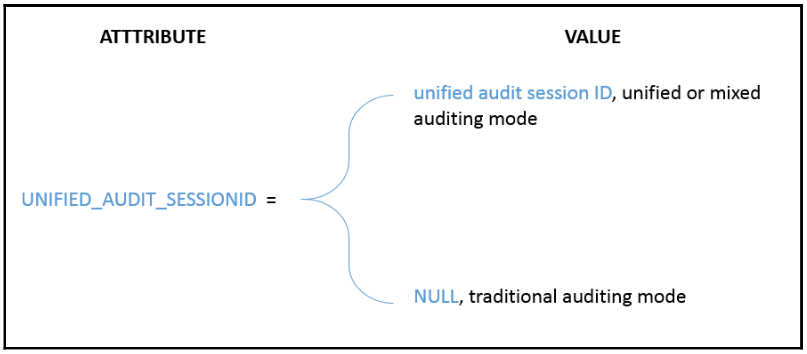
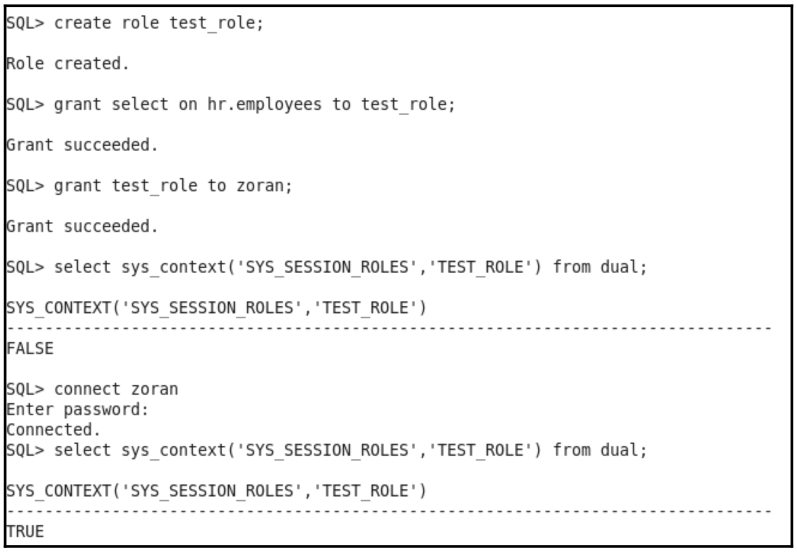

ATTTRIBUTE
VALUE
UNIFIED_AUDIT_SESSIONID =
unified audit session ID, unified or mixed auditing mode
NULL, traditional auditing mode

Figure 6 – The value of the UNIFIED_AUDIT_SESSIONID

Note that in mixed auditing mode, the `UNIFIED_AUDIT_SESSIONID` value in the `USERENV` context is different from the `SESSIONID` value.

There's more…

Another built-in context is `SYS_SESSION_ROLES`. You can use it to check whether a specified role is currently enabled for the session. For example, you'll create the `test_role` role, grant `select` privilege on `hr.employees` table, and grant the role to an existing user (for example, `zoran`). Afterwards, you'll verify that `zoran` has the `test_role` role by using the `SYS_CONTEXT` function. The example is shown in Figure 7.



```
SQL> create role test_role;

Role created.

SQL> grant select on hr.employees to test_role;

Grant succeeded.

SQL> grant test_role to zoran;

Grant succeeded.

SQL> select sys_context('SYS_SESSION_ROLES','TEST_ROLE') from dual;

SYS_CONTEXT('SYS_SESSION_ROLES','TEST_ROLE')
--------------------------------------------------------------------------------
FALSE

SQL> connect zoran
Enter password:
Connected.
SQL> select sys_context('SYS_SESSION_ROLES','TEST_ROLE') from dual;

SYS_CONTEXT('SYS_SESSION_ROLES','TEST_ROLE')
--------------------------------------------------------------------------------
TRUE
```

Figure 7 – Using the SYS_SESSION_ROLES namespace

When working in the multitenant environment, some useful attributes are `CON_ID`, `CON_NAME`, and `CDB_NAME`.

See also

- The full list of attributes that exist in the `USERENV` namespace is available in the official Oracle documentation-*Oracle Database SQL Language Reference, Chapter 7, The SYS_CONTEXT function*.

Creating an application context

In this recipe, you'll create a local application context (for example, `sh_client`). In the next recipes, you will use it to store clients' identifiers.

Getting ready

To complete this recipe, you'll need an existing user who can create an application context (it needs the `CREATE ANY CONTEXT` privilege or a DBA role), for example, the user `maja`.

How to do it…

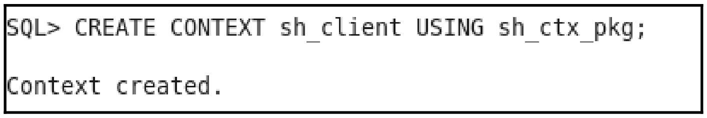
1. Connect to the database as a user who has appropriate privileges (for example, user `maja`).

   ```
   $ sqlplus maja
   ```

2. Create a local application context (for example, `sh_client`).

The PL/SQL package that will be used to set application context attributes doesn't have to exist at this time, but you have to specify its name.

```
SQL> CREATE CONTEXT <context_name> USING <PL/SQL_package_name>;
```



```
SQL> CREATE CONTEXT sh_client USING sh_ctx_pkg;

Context created.
```

Figure 8 – Creating an application context

How it works…

In step 2, you created application context `sh_client` and defined that the PL/SQL package `sh_ctx_pkg` will be used to create and set application context attributes. At this moment, attributes aren't set in the application context.

Context names must be unique within the database.

Setting application context attributes

In this recipe, you'll create the PL/SQL package (for example, `sh_ctx_pkg`) that will set application context attributes for the application context you created in the previous recipe (for example, `sh_client`). Also, you'll create a logon trigger.

Getting ready

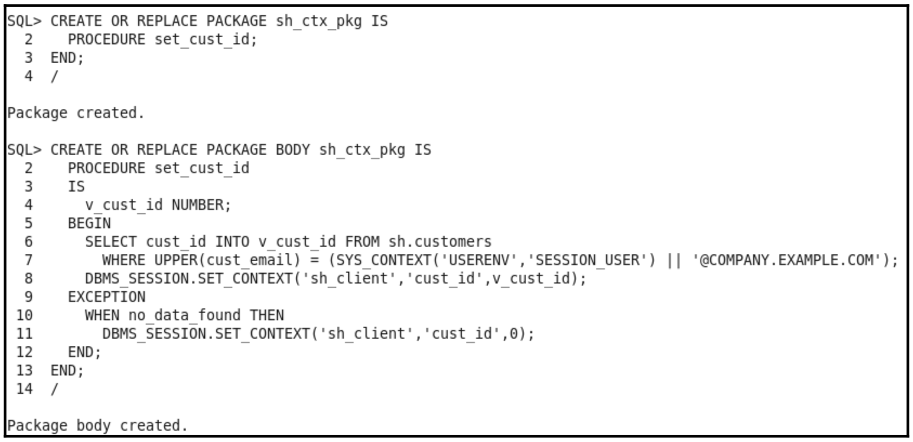
To complete this recipe, you'll need an existing user who can create `sh_ctx_pkg`. Make sure that the user has direct privileges on the `sh.customers` table (even if he/she has a DBA role) so that you don't receive this message in SQL*Plus: `Warning: Package Body created with compilation errors.` or error `Table or view doesn't exist in SQL Developer` (for more information, see `Chapter 3, PL/SQL Security`).

How to do it…

1. Connect to the database as a user who has appropriate privileges (for example, user `maja`):

```
$ sqlplus maja
```

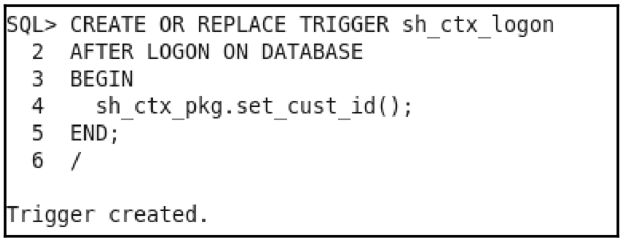
2. Create the PL/SQL package that will set the `cust_id` attribute with the value, which is equal to the value of the `cust_id` column when the following statement is evaluated: `UPPER(cust_email) = (SYS_CONTEXT('USERENV', 'SESSION_USER') || '@COMPANY.EXAMPLE.COM')`. In case session user is not a customer, set the value for `cust_id` attribute in the application context to .



```
SQL> CREATE OR REPLACE PACKAGE sh_ctx_pkg IS
    PROCEDURE set_cust_id;
  END;
  /

Package created.

SQL> CREATE OR REPLACE PACKAGE BODY sh_ctx_pkg IS
    PROCEDURE set_cust_id
    IS
      v_cust_id NUMBER;
    BEGIN
      SELECT cust_id INTO v_cust_id FROM sh.customers
        WHERE UPPER(cust_email) = (SYS_CONTEXT('USERENV','SESSION_USER') || '@COMPANY.EXAMPLE.COM');
      DBMS_SESSION.SET_CONTEXT('sh_client','cust_id',v_cust_id);
    EXCEPTION
      WHEN no_data_found THEN
        DBMS_SESSION.SET_CONTEXT('sh_client','cust_id',0);
    END;
  END;
  /

Package body created.
```

Figure 9 – Creating a PL/SQL package

3. Create a logon trigger that calls the `sh_ctx_pkg.set_cust_id` procedure.



```
SQL> CREATE OR REPLACE TRIGGER sh_ctx_logon
  AFTER LOGON ON DATABASE
  BEGIN
    sh_ctx_pkg.set_cust_id();
  END;
  /

Trigger created.
```

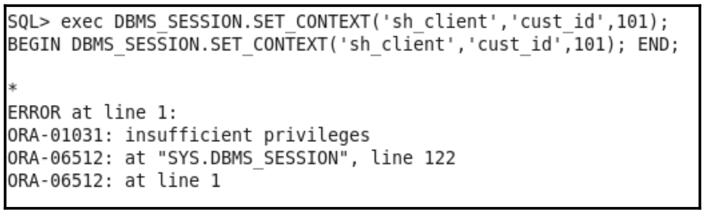
Figure 10 – A logon trigger

How it works…

In step 3, you created a logon trigger so that every user who connects to the database is going to have an application context set. This step is optional because your application can set the application context by calling the same procedure.

There's more…

It is very important to note that if you try to set or change key-value pairs outside the package you specified when you created application context, you will receive the error `insufficient privileges` (see Figure 11).



```
SQL> exec DBMS_SESSION.SET_CONTEXT('sh_client','cust_id',101);
BEGIN DBMS_SESSION.SET_CONTEXT('sh_client','cust_id',101); END;

*
ERROR at line 1:
ORA-01031: insufficient privileges
ORA-06512: at "SYS.DBMS_SESSION", line 122
ORA-06512: at line 1
```

Figure 11 – An error message

See also

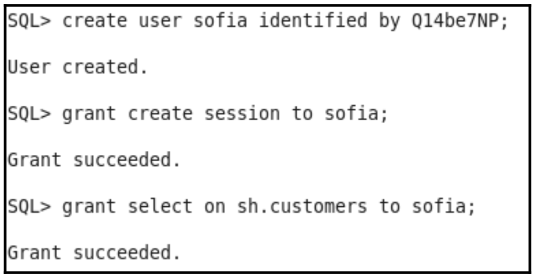
- You can see `Chapter 3`, *PL/SQL Security*.

Using an application context

In this recipe, you'll see one possible usage (in SQL) of the application contexts. Some other usages are shown in other parts of the book, and their references are given in the *See also* section of this recipe.

Getting ready

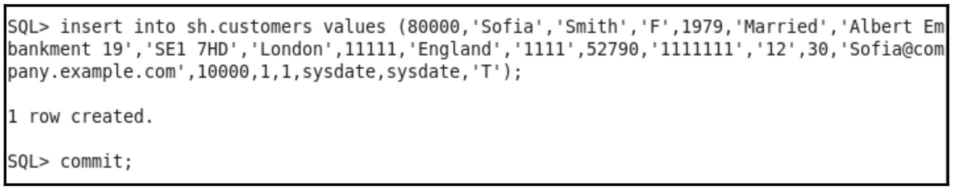
Create a new user (for example, `sofia`). Make sure that his or her e-mail in the format `user@company.example.com` is unique. Grant him or her privileges: `create session` and `select` on `sh.customers` table.



```
SQL> create user sofia identified by Q14be7NP;

User created.

SQL> grant create session to sofia;

Grant succeeded.

SQL> grant select on sh.customers to sofia;

Grant succeeded.
```

Figure 12 – New user

Insert data about him or her into the `sh.customers` table.



```
SQL> insert into sh.customers values (80000,'Sofia','Smith','F',1979,'Married','Albert Em
bankment 19','SE1 7HD','London',11111,'England','1111',52790,'1111111','12',30,'Sofia@com
pany.example.com',10000,1,1,sysdate,sysdate,'T');

1 row created.

SQL> commit;
```

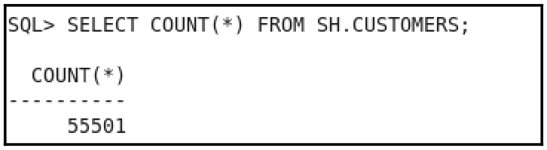
Figure 13 – The new data in sh.customers

How to do it…

1. Connect to the database as a newly created user (for example, user `sofia`):

```
$ sqlplus sofia
```

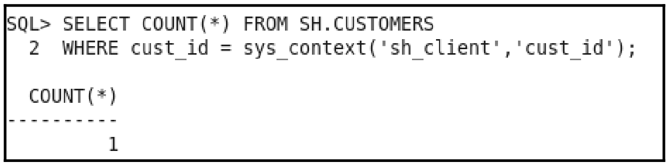
2. Verify that the user (for example, `sofia`) can access all data in the `sh.customers` table.



```
SQL> SELECT COUNT(*) FROM SH.CUSTOMERS;

  COUNT(*)
----------
     55501
```

Figure 14 – The entire data in sh.customers

3. Verify that when executing the following statement, he or she (for example, `sofia`) can view only his or her data.



```
SQL> SELECT COUNT(*) FROM SH.CUSTOMERS
  2  WHERE cust_id = sys_context('sh_client','cust_id');

  COUNT(*)
----------
         1
```

Figure 15 – Only data about newly created user

How it works…

In step 3, a simple way how an application can leverage application contexts in SQL statements was shown.

See also

- You can refer to `Chapter 4`, *Virtual Private Database*, `Chapter 5`, *Data Redaction*, and `Chapter 10`, *Unified Auditing*.

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