Oracle Database Privilege Analysis

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RACSIG Real Application Clusters Special Interest Group

DOAG

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FOUNDED IN
1994

16 TRIVADIS WORKSPACES

SWITZERLAND, GERMANY, AUSTRIA, DENMARK, ROMANIA

118 MILLION CHF
TURNOVER

250 SLA's
(SERVICE LEVEL AGREEMENTS)

4000
TRAINING PARTICIPANTS PER YEAR

800
CUSTOMERS

700
EMPLOYEES

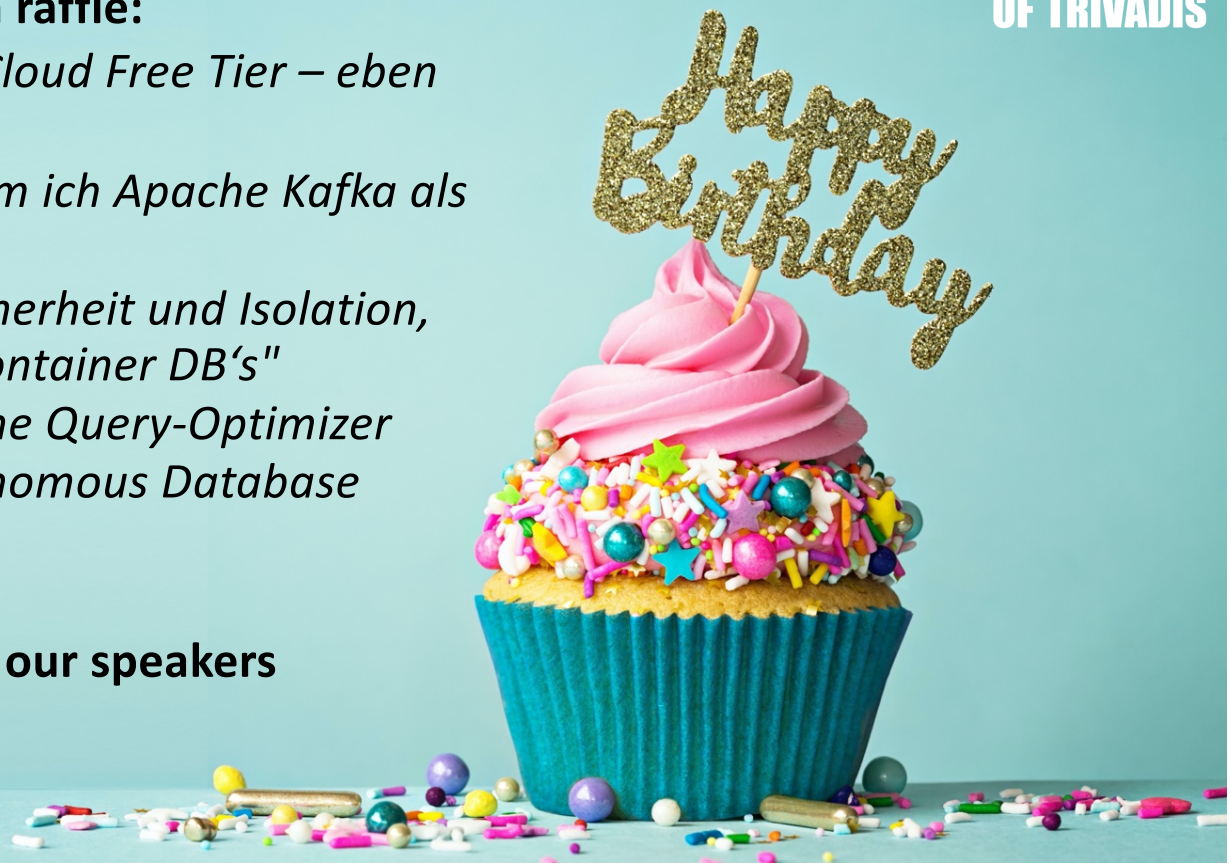
5 MILLION CHF
BUDGET FOR SCIENCE AND DEVELOPMENT PER YEAR

1900 PER YEAR
PROJECTS

Visit us at our booth on level 3

25 YEARS OF TRIVADIS

- **Trivadis barista (good coffee from morning to night)**
- **Birthday cake (daily from 14:00)**
- **Speed-Sessions at the booth with raffle:**
  - **Di 14:45:** Martin Berger *"Oracle Cloud Free Tier – eben mal kurz ausprobiert…"*
  - **Mi 10:45:** Guido Schmutz *"Warum ich Apache Kafka als IT-Spezialist kennen sollte!"*
  - **Mi 14:45:** Stefan Oehrli *"PDB Sicherheit und Isolation, Herausforderungen von Oracle Container DB's"*
  - **Do 10:45:** Chris Antognini *"Welche Query-Optimizer Funktionalitäten sind nur in Autonomous Database verfügbar? "*
- **Participation in our DOAG raffle**
- **Networking and discussions with our speakers**



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Agenda

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- Introduction
- Package DBMS_PRIVILEGE_CAPTURE & Data Dictionary Objects
- Workflow
- Evaluation of the results and adopting the privileges
- Summary & Further Information

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Introduction

History

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- Security simply wasn't a focus for many legacy applications
- Many applications run with DBA-like privileges
- No privilege specification or analysis performed at design time
- Focus was on getting the application completed versus least privilege

```
SQL> grant DBA to PUBLIC with admin option;
Grant succeeded.
```

Principle of the Least Privilege

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"Every program and every privileged user of the system should operate using the least amount of privilege necessary to complete the job."

Jerome Salzer, Communications of the ACM, 1974

Oracle 12c introduced Privilege Analysis

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- Captures the privileges which are used by an application resp. a database user
- Reports the used privileges (and the way ("path") the privileges have been granted)
- Reports the privileges which have been granted but have not be used

- Helps you to achieve the "Least Privilege Principle" for your own database applications

- However, there was this small note in the "Oracle Database Licensing Information":

Feature / Option / Pack	SE2	EE	EE-ES	DBCS SE	DBCS EE	DBCS EE-HP	DBCS EE-EP	ExaCS	Notes
Privilege Analysis	N	Y	Y	N	N	Y	Y	Y	**EE** and **EE-ES**: Requires the Oracle Database Vault option

November 2018: Licensing changed

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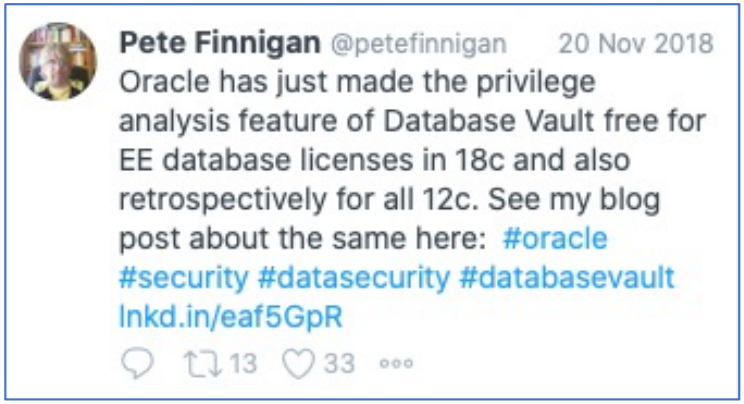

Feature / Option / Pack	SE2	EE	EE-ES	DBCS SE	DBCS EE	DBCS EE-HP	DBCS EE-EP	ExaCS	Notes
Privilege Analysis	N	Y	Y	N	Y	Y	Y	Y	

- Privilege Analysis is now available for Oracle Database Enterprise Edition (for all versions since Oracle Database 12c Release 1), **Database Vault is not required anymore**

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Package DBMS_PRIVILEGE_CAPTURE & Data Dictionary Objects

Package DBMS_PRIVILEGE_CAPTURE

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Procedure	Purpose
CREATE_CAPTURE	Defines a capture policy
ENABLE_CAPTURE	Starts a privilege capture run
DISABLE_CAPTURE	Ends a privilege capture run
GENERATE_RESULT	Fills the result views with the results of a capture run
DROP_CAPTURE	Drops a capture policy and the associated results
DELETE_RUN	Deletes the results of a capture run (but not the policy)
CAPTURE_DEPENDENCY_PRIVS	Captures the privileges that are used by definer's rights and invoker's rights PL/SQL program units for compilation (has to be enabled manually after a capture was started)

Data Dictionary Views & Internal Tables

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Name	Purpose / Content
DBA_PRIV_CAPTURES	defined capture policies (via "DBMS_PRIVILEGE_CAPTURE.CREATE_CAPTURE")
PRIV_CAPTURE$	(basis of DBA_PRIV_CAPTURES)
CAPTURED_PRIV$	Captured privileges
CAPTURE_RUN_LOG$	Information on the capture runs

Result Views (1)

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Views for used privileges	Views for unused privileges
Overview (all privileges resp. grants)	
DBA_USED_PRIVS	DBA_UNUSED_PRIVS
	DBA_UNUSED_GRANTS
Privileges granted to Public	
DBA_USED_PUBPRIVS	DBA_UNUSED_PUBPRIVS
System Privileges	
DBA_USED_SYSPRIVS	DBA_UNUSED_SYSPRIVS
DBA_USED_SYSPRIVS_PATH	DBA_UNUSED_SYSPRIVS_PATH

Result Views (2)

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Views for used privileges	Views for unused privileges
Object Privileges	
DBA_USED_OBJPRIVS	DBA_UNUSED_OBJPRIVS
DBA_USED_OBJPRIVS_PATH	DBA_UNUSED_OBJPRIVS_PATH
User Privileges	
DBA_USED_USERPRIVS	DBA_UNUSED_USERPRIVS
DBA_USED_USERPRIVS_PATH	DBA_UNUSED_USERPRIVS_PATH

- CDB_%-Views are available, too.

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Workflow

Define Capture Policy (1) – What to capture?

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- You must know, how to identify the application in the database, e.g.
  - Specific user
  - Role(s) granted to the user which is used by the application
  - Session context

- Based on that you can define the capture policy

- Possible capture types
  - All database activities
  - Validate role privileges by capturing all privileges which are included in a role or a set of roles
  - Database sessions which fulfill certain context conditions (function SYS_CONTEXT)

Define Capture Policy (2) – What to capture?

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- Constants in DBMS_PRIVILEGE_CAPTURE (for capture type):

G_DATABASE	capture all database activities (resp. privilege usage) except SYS activities
G_ROLE	captures privilege use of one ore more roles
G_CONTEXT	captures all privilege use in a specified context
G_ROLE_AND_CONTEXT	combination of G_ROLE and G_CONTEXT

Define Capture Policy (3) – CREATE_CAPTURE

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```
Procedure DBMS_PRIVILEGE_CAPTURE.CREATE_CAPTURE

Argument Name                  Type                 In/Out Default?
 ------------------------- ---------------- ------ --------
 NAME                      VARCHAR2         IN
 DESCRIPTION               VARCHAR2         IN     DEFAULT
 TYPE                      NUMBER           IN     DEFAULT
 ROLES                     ROLE_NAME_LIST   IN     DEFAULT
 CONDITION                 VARCHAR2         IN     DEFAULT
```

- "CONDITION" has to be used to define the context for the capture types "G_CONTEXT" and "G_ROLE_AND_CONTEXT"

Define Capture Policy (4) - Examples

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```
REM policy to capture all database activities

execute DBMS_PRIVILEGE_CAPTURE.CREATE_CAPTURE(
  name => POLICY_ALL_DB_ACTIVITIES',
  description =>'captures all database privileges used by all users',
  type => DBMS_PRIVILEGE_CAPTURE.G_DATABASE'
  );


REM which PUBLIC privileges are used by an application/user
execute DBMS_PRIVILEGE_CAPTURE.CREATE_CAPTURE(
  name => POLICY_CAPTURE_PUBLIC',
  description =>'captures all required privileges granted to public',
  type => DBMS_PRIVILEGE_CAPTURE.G_ROLE',
  roles => 'PUBLIC'
  );
```

Define Capture Policy (5) - Examples

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```
REM which privileges are used by a specific user

execute DBMS_PRIVILEGE_CAPTURE.CREATE_CAPTURE(
  name => POLICY_CAPTURE_SCOTT',
  description =>'captures the privileges required by SCOTT',
  type => DBMS_PRIVILEGE_CAPTURE.G_CONTEXT',
  condition=> q'[sys_context('USERENV','SESSION_USER') = 'SCOTT']'
  );

REM which DBA privileges are used by a specific user
execute DBMS_PRIVILEGE_CAPTURE.CREATE_CAPTURE(
  name => POLICY_CAPTURE_SCOTT_DBA',
  description =>'captures all required privileges granted to public',
  type => DBMS_PRIVILEGE_CAPTURE.G_ROLE_AND_CONTEXT',
  roles => 'DBA',
  condition=> q'[sys_context('USERENV','SESSION_USER') = 'SCOTT']'
  );
```

Define Capture Policy (6) - SYS_CONTEXT

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- SYS_CONTEXT is the only function which can be used to specify the conditions for "DBMS_PRIVILEGE_CAPTURE.G_CONTEXT"
- No user defined functions (but you can use a user defined context)
- Examples:

SESSION_USER	User who logged in
HOST	Client machine
OS_USER	Client OS User
MODULE	via DBMS_APPLICATION_INFO
ACTION	via DBMS_APPLICATION_INFO
User defined context	via DBMS_SESSSION.SET_CONTEXT

Start Privilege Capture

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- Start privilege capture

```
PROCEDURE DBMS_PRIVILEGE_CAPTURE.ENABLE_CAPTURE
 Argument Name                  Type                    In/Out Default?
 ------------------------------ ------------------------ ------ --------
 NAME                           VARCHAR2                 IN
 RUN_NAME                       VARCHAR2                 IN     DEFAULT
```

- For one profile multiple test runs can be stored
- Enable capture of dependency privileges if required
- Example for starting a privilege capture

```
Execute DBMS_PRIVILEGE_CAPTURE.ENABLE_CAPTURE(
 name => 'POLICY_CAPTURE_SCOTT',
 run_name => 'TEST_RUN_20191110');
```

Run your Application

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- **That's the critical part**

- You have to run all modules, screen, batch jobs etc. which are ever used by your application
- Hopefully you have a complete set of automated tests

- Missing a function which runs e.g. once a year and which requires a special privilege will cause this function to fail (some time later) if you adopt the privileges according to the results of the privilege capture!

Stop Privilege Capture

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- After the tests are complete the capture can be stopped

```
PROCEDURE DBMS_PRIVILEGE_CAPTURE.DISABLE_CAPTURE
 Argument Name                  Type                    In/Out Default?
 ------------------------ ---------------- ------ --------
 NAME                           VARCHAR2                IN
```

- Example:

```
Execute DBMS_PRIVILEGE_CAPTURE.DISABLE_CAPTURE(
 name => 'POLICY_CAPTURE_SCOTT');
```

Fill Result Views

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- The results which are stored in internal tables after the run has been stopped have to transferred into the DBA_USED_%- and DBA_UNUSED_%-views

```
PROCEDURE DBMS_PRIVILEGE_CAPTURE.GENERATE_RESULT
 Argument Name                  Type                 In/Out Default?
 ------------------------------ ---------------------- ------ --------
 NAME                           VARCHAR2             IN
 RUN_NAME                       VARCHAR2             IN     DEFAULT
 DEPENDENCY                     BOOLEAN              IN     DEFAULT
```

- Setting DEPENDENCY=TRUE is required when capturing dependent privileges (CAPTURE_DEPENDENCY_PRIVS)
- Example:

```
Execute DBMS_PRIVILEGE_CAPTURE.DISABLE_CAPTURE(
 name => POLICY_CAPTURE_SCOTT',
 run_name => 'TEST_RUN_20191110');
```

Miscellaneous

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- The role CAPTURE_ADMIN is required to run procedures of the package DBMS_PRIVILEGE_CAPTURE

- Only one privilege capture policy can be active at a time
- Enabled capture policies remain active even after a restart of the database instance

- Results are stored until the run is deleted (DBMS_PRIVILEGE_CAPTURE.DELETE_RUN) or the policy is dropped (DBMS_PRIVILEGE_CAPTURE.DROP_POLICY)

- In a Container Database you can run privilege analysis on container level only (CDB$ROOT and individual PDBs), not globally for all containers

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Evaluating the results
&
Adopting the privileges

Example Result Queries (1)

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- Which system privileges were used and how were they granted? ("grant path")

```
SQL> select USED_ROLE,SYS_PRIV,PATH
  2  from DBA_USED_SYSPRIVS_PATH where CAPTURE='POLICY_CAPTURE_SCOTT'
  3  and RUN_NAME= 'TEST_RUN_20191110';

USED_ROLE  SYS_PRIV          PATH
---------- ----------------- ----------------------------------------------
TOP_SECRET SELECT ANY TABLE  GRANT_PATH('SCOTT')
TOP_SECRET SELECT ANY TABLE  GRANT_PATH('SCOTT', 'SECRET', 'TOP_SECRET')
TOP_SECRET ANALYZE ANY       GRANT_PATH('SCOTT', 'SECRET', 'TOP_SECRET')
CONNECT    CREATE SESSION    GRANT_PATH('SCOTT', 'CONNECT')
```

The privilege "SELECT ANY TABLE" was granted in two ways

Role TOP_SECRET was granted to the role SECRET and the role SECRET was granted to SCOTT

Example Result Queries (2)

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- Which object privileges were used?

```
SQL> select USERNAME,USED_ROLE,OBJ_PRIV,
  2  OBJECT_OWNER O_OWNER,OBJECT_TYPE O_TYPE,OBJECT_NAME O_NAME
  3  from DBA_USED_OBJPRIVS
  4  where CAPTURE='POLICY_CAPTURE_SCOTT'
  5  and RUN_NAME= 'TEST_RUN_20191110';


USERNAME USED_ROLE OBJ_PRIV  O_OWNER O_TYPE   O_NAME
-------- --------- --------- ------ --------- ---------------------
SCOTT     PUBLIC    EXECUTE   SYS    PACKAGE   DBMS_APPLICATION_INFO
SCOTT     PUBLIC    SELECT    SYS    TABLE     DUAL
SCOTT     SCOTT     SELECT    HR     TABLE     DEPARTMENTS
SCOTT     SCOTT     SELECT    HR     TABLE     EMPLOYEES
SCOTT     SCOTT     UPDATE    HR     TABLE     EMPLOYEES
```

Example Result Queries (3)

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- All privileges which were used during the privilege analysis capture

```
SQL> select OBJ_PRIV,SYS_PRIV,OBJECT_OWNER O_OWNER,
  2  OBJECT_NAME O_NAME,OBJECT_TYPE O_TYPE from DBA_USED_PRIVS
  3  where CAPTURE='POLICY_CAPTURE_SCOTT' and RUN_NAME= 'TEST_RUN_20191110';

OBJ_PRIV   SYS_PRIV                O_OWNER    O_TYPE      O_NAME
---------- ---------------- ------------ --------- ---------------------
UPDATE                            HR          TABLE     EMPLOYEES
          SELECT ANY TABLE        HR          TABLE     EMPLOYEES
          SELECT ANY TABLE        HR          TABLE     EMPLOYEES
SELECT                            HR          TABLE     DEPARTMENTS
          ANALYZE ANY             HR          TABLE     EMPLOYEES
SELECT                            SYS         TABLE     DUAL
SELECT                            HR          TABLE     EMPLOYEES
          CREATE SESSION
EXECUTE                           SYS         PACKAGE    DBMS_APPLICATION_INFO
```

Example Result Queries (4)

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- All privileges which were granted to the to the user SCOTT but not used during the privilege analysis capture

```
SQL> select OBJ_PRIV,SYS_PRIV,OBJECT_OWNER O_OWNER,
  2  OBJECT_NAME O_NAME,OBJECT_TYPE O_TYPE from DBA_UNUSED_PRIVS
  3  where CAPTURE='POLICY_CAPTURE_SCOTT' and RUN_NAME= 'TEST_RUN_20191110';
OBJ_PRIV  SYS_PRIV                O_OWNER O_TYPE     O_NAME
--------- --------------------- ------- ---------- --------------------
          SELECT ANY DICTIONARY
EXECUTE                          SYS     DIRECTORY  DATA_PUMP_DIR
READ                             SYS     DIRECTORY  DATA_PUMP_DIR
WRITE                            SYS     DIRECTORY  DATA_PUMP_DIR
SELECT                           SYS     VIEW       V_$SQL_PLAN_STATISTICS_ALL
SELECT                           SYS     VIEW       V_$SESSION
SELECT                           SYS     VIEW       V_$SQL_PLAN
SELECT                           SYS     VIEW       V_$SQL
EXECUTE                          SYS     PACKAGE    DBMS_FLASHBACK_ARCHIVE
EXECUTE                          SYS     PACKAGE    DBMS_FLASHBACK
EXECUTE                          SYS     PACKAGE    DBMS_MONITOR
SELECT                           HR      TABLE      LOCATIONS
UPDATE                           HR      TABLE      LOCATIONS
[..]
```

Example Result Queries (5)

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- The views contain much more information

```
SQL> desc DBA_USED_PRIVS
 Name                                      Null?    Type
 ----------------------------------------- -------- ------------------------------------
 CAPTURE                                   NOT NULL VARCHAR2(128)
 SEQUENCE                                  NOT NULL NUMBER
 OS_USER                                            VARCHAR2(128)
 USERHOST                                           VARCHAR2(128)
 MODULE                                             VARCHAR2(64)
 USERNAME                                  NOT NULL VARCHAR2(128)
 USED_ROLE                                          VARCHAR2(128)
 SYS_PRIV                                           VARCHAR2(40)
 OBJ_PRIV                                           VARCHAR2(40)
 USER_PRIV                                          VARCHAR2(25)
 OBJECT_OWNER                                       VARCHAR2(128)
 OBJECT_NAME                                        VARCHAR2(128)
 OBJECT_TYPE                                        VARCHAR2(23)
 COLUMN_NAME                                        VARCHAR2(128)
 OPTION$                                            NUMBER
 PATH                                               GRANT_PATH
 RUN_NAME                                           VARCHAR2(128)
```

Privilege Analysis & OEM Cloud Control (1)

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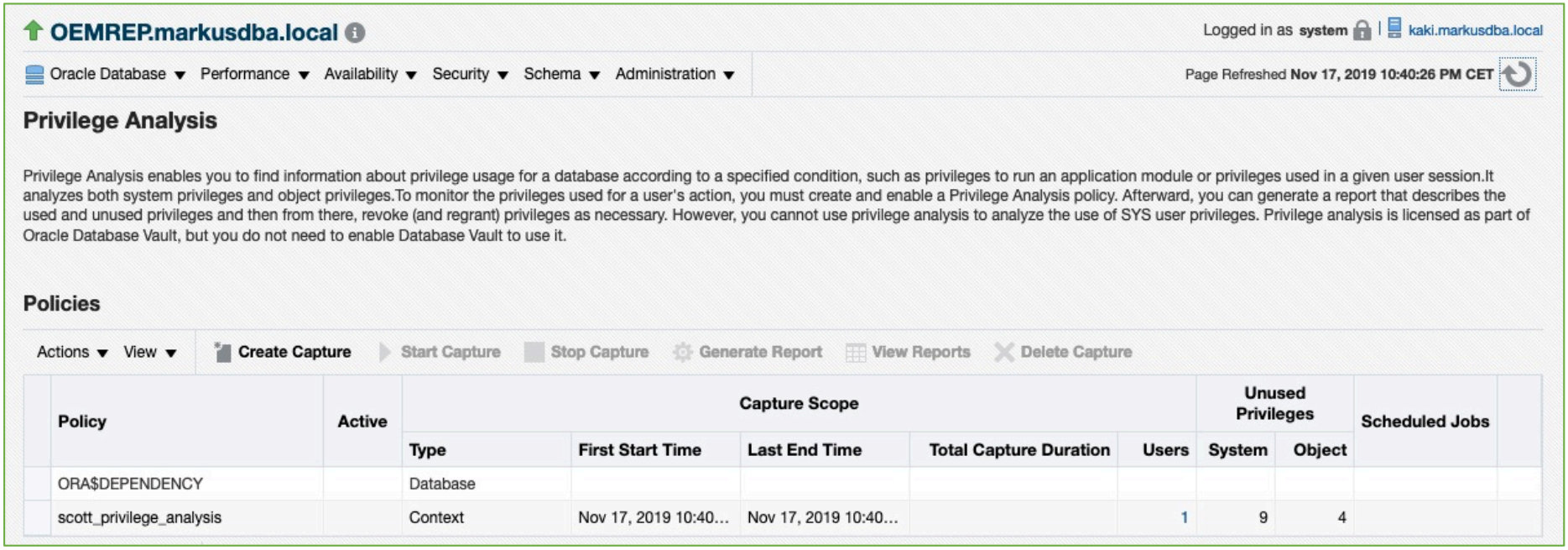
- OEM Cloud Control 13c can be used to manage Privilege Analysis
  - Targets → Database → Security → Privilege Analysis



Policy	Active	Capture Scope					Unused Privileges		Scheduled Jobs
		Type	First Start Time	Last End Time	Total Capture Duration	Users	System	Object	
ORA$DEPENDENCY		Database							
scott_privilege_analysis		Context	Nov 17, 2019 10:40...	Nov 17, 2019 10:40...		1	9	4	

Privilege Analysis & OEM Cloud Control (2)

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Oracle Database ▾ Performance ▾ Availability ▾ Security ▾ Schema ▾ Administration ▾ Page Refreshed **Nov 17, 2019 10:40:57 PM CET**

Privilege Analysis: Reports Return

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 scott_privilege_analysis * **Grantee** SCOTT

Revoke Regrant

Grantee	Type	Used	Revoked	System Privileges		Object Privileges	
				Unused	Used	Unused	Used
SCOTT	User			9	3	4	6
Object Privileges	Folder					2	2
HR	Schema					2	2
TABLE	Object Type					2	2
EMP_TEST2	Object Name						2
LOCATIONS	Object Name					2	
CONNECT	Role	✓		1	1		
RESOURCE	Role			8		2	
SECRET	Role	✓					

Generate "GRANT" commands (1)

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- The results of a privilege capture can be used to create a GRANT-script
- Example: GRANT all required privileges to a new role SCOTT_RESTRICTED_PRIVS_ROLE
- Part 1: System Privileges

```
SQL> SELECT 'grant '||sys_priv||' to SCOTT_RESTRICTED_PRIVS_ROLE;' PRIVS_TO_GRANT
  2  FROM DBA_USED_PRIVS where SYS_PRIV not like '%ANY%'
  3  and CAPTURE='POLICY_CAPTURE_SCOTT'
  4  and RUN_NAME= 'TEST_RUN_20191110';
```

Generate "GRANT" commands (2)

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- Part 2. Object Privileges
- Query originally based on
  https://apex.oracle.com/pls/apex/germancommunities/dbacommunity/tipp/7141/index.html
  Credits to Norman Sibbing from Oracle

```
SQL> SELECT DISTINCT 'grant '||
  2  CASE SYS_PRIV
  3        WHEN 'SELECT ANY TABLE' THEN 'SELECT'
  4        WHEN 'EXECUTE ANY PROCEDURE'THEN 'EXECUTE'
  5            WHEN 'INSERT ANY TABLE' THEN 'INSERT'
  6        WHEN 'UPDATE ANY TABLE' THEN 'UPDATE'
  7            WHEN 'DELETE ANY TABLE' THEN 'DELETE'
  8            WHEN 'ANALYZE ANY' THEN 'ANALYZE'
  9            WHEN 'SELECT ANY SEQUENCE' THEN 'SELECT'
 10        ELSE
 11           OBJ_PRIV
 12            END
 13  ||' on '||OBJECT_OWNER||'.'|| OBJECT_NAME||' to SCOTT_RESTRICTED_PRIVS_ROLE;'
PRIVS_TO_GRANT
 14  FROM DBA_USED_PRIVS where object_name is not null;
```

Generate "GRANT" commands (3) - Result

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```
grant CREATE SESSION to SCOTT_RESTRICTED_PRIVS_ROLE;

grant EXECUTE on SYS.DBMS_APPLICATION_INFO to SCOTT_RESTRICTED_PRIVS_ROLE;
grant SELECT on HR.EMPLOYEES to SCOTT_RESTRICTED_PRIVS_ROLE;
grant SELECT on HR.EMP_TEST2 to SCOTT_RESTRICTED_PRIVS_ROLE;
grant SELECT on HR.DEPARTMENTS to SCOTT_RESTRICTED_PRIVS_ROLE;
grant ANALYZE on HR.EMPLOYEES to SCOTT_RESTRICTED_PRIVS_ROLE;
grant UPDATE on HR.EMP_TEST2 to SCOTT_RESTRICTED_PRIVS_ROLE;
grant SELECT on SYS.DUAL to SCOTT_RESTRICTED_PRIVS_ROLE;
```

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Summary
&
Further Information

Summary

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- "Privilege Analysis" is a great tool for achieving the "Principle of the Least Privilege"
- Privilege Analysis should be included in your tests
- It's critical that you run all functions, modules, batch jobs etc. of your application during the capture phase (Automation can help ☺)
- Removing the license restrictions (Database Vault) was an important step made by Oracle to help the customers making their applications more secure

Further Information

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- Wikipedia: "Principle of least privilege": https://en.wikipedia.org/wiki/Principle_of_least_privilege
- Documentation of the package DBMS_PRIVILEGE_CAPTURE: https://docs.oracle.com/en/database/oracle/oracle-database/19/arpls/DBMS_PRIVILEGE_CAPTURE.html#GUID-6522AC3E-A457-4C7B-8996-B065957F73E4
- Database Security Guide, Chapter 5 " Performing Privilege Analysis to Find Privilege Use": https://docs.oracle.com/en/database/oracle/oracle-database/19/dbseg/performing-privilege-analysis-find-privilege-use.html#GUID-44CB644B-7B59-4B3B-B375-9F9B96F60186
- Deutschsprachiger Datenbank & Cloud Technologie Blog: "Least Privileges mit Oracle Privilege Analysis" https://blogs.oracle.com/coretec/least-privileges-mit-oracle-privilege-analysis
- MOS-Note "Privilege Analysis Feature of Database Vault (Doc ID 2588251.1)"
- https://gavinsoorma.com/2015/02/oracle-12c-new-feature-privilege-analysis/

Questions & Answers

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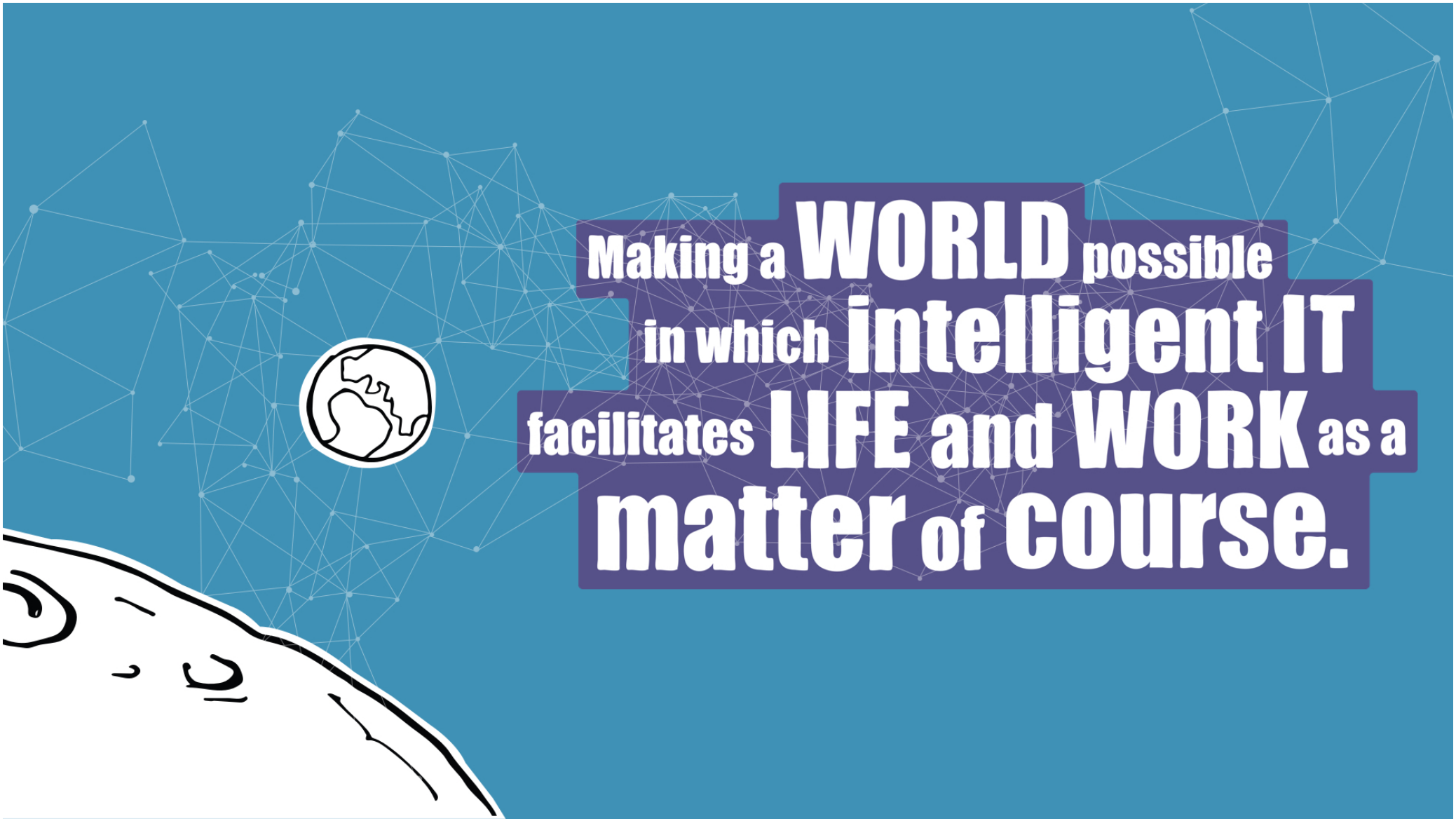
Making a WORLD possible
in which intelligent IT
facilitates LIFE and WORK as a
matter of course.