ORACLE

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Data Pump Cool Features

May 2025

Oracle

DBAs

run the world

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Web Seminar	Slides
Episode 16 (replaces Episode 1 from Feb 2021) Oracle Database Release and Patching Strategy for 19c and 23c *115 minutes – May 10, 2023*	
Episode 17 From SR to Patch – Insights into the Oracle Database Development process *55 minutes – June 22, 2023*	
NEW Episode 18 Cross Platform Migration – Transportable Tablespaces to the Extreme *145 min – February 22, 2024*	
Episode 2 AutoUpgrade to Oracle Database 19c *115 minutes – Feb 20, 2021*	
Episode 3 Performance Stability, Tips and Tricks and Underscores *120 minutes – Mar 4, 2021*	
Episode 4 Migration to Oracle Multitenant	

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Webinar | Autonomous Database

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Migration to Oracle Autonomous Database

– Part 2: Preparation

May 15, 15:00 CET

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Data Pump Top Tips

Supercharge data loading/unloading

Always use the Data Pump Bundle Patch

More than 200 functional and performance fixes

- Data Pump Recommended Proactive Patches For 19.10 and Above (Doc ID 2819284.1)

Importing a complete application with data drops from almost 2.5 hours to 48 minutes – by just applying the Data Pump bundle patch

A global provider of financial services

Bundle Patch

The patch is non-binary online installable

- Apply while the database instance is running
- Don't use Data Pump or `DBMS_METADATA`

The patch is not RAC rolling installable

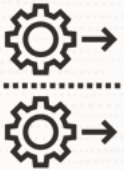
Ensure dictionary and fixed objects statistics are accurate

- Before export
- Before import
- Immediately after import

```
begin
    --dbms_stats.gather_dictionary_stats;
    dbms_stats.gather_schema_stats('SYS');
    dbms_stats.gather_schema_stats('SYSTEM');
    dbms_stats.gather_fixed_objects_stats;
end;
/
```


```
begin
   --dbms_stats.gather_dictionary_stats;
   dbms_stats.gather_schema_stats('SYS');
   dbms_stats.gather_schema_stats('SYSTEM');
   dbms_stats.gather_fixed_objects_stats;
end;
/
```

"After gathering dictionary stats, our Data Pump export went from 46 to 8 minutes"



Use parallel and multiple dump files

```
--Apply parallelism by simply specifying a degree
expdp ... parallel=8


--Use different parallel degree on import
impdp ... parallel=32
```


Oracle Cloud Infrastructure

Number of OCPUs

Number of ECPUs / 4

On-prem (x86-64)

2 x physical cores

On-prem (other)

Depends

Parallel Architecture

```
expdp ... parallel=4
```


Parallel Architecture

Control process

Worker processes

Parallel Architecture

```
expdp ... parallel=4
```

```
select /*+ parallel(2) */ * from t1
select * from t2
select * from t3
select * from t4
```

Worker 4 goes idle

Control process

Worker processes

```
--Use %L to allow multiple dump files
expdp ... parallel=8 dumpfile=exp%L.dmp
```

```
--Split dump files into minor files for easier transport
expdp ... parallel=8 dumpfile=exp%L.dmp filesize=10G
```


```
-- After export, store a checksum in the dump file.
-- Detects in-flight corruption or alteration.
-- Specify other algorithms using checksum_algorithm parameter.

expdp ... checksum=yes

impdp ... verify_checksum=yes
          verify_only=yes
```


For best protection against dump file tampering, use encrypted dump files

- Checksum is a weaker protection
- Requires Advanced Security Option

```
-- Protect your dump files from alteration by using encryption
-- Creating an encrypted dump file requires Advanced Security Option

expdp ... encryption=all encryption_algorithm=AES256
```


```
-- Protect your dump files from alteration by using encryption
-- Creating an encrypted dump file requires Advanced Security Option

expdp ... encryption=all encryption_algorithm=AES256
```

Transportable jobs can use parallel in Oracle Database 21c

```
-- Any transportable jobs can now run in parallel
-- Parallel unload/load of metadata provide a significant performance boost

expdp ... full=y transportable=always parallel=16
expdp ... tablespace=<list> parallel=16

impdp ... parallel=16
```


Parallel Transportable | Benchmark

Oracle E-Business Suite database

600.000+ objects

Export parallel 1	2h 2m
Import parallel 1	6h 44m
Total	**8h 46m**

Export parallel 16	1h 8m
Import parallel 16	1h 23m
Total	**2h 31m**

You get the fastest LOB operations with SecureFile LOBs

2007

Oracle Database 11*g* Release 1

```
-- Do you still have any old BasicFile LOBs in your database?

select * from dba_lobs where securefile='NO';
```


If exporting SecureFile LOBs is slow, apply 19.23.0 Data Pump Bundle Patch

- Alternatively, trick Data Pump with fake stats

By applying the Data Pump Bundle Patch our 4.3 TB export with huge LOBs went from over 21 hours to 3 hours 22 minutes

A European government agency

… Plus, by increasing parallel from 4 to 12 the export dropped to 1 hour 51 minutes

A European government agency

… Finally, we moved to faster ASM based storage bringing it to 1 hour 7 minutes

A European government agency

Do you still have BasicFile LOBs?

- Use DIY parallelism during export

```
--Converting a BasicFile LOB to SecureFile during import,
--is faster than not converting it.
--Overview of Oracle LOBs (Doc ID: 1490228.1)

impdp ... transform=lob_storage:securefile
```


Importing as BasicFile LOBs

```
... imported "SCHEMA"."TABLE"   31.83 GB  681025 rows in 804 seconds using direct_path
```

Importing as SecureFile LOBs

```
... imported "SCHEMA"."TABLE"   31.83 GB  681025 rows in 261 seconds using external_table
```


Do you still have **LONG** and **LONG RAW**?

- Deprecated since Oracle8i

```
-- Convert LONG to CLOB, and LONG RAW to BLOB on import
-- Be sure to change your application as well,
-- PL/SQL interface for accessing LOBs and LONGs are not the same

impdp ... transform=long_to_lob:y
```


Speed up imports by using NOVALIDATE constraints

A Constraint Can Be

VALIDATED

All data in the table obeys the constraint.
The database guarantees that data is good.

NOT VALIDATED

All data in the table may obey the constraint.
The database does not know if data is good.

Most constraints are VALIDATED

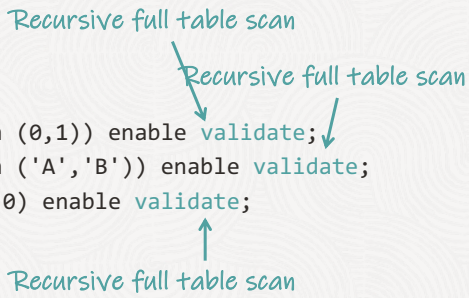
On import, Data Pump creates constraints in the same state as in the source

```
--Example of which commands Data Pump import might execute as part of an import

create table sales ( .... );

insert into sales as select ... ;

alter table sales add constraint c_sales_1 check (c1 in (0,1)) enable validate;
alter table sales add constraint c_sales_2 check (c2 in ('A','B')) enable validate;
alter table sales add constraint c_sales_3 check (c3 > 0) enable validate;
```



```
-- Add constraints with NOVALIDATE keyword regardless of state in source database
-- Significantly speeds up add constraints for larger tables

impdp ... transform=constraint_novalidate
```


```
--Transforming constraints to NOVALIDATE to speed up import

alter table sales add constraint c_sales_1 check (c1 in (0,1)) enable novalidate;
alter table sales add constraint c_sales_2 check (c2 in ('A','B')) enable novalidate;
alter table sales add constraint c_sales_3 check (c3 > 0) enable novalidate;
```

```
--Transforming constraints to NOVALIDATE to speed up import

alter table sales add constraint c_sales_1 check (c1 in (0,1)) enable novalidate;
alter table sales add constraint c_sales_2 check (c2 in ('A','B')) enable novalidate;
alter table sales add constraint c_sales_3 check (c3 > 0) enable novalidate;
```

Database validates new rows

Benchmark, 1 billion rows

Importing VALIDATE constraints

```
10-AUG-24 00:32:28.716: W-1 Processing object type TABLE_EXPORT/TABLE/TABLE_DATA
10-AUG-24 00:36:42.762: W-1 . . imported "FUSION"."hwr_topic_tl" 151.2 GB 1044625000 rows in 254 seconds using external_table
10-AUG-24 00:45:41.226: W-1 Processing object type TABLE_EXPORT/TABLE/CONSTRAINT/CONSTRAINT
10-AUG-24 00:55:35.787: W-1      Completed 7 CONSTRAINT objects in 594 seconds
```

Importing NOVALIDATE constraints

```
10-AUG-24 00:14:56.050: W-1 Processing object type TABLE_EXPORT/TABLE/TABLE_DATA
10-AUG-24 00:19:10.311: W-1 . . imported "FUSION"."hwr_topic_tl" 151.2 GB 1044625000 rows in 254 seconds using external_table
10-AUG-24 00:29:20.841: W-1 Processing object type TABLE_EXPORT/TABLE/CONSTRAINT/CONSTRAINT
10-AUG-24 00:29:21.101: W-1      Completed 7 CONSTRAINT objects in 1 seconds
```

NOVALIDATE constraints prevent the optimizer from certain query rewrites

- Check `QUERY_REWRITE_INTEGRITY`

```
alter table sales add constraint c_sales_1 check (c1 in (0,1)) enable novalidate;

------------------------
------- GO LIVE -------
------------------------

#Validate constraints
#Optionally, use parallel query
alter session force parallel query;
alter table sales modify constraint c_sales_1 enable validate;
```


Exceptions

Data Pump always validates certain constraints:

1. On `DEFAULT ON NULL` columns
2. Used by a reference partitioned table
3. Used by a reference partitioned child table
4. Table with Primary key OID
5. Used as clustering key on a clustered table

Validate constraints after import, or even after go-live

- Still requires a full scan of the table
- But can use parallel query
- And no table lock!

Exceptions

Data Pump always validates certain constraints:

1. On `DEFAULT ON NULL` columns
2. Used by a reference partitioned table
3. Used by a reference partitioned child table
4. Table with Primary key OID
5. Used as clustering key on a clustered table

Use with care if
you are transforming data on import

Also available in Oracle Database 19c via 19.23.0 Data Pump Bundle Patch

- Plus patch 37280692 - or be on 19.27

Even faster index imports

Use index size to determine parallel degree on index creation

- Coming in future 23ai Data Pump Bundle Patch

Index Creation

```
impdp ... parallel=16
```

Really good for few big indexes

Before 12.1

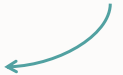
Worker 1 `CREATE INDEX .... PARALLEL 16`

Index Creation

```
impdp ... parallel=16
```

From 12.1

Really good for many small indexes



Worker 1	`CREATE INDEX .... PARALLEL 1`
Worker 2	`CREATE INDEX .... PARALLEL 1`
...	`CREATE INDEX .... PARALLEL 1`
Worker 16	`CREATE INDEX .... PARALLEL 1`

Index Creation

```
impdp ... parallel=16
```

From 23

The best of both worlds

Worker 1	`CREATE INDEX .... PARALLEL 1`
Worker 2	`CREATE INDEX .... PARALLEL 8`
Worker 3	`CREATE INDEX .... PARALLEL 4`
Worker 4	`CREATE INDEX .... PARALLEL 3`

How Data Pump Create Indexes

1. Calculate the optimal parallel degree
2. Create indexes

How Data Pump Create Indexes

1 Calculate the optimal parallel degree

- Always parallel 1 when a table is less than 150 MB
- Customizable via `INDEX_THRESHOLD`
- Get optimal parallel degree using `EXPLAIN PLAN`

```
SQL> explain plan for create index i1 on t1(c1) parallel;

Explained.
```


```
SQL> explain plan for create index i1 on t1(c1) parallel;

Explained.

SQL> select * from table(dbms_xplan.display(format => 'ALL'));

...

Note
-----
   - automatic DOP: Computed Degree of Parallelism is 4 because of degree limit
   - estimated index size: 655K bytes
```

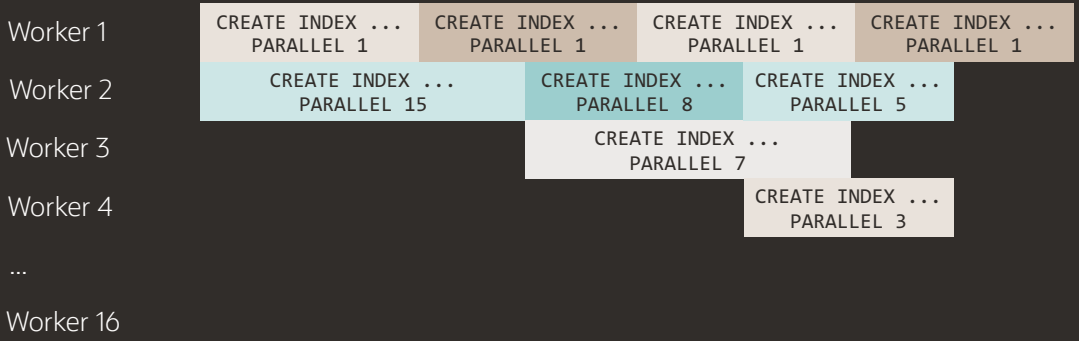

How Data Pump Creates Indexes

2 Create indexes

- One worker creates small indexes (parallel 1) in large batches
- The next worker starts with the biggest index (measured by optimal parallel degree)

How Data Pump Creates Indexes

```
impdp ... parallel=16
```



Benchmark, 1 billion rows

Importing with 19c settings constraints

```
10-AUG-24 00:55:35.830: Job "SYSTEM"."SYS_IMPORT_TABLE_01" successfully completed at Sat Aug 10 00:55:35 2024 elapsed 0 00:23:09
```

Importing NOVALIDATE constraints + new index method

```
10-AUG-24 01:48:38.844: Job "SYSTEM"."SYS_IMPORT_TABLE_01" successfully completed at Sat Aug 10 01:48:38 2024 elapsed 0 00:10:40
```

We expect much better result
with more complex schemas

Also available in Oracle Database 19c
via 19.26.0 Data Pump Bundle Patch

Bits and pieces

Time Zone File Version Check

Source
Version 43

Target
Version 42

```
create table t1 (
   ...
   c1 timestamp with timezone
   ...
)
```

```
Import: Release 19.0.0.0.0 - Production on Sun Sep 1 06:17:06 2024
Version 19.21.0.0.0

Copyright (c) 1982, 2019, Oracle and/or its affiliates.  All rights reserved.

Connected to: Oracle Database 19c Enterprise Edition Release 19.0.0.0.0 - Production
ORA-39002: invalid operation
ORA-39405: Oracle Data Pump does not support importing from a source database with
TSTZ version 43 into a target database with TSTZ version 42.
```

Works in 19.27 plus Data Pump Bundle Patch by converting the data

```
-- How do you deal with large Data Pump import log files?
-- In this example, the Data Pump import log file has almost 200.000 lines

$ du -h import.log
 29M   import.log

$ wc -l import.log
  189931 import.log
```


```
$ python3 dpla.py import.log

========================
 Data Pump Log Analyzer
========================

...

Operation Details
~~~~~~~~~~~~~~~~~
 Operation:                  Import
 Data Pump Version:          19.22.0.0.0
 DB Info:                    Oracle Database 19c EE Extreme Perf Release 19.0.0.0.0
 Job Name:                   DPJOB1
 Status:                     COMPLETED
   Processing:               -
 Errors:                     1267
   ORA- Messages:            1267
 Start Time:                 2024-04-11 09:30:55
 End Time:                   2024-04-12 10:33:01
 Runtime:                    25:03:06

Data Processing
~~~~~~~~~~~~~~~
 Parallel Workers:           128
 Schemas:                    27
 Objects:                    224755
 Data Objects:               188084
 Overall Size:               13.16 TB
```

```
$ python3 dpla.py import.log -e

========================
 Data Pump Log Analyzer
========================

...

ORA- MESSAGES DETAILS
~~~~~~~~~~~~~~~~~~~~~
(sorted by count):

 Message                                                                                                  Count
 -------------------------------------------------------------------------------------------------------- ---------
 ORA-39346: data loss in character set conversion for object COMMENT                                        919
 ORA-39082: Object type PACKAGE BODY created with compilation warnings                                      136
 ORA-39346: data loss in character set conversion for object PACKAGE_BODY                                    54
 ORA-39082: Object type TRIGGER created with compilation warnings                                            36
 ORA-39082: Object type PROCEDURE created with compilation warnings                                          29
 ORA-31684: Object type USER already exists                                                                  27
 ORA-39111: Dependent object type PASSWORD_HISTORY skipped, base object type USER already exists             27
 ORA-39346: data loss in character set conversion for object PACKAGE                                         18
 ORA-39082: Object type PACKAGE created with compilation warnings                                            10
 ORA-39082: Object type VIEW created with compilation warnings                                                7
 ORA-39346: data loss in character set conversion for object PROCEDURE                                        2
 ORA-39082: Object type FUNCTION created with compilation warnings                                            2
 -------------------------------------------------------------------------------------------------------- ---------
 Total                                                                                                     1267
 -------------------------------------------------------------------------------------------------------- ---------
```

```
$ python3 dpla.py import.log -o

========================
 Data Pump Log Analyzer
========================

...

 Object                              Count     Seconds     Workers     Duration
 ---------------------------------- ---------- ----------- ----------- ------------
 SCHEMA_EXPORT/TABLE/TABLE_DATA         188296     6759219         128      6759219
 CONSTRAINT                                767       37253           1        37253
 TABLE                                    2112        3225          51          156
 COMMENT                                 26442         639         128           18
 PACKAGE_BODY                              197         125         128            5
 OBJECT_GRANT                             5279          25           1           25
 TYPE                                      270           6           1            6
 ALTER_PROCEDURE                           149           5           2            3
 ALTER_PACKAGE_SPEC                        208           4           3            2
 PACKAGE                                   208           3           3            1
 PROCEDURE                                 149           2           2            1

 ...

 ---------------------------------- ---------- ----------- ----------- ------------
 Total                                  224755     6800515         128      6796697
 ---------------------------------- ---------- ----------- ----------- ------------
```

How about NOVALIDATE constraints?

≡ Data Pump Log Analyzer

Table Details

Search for Table...

Table	Rows	Size	Seconds	Part	Subpart
SALES.ORDERS	118914251151	1.73 TB	878854	278	4448
SALES.INVOICES	115668171592	4.33 TB	805901	588	9408
SALES.TRANSACTIONS	115720037994	3.61 TB	611891	451	7216
FINANCE.EXPENSES	35091517646	258.14 GB	112962	367	0
MARKETING.CAMPAIGNS	11621627768	458.93 GB	82801	16	0
HR.EMPLOYEES	19433932893	296.19 GB	66156	2254	0
SALES.DOCUMENTS	4743542596	345.97 GB	48117	589	9424
SALES.REPORTS	4744610748	263.63 GB	42904	440	7040
INVENTORY.EQUIPMENT	9824954344	51.01 GB	33290	130	0
HR.PARTNERS	3983265247	83.62 GB	16388	3046	0

Data Pump Log Analyzer

- Free to use
- Download from GitHub
- Not an official Oracle tool
- Created by Marcus Doeringer
  Our migration superstar

Troubleshooting and Data Pump

In root and PDB

```
-- Change AWR snap interval to 15 minutes and create snapshot
exec dbms_workload_repository.modify_snapshot_settings(null, 15);
exec dbms_workload_repository.create_snapshot;
```


```
-- Change AWR snap interval to 15 minutes and create snapshot
exec dbms_workload_repository.modify_snapshot_settings(null, 15);
exec dbms_workload_repository.create_snapshot;

-- Optionally, enable SQL trace for Data Pump processes or specific SQL ID
alter system set events 'sql_trace {process: pname = dw | process: pname = dm} level=8';
alter system set events 'sql_trace[SQL: 03g1bnw08m4ds]';
```

```
-- Change AWR snap interval to 15 minutes and create snapshot
exec dbms_workload_repository.modify_snapshot_settings(null, 15);
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alter system set events 'sql_trace {process: pname = dw | process: pname = dm} level=8';
alter system set events 'sql_trace[SQL: 03g1bnw08m4ds]';

-- Run Data Pump job with trace (Doc ID 286496.1)
expdp ... metrics=yes logtime=all trace=1FF0300
impdp ... metrics=yes logtime=all trace=1FF0300
```

```
-- Change AWR snap interval to 15 minutes and create snapshot
exec dbms_workload_repository.modify_snapshot_settings(null, 15);
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alter system set events 'sql_trace[SQL: 03g1bnw08m4ds]';

-- Run Data Pump job with trace (Doc ID 286496.1)
expdp ... metrics=yes logtime=all trace=1FF0300
impdp ... metrics=yes logtime=all trace=1FF0300

-- Create AWR snapshot and produce AWR report
exec dbms_workload_repository.modify_snapshot_settings(null, <original-value>);
exec dbms_workload_repository.create_snapshot;
@?/rdbms/admin/awrrpt
```

In root and PDB

Troubleshooting

Collect:

- Data Pump log file
- AWR report - CDB and PDB level
- Data Pump trace files
  - Stored in the database trace directory
  - Control process file name: `*dm*`
  - Worker process file names: `*dw*`

New Data Pump diagnostic views

```
select waiting_session, event, dp_state_in_wait
from v$datapump_sessionwait_info;

WAITING_SESSION EVENT                DP_STATE_IN_WAIT
--------------- -------------------- ----------------
10              direct path sync     WAITING
77              log buffer space     WAITING
191             enq: TT - contention WAITING
428             enq: TT - contention WAITING
```

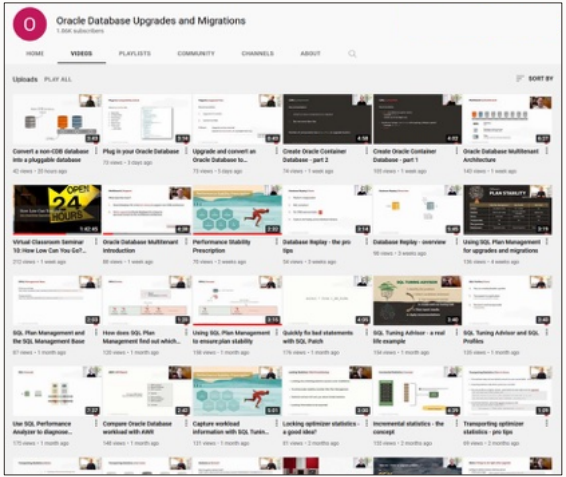

```
select * from v$datapump_process_info;

select * from v$datapump_processwait_info;
```


Key Learnings

1. Use Data Pump Bundle Patch
2. Transform to NOVALIDATE constraints
3. Faster index creation

YouTube | Oracle Database Upgrades and Migrations



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- No marketing
- No buzzword
- All tech

SCAN ME

Thank You