

Even Newer Features of Oracle Data Pump 23ai

- Migrate Like a Pro

AIOUG Webinar, October 2024



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DBAs
run the world





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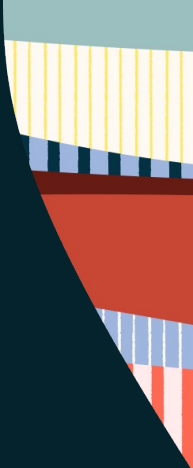
<https://dohdatabase.com>

Even **faster** exports and imports



Use the Data Pump Bundle Patch

- 196 functional and performance fixes
- 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

```
-- Gather stats before export, before import and after import
```

```
begin
```

```
    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*

—
A global provider of sports betting and gambling



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

Parallel Degree



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

expdp ... parallel=4



select * from t1

select * from t2

select * from t3

select * from t4

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
```

--Use %U in older releases of Oracle Database
--%L is introduced in Oracle Database 12.2

~~expdp ... parallel=8 dumpfile=exp%L.dmp~~

expdp ... parallel=8 dumpfile=exp%U.dmp



Parallel import does **not**
need multiple dump files

--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
```

↑
New default value



Use parallel on transportable jobs

Benchmark Transportable Jobs

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

Even **faster** constraint imports





Speed up imports by adding constraints
in **NOVALIDATE** mode

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**

A Constraint Can Be

A constraint becomes validated by:

- Checking all existing data
- Checking all data during insert and update



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;
```

Recursive full table scan

Recursive full table scan

Recursive full table scan

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

```
impdp ... transform=constraint_novalidate:y
```

--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 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;
```

↑
Instant, no full table scan

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

```
create table sales ( .... );
```

```
insert into sales as select ... ;
```

```
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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_t1" 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_t1" 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

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!

```
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



Use with care if
you are transforming data on import



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

- Doc ID [2819284.1](#)

Even **faster** LOB operations



You get the fastest LOB operations
with **SecureFile** LOBs

2007

Oracle Database 11g Release 1

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

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

From Oracle CloudWorld 2023

LOB Export | **Manipulating Statistics**



```
begin
  DBMS_STATS.SET_TABLE_STATS (
    ownname => 'HUGO',
    tabname => 'TAB1',
    numrows => 10000000,
    numblks => 1000000);
end;
/
```





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
- Be sure to convert to SecureFile LOB on import

--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
```

Even **faster** index imports



Use table size to determine
parallel degree on index creation

- Coming in future 23ai Data Pump Bundle Patch

How Data Pump Create Indexes

Before 12.1

Worker 1

```
CREATE INDEX ... PARALLEL 16
```

Really good for big indexes

From 12.1

Worker 1

```
CREATE INDEX ... PARALLEL 1
```

Worker 2

```
CREATE INDEX ... PARALLEL 1
```

...

```
CREATE INDEX ... PARALLEL 1
```

Worker 16

```
CREATE INDEX ... PARALLEL 1
```

Really good for small indexes

How Data Pump Create Indexes

From 23

Worker 1

```
CREATE INDEX ... PARALLEL 1
```

Worker 2

```
CREATE INDEX ... PARALLEL 8
```

Worker 3

```
CREATE INDEX ... PARALLEL 4
```

Worker 4

```
CREATE INDEX ... PARALLEL 3
```

The best of both worlds



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

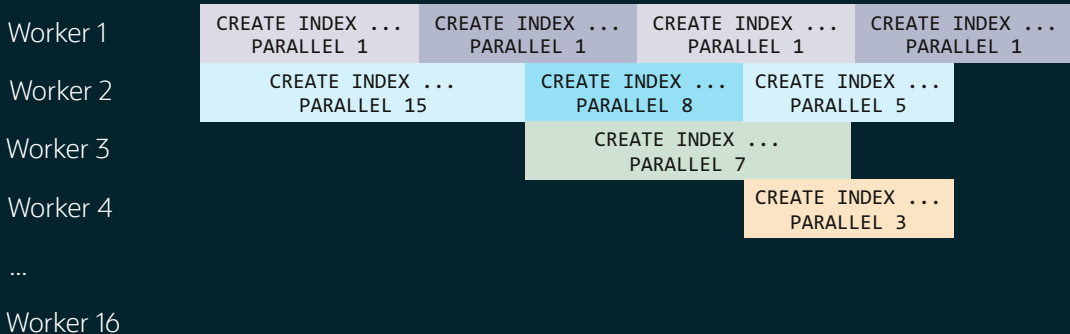
How Data Pump Create Indexes

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 Create Indexes

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





New way of creating indexes on by default

- Controlled by parameter `ONESTEP_INDEX`

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



We'd love to see this feature
in Oracle Database 19c

- Planned for future Data Pump Bundle Patch

Bits and pieces

```
-- Transforms all tablespace storage clauses to the user's default tablespace
```

```
impdp ... transform=tablespace:y
```



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.



Time zone conversion is a one-way street



... But my dump file doesn't contain
any tables with TSTZ columns

- Disable Data Pump time zone file version check during import.
- Use with care and manually ensure no TSTZ is included in the dump file.
- Currently available in Oracle Database 21c and 23ai, coming in 19c.

```
alter system set "_datapump_bypass_tstz_check"=true;
```



Improper use may
logically corrupt your TSTZ data

- Use with caution

-- Always add diagnostic information to the Data Pump log files

```
expdp ... logtime=all metrics=yes
```

```
impdp ... logtime=all metrics=yes
```

No diagnostics

```
Processing object type DATABASE_EXPORT/FINAL_POST_INSTANCE_IMPCALLOUT/MARKER
Processing object type DATABASE_EXPORT/AUDIT_UNIFIED/AUDIT_POLICY_ENABLE
Processing object type DATABASE_EXPORT/POST_SYSTEM_IMPCALLOUT/MARKER
. . exported "SYS"."KU$_USER_MAPPING_VIEW"          5.890 KB      25 rows
. . exported "SYSTEM"."REDO_DB"                      25.59 KB      1 rows
```

Full diagnostics

```
02-NOV-21 19:43:56.061: W-1 Processing object type DATABASE_EXPORT/FINAL_POST_INSTANCE_IMPCALLOUT/MARKER
02-NOV-21 19:43:56.064: W-1      Completed 1 MARKER objects in 0 seconds
02-NOV-21 19:43:59.171: W-1 Processing object type DATABASE_EXPORT/AUDIT_UNIFIED/AUDIT_POLICY_ENABLE
02-NOV-21 19:43:59.195: W-1      Completed 2 AUDIT_POLICY_ENABLE objects in 0 seconds
02-NOV-21 19:43:59.380: W-1 Processing object type DATABASE_EXPORT/POST_SYSTEM_IMPCALLOUT/MARKER
02-NOV-21 19:43:59.387: W-1      Completed 1 MARKER objects in 0 seconds
02-NOV-21 19:43:59.830: W-1 . . exported "SYS"."KU$_USER_MAPPING_VIEW"      5.890 KB   25 rows in 0 seconds using external_table
02-NOV-21 19:43:59.923: W-1 . . exported "SYSTEM"."REDO_DB"                25.59 KB   1 rows in 0 seconds using direct_path
```

-- 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

How about
NOVALIDATE constraints?

```
...
```

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

≡ 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;

-- 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 ]';

-- 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
```

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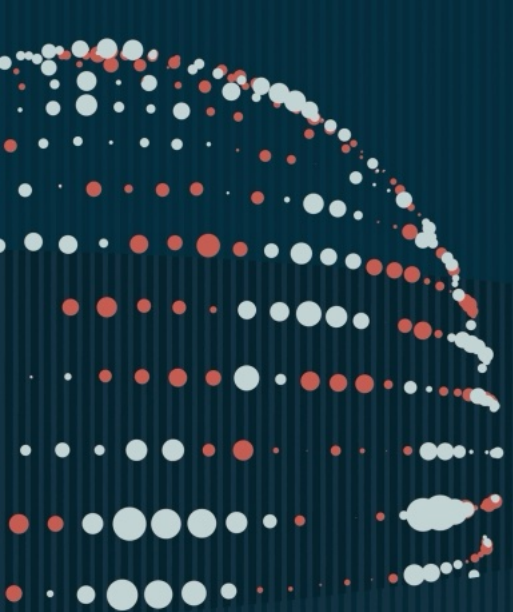
↑
In root and PDB

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*`

Even **faster** exports and imports



Thank You