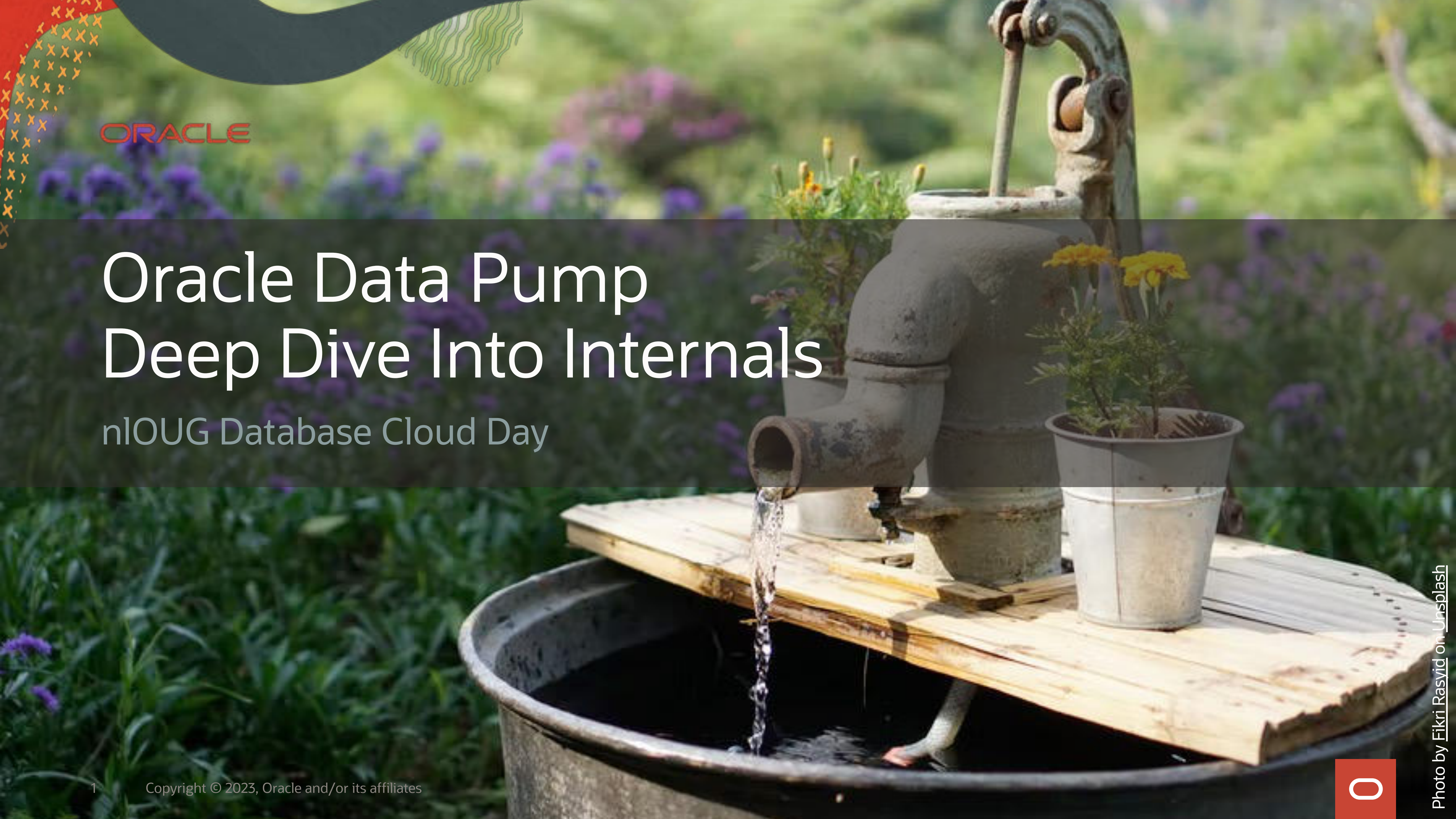

Oracle Data Pump
Deep Dive Into Internals

nlOUG Database Cloud Day

Daniel Overby Hansen

Senior Principal Product Manager

dohdatabase

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https://dohdatabase.com

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Architecture

Oracle Data Pump technology enables very high-speed movement of data and metadata from one database to another.

Data Pump New Features in Release 23c

New dump file format

- Needed for Native OCI API for the Object Store
- Replaces previous Swift API

```
# New format - default
# Trailer block format = 6.1 dump file version
expdp ... version=23


# Header block format (legacy) = 5.1 dump file version
expdp ... version=19
```

Pro Tip: Doc ID 864582.1 discusses header blocks

Data Pump is fully backwards compatible

- Import from previous releases
- Export to previous release using `version` parameter

Data Pump | Dump File Format

- When exporting to the object store, Data Pump chooses the dump file format based on your credential format
- OCI Native API supports only `version=23`
- SWIFT API supports all versions
- Export using `version=19` and OCI Native credentials aborts:

```
ORA-39463 "header block format is not supported for object-store URI dump file
```

Support for SQL domains and boolean and vector data types

New transformation allows removal of sharding on import

- `TRANSFORM=INCLUDE_SHARDING_CLAUSES:[Y|N]`

New transformation allows removal of ACDR metadata on import

- `TRANSFORM=OMIT_ACDR_METADATA:[Y|N]`

Data Pump New Features in Release 21c

Universal Data Pump client

- Client and database release no longer have to match

```
-- Include and exclude keywords are no longer mutually exclusive
-- Works for all object paths and on import as well.

expdp ... include=tables exclude=statistics
```

Transportable jobs are restartable

```
-- 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**

Parallel Transportable | Architecture

Parallel export:

- Each worker processes an object path serially
- Parallel happens by multiple workers working on multiple object paths

Parallel import:

- Control process orders the object paths
- All workers work on one object path in parallel
- Parallel happens by all workers working on the same object path

```
-- 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
```

`remap_tablespace` allows % wildard

- e.g., for ADB-S, `REMAP_TABLESPACE=%:DATA`

The Data Pump LOB Mystery

A short history of binary data types

v4	LONG and LONG RAW
8.0	CLOB and BLOB
11g	SecureFile LOBs

v4	**LONG and LONG RAW**
8.0	**BasicFile LOBs**
11g	**SecureFile LOBs**

v4

LONG and LONG RAW

- Only 1 column per table
- Max size: 2GB - 1

8.0

BasicFile LOBs

- Performance constraints
- No Parallel DML allowed
- Max size: (4GB - 1) * DB_BLOCK_SIZE

11g

SecureFile LOBs

- Improved performance
- Data Pump can use multiple workers or Parallel Query
- Deduplication, encryption and more
- Max size: same as with CLOB/BLOB

As of today, all legacy binary data types should have been migrated to SecureFile LOBs

```
--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
```

Different LOB types

Internal LOBs stored inside the database

- `CLOB`
- `NCLOB`
- `BLOB`

External LOBs stored outside the database

- `BFILE`

Initialization Parameter

`DB_SECUREFILE`

- `NEVER`
- `PERMITTED`
- `PREFERRED` ⬅ LOBs are created as SecureFile LOBs unless explicitly stated
- `ALWAYS`
- `IGNORE`

Tablespace must use Automatic Segment Space Management (ASSM)

Data Pump & LOBs
Things to know and consider

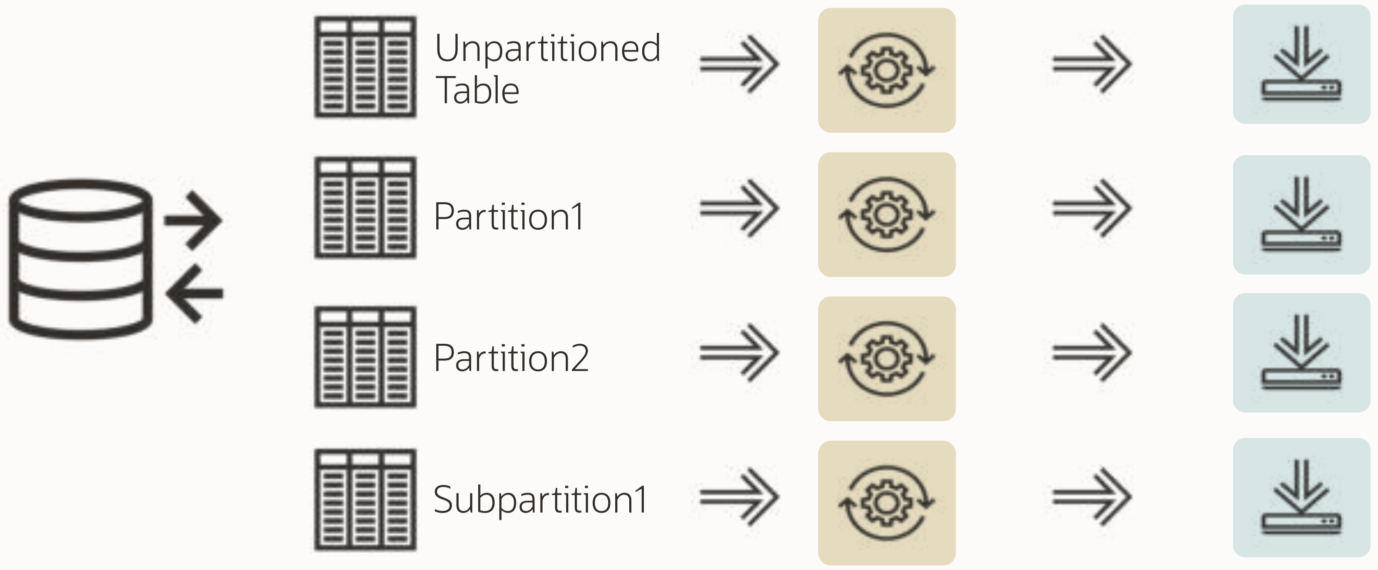
No parallelism with BasicFile LOBs

Always use SecureFile LOBs

But why is there only one worker?

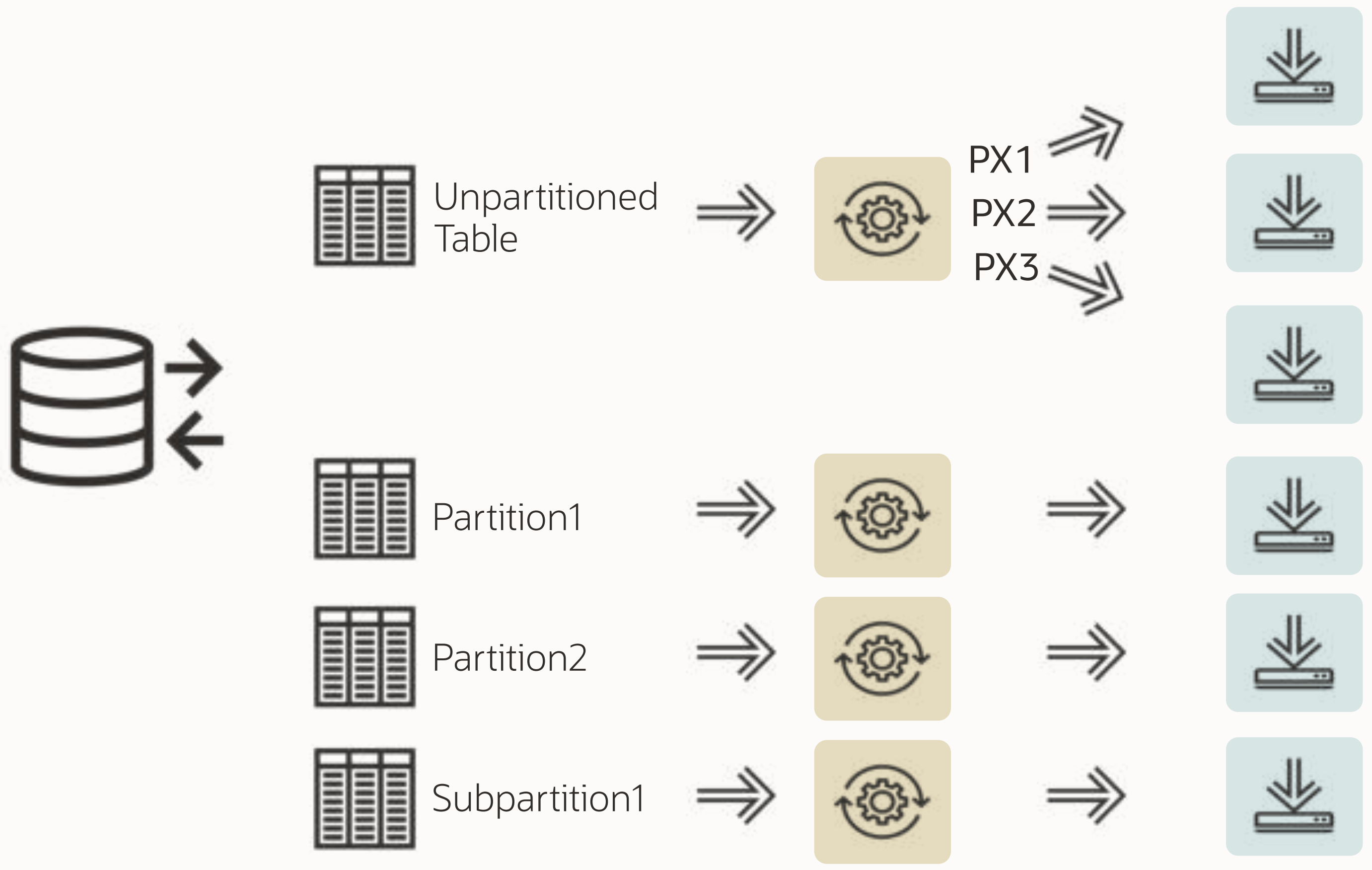
Data Pump | Parallel Worker Activity

Data Pump employs one worker per table data object



Data Pump | Worker as PQ Coordinator

If a table data object is >250MB, Data Pump can invoke parallel query



LOB Export | Example Table

```
CREATE OR REPLACE DIRECTORY BLOB_DIR AS '/tmp/mydir';
```

1GB

```
CREATE TABLE tab1 ( id NUMBER, blob_data BLOB )
  LOB (blob_data) store as securefile;
```

```
BEGIN ... DBMS_LOB.LOADBLOBFROMFILE ...
```

```
exec DBMS_STATS.GATHER_TABLE_STATS('HUGO','TAB1');
```

For a complete example, please visit oracle-base.com

LOB data is stored out-of-row in a separate LOB segment

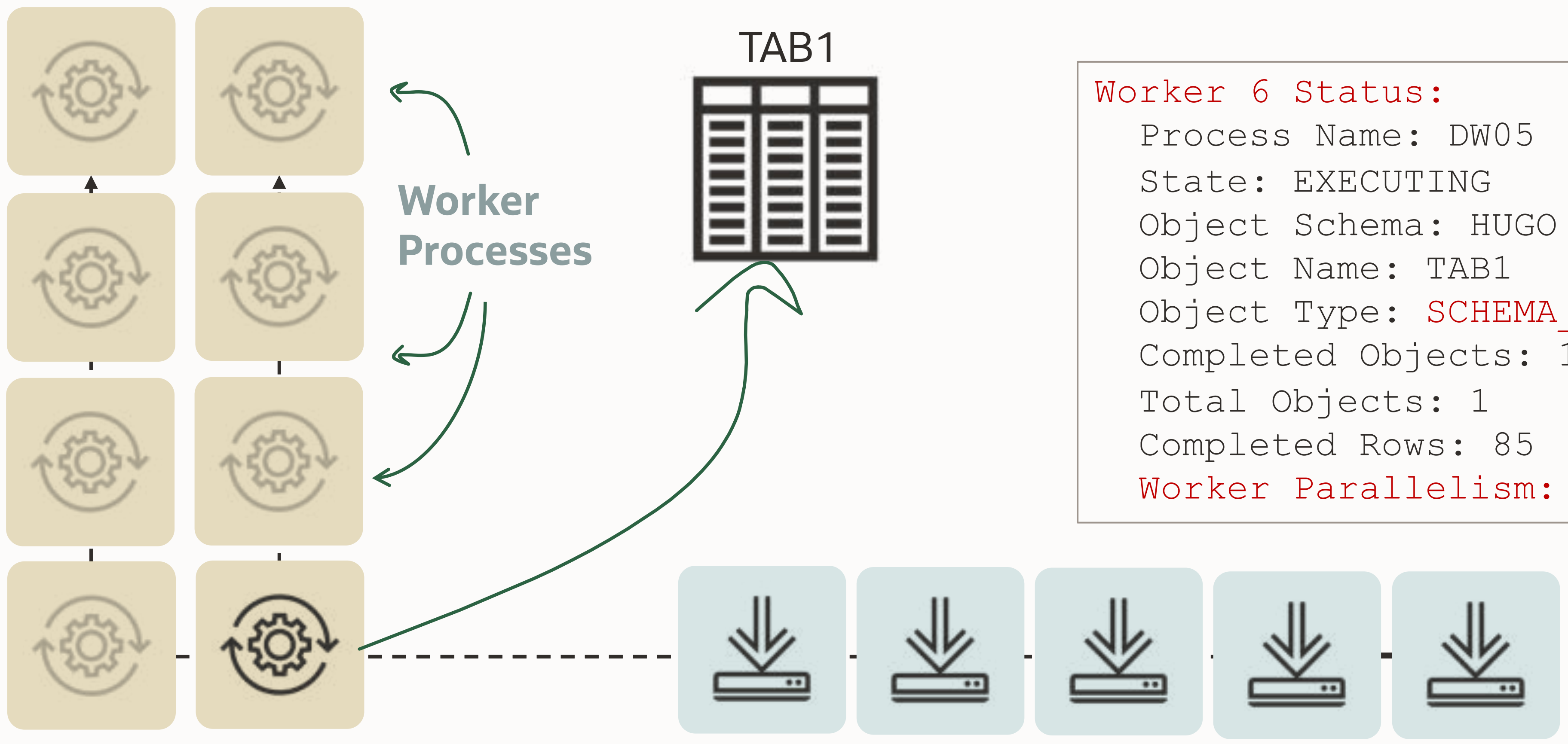
- Smaller LOBs less than 4000 byte store in-line
- Up to 8000 bytes in Oracle Database 23c

Starting Data Pump – Test:

```
DIRECTORY=DATA_PUMP_DIR
DUMPFILE=MYDUMP%L.DMP
LOGFILE=MYDUMP01.LOG
SCHEMAS=HUGO
LOGTIME=ALL
METRICS=YES
PARALLEL=8
```

LOB Export | Lazy Workers?

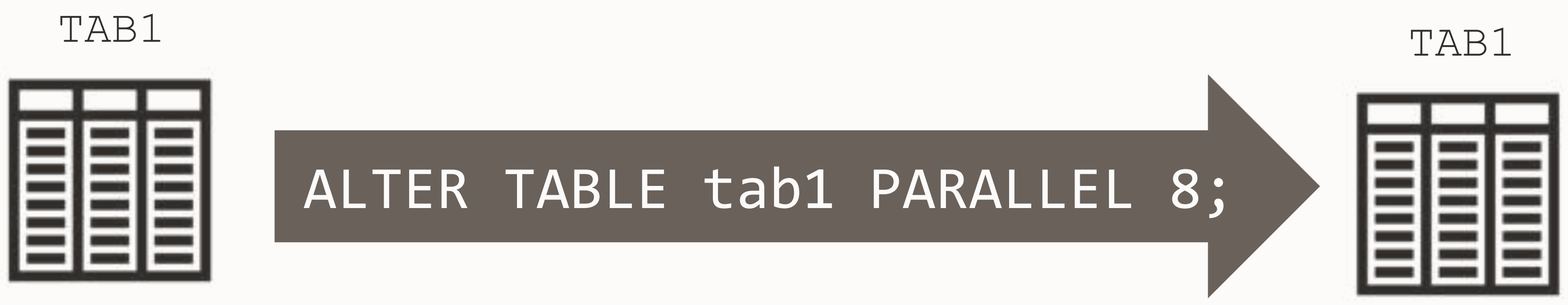
8 workers, 5 dump files – and only 1 worker exports TAB1



```
Worker 6 Status:
  Process Name: DW05
  State: EXECUTING
  Object Schema: HUGO
  Object Name: TAB1
  Object Type: SCHEMA_EXPORT/...
  Completed Objects: 1
  Total Objects: 1
  Completed Rows: 85
  Worker Parallelism: 1
```

Maybe the table's PARALLEL DEGREE is too low?

LOB Export | Parallel Degree



```
ALTER TABLE tab1 PARALLEL 8;
```

```
select degree
from DBA_TABLES
where table_name='TAB1';

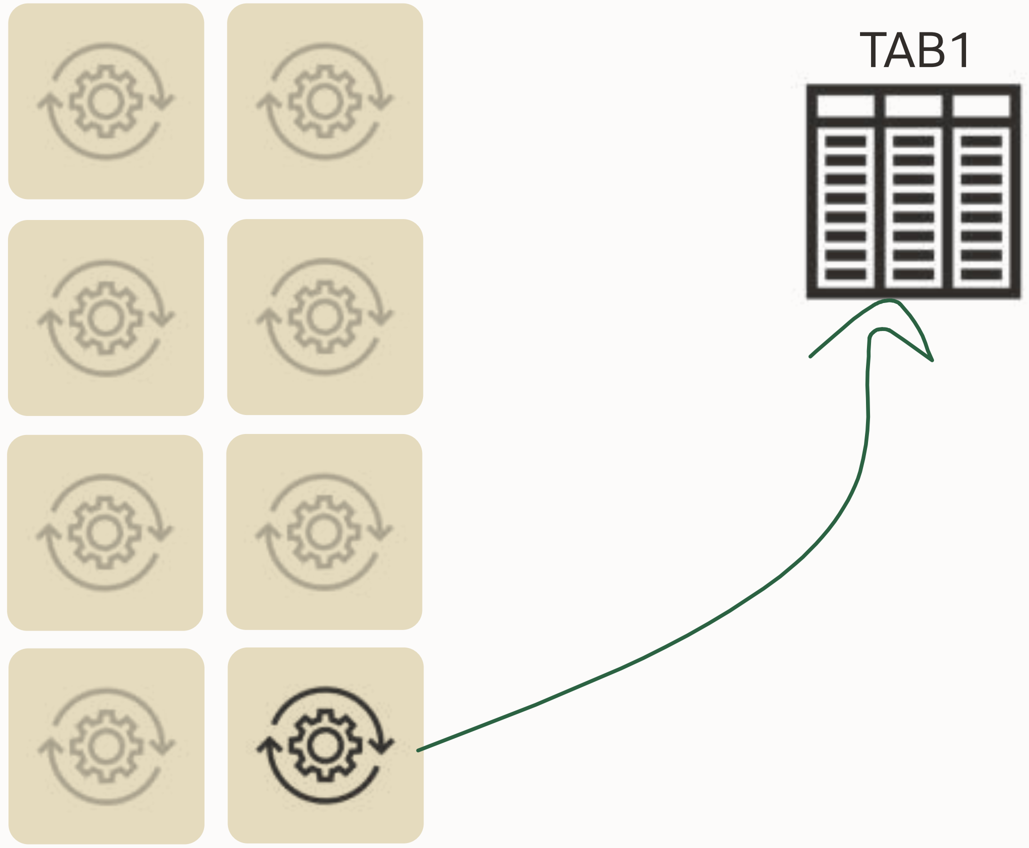
 DEGREE
_____________
             1
```

```
select degree
from DBA_TABLES
where table_name='TAB1';

 DEGREE
_____________
             8
```

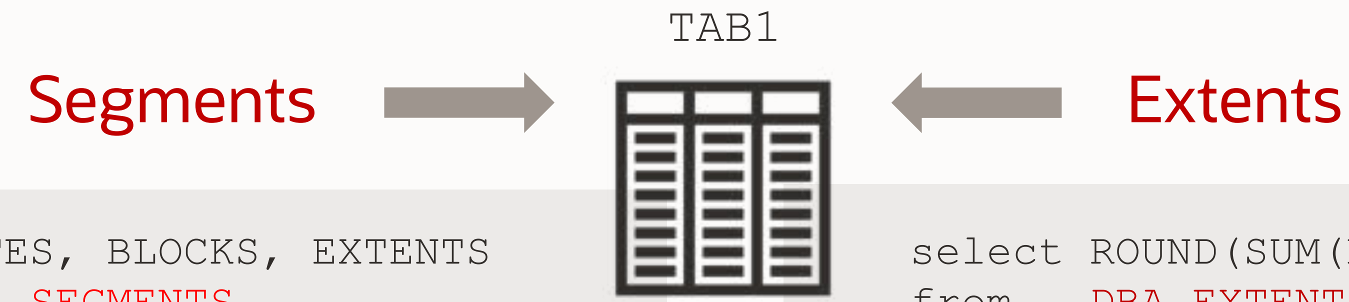
LOB Export | Parallel Degree

8 workers, 5 dump files – and only 1 worker exports TAB1



```
Worker 1 Status:
  Process Name: DW08
  State: EXECUTING
  Object Schema: HUGO
  Object Name: TAB1
  Object Type: SCHEMA_EXPORT/...
  Completed Objects: 1
  Total Objects: 1
  Completed Rows: 85
  Worker Parallelism: 1
```

LOB Export | Table Segments and Extents



```
select BYTES, BLOCKS, EXTENTS
from   DBA_SEGMENTS
where  SEGMENT_NAME = 'TAB1'
and    OWNER = 'HUGO';


     BYTES     BLOCKS     EXTENTS
__________ __________ ___________
    131072         16           2
```

```
select ROUND(SUM(BYTES)/1024/1024/1024,2) "GB"
from   DBA_EXTENTS
where  SEGMENT_NAME IN
          (select SEGMENT_NAME
           from   DBA_LOBS
           where  TABLE_NAME = 'TAB1'
           and    OWNER = 'HUGO');

        GB
_________
     10.31
```

LOB Export | Table Statistics

TAB1

Table

Columns

```
select NUM_ROWS, BLOCKS, AVG_ROW_LEN
from   DBA_TAB_STATISTICS
where  TABLE_NAME = 'TAB1';


 NUM_ROWS    BLOCKS    AVG_ROW_LEN
_________ ________ _____________
       85        13            720
```

```
select COLUMN_NAME, NUM_DISTINCT,
       SAMPLE_SIZE, AVG_COL_LEN
from   DBA_TAB_COL_STATISTICS
where  TABLE_NAME='TAB1';


COLUMN_N NUM_DIST  SAMPLE_SIZE  AVG_COL_LEN
________ ________ ____________ ____________
ID              1           85            3
BLOB_DATA       0           85          717
```

It looks like as if Data Pump does not know anything about the dimensions of the LOB segment

LOB Export | User Objects

```
select OBJECT_NAME, OBJECT_TYPE from DBA_OBJECTS
where OWNER = 'HUGO';

                 OBJECT_NAME    OBJECT_TYPE
____________________________  ______________
TAB1                          TABLE
SYS_IL0000070285C00002$$      INDEX
SYS_LOB0000070285C00002$$     LOB
```

Is it possible to *analyze* the LOB segment?

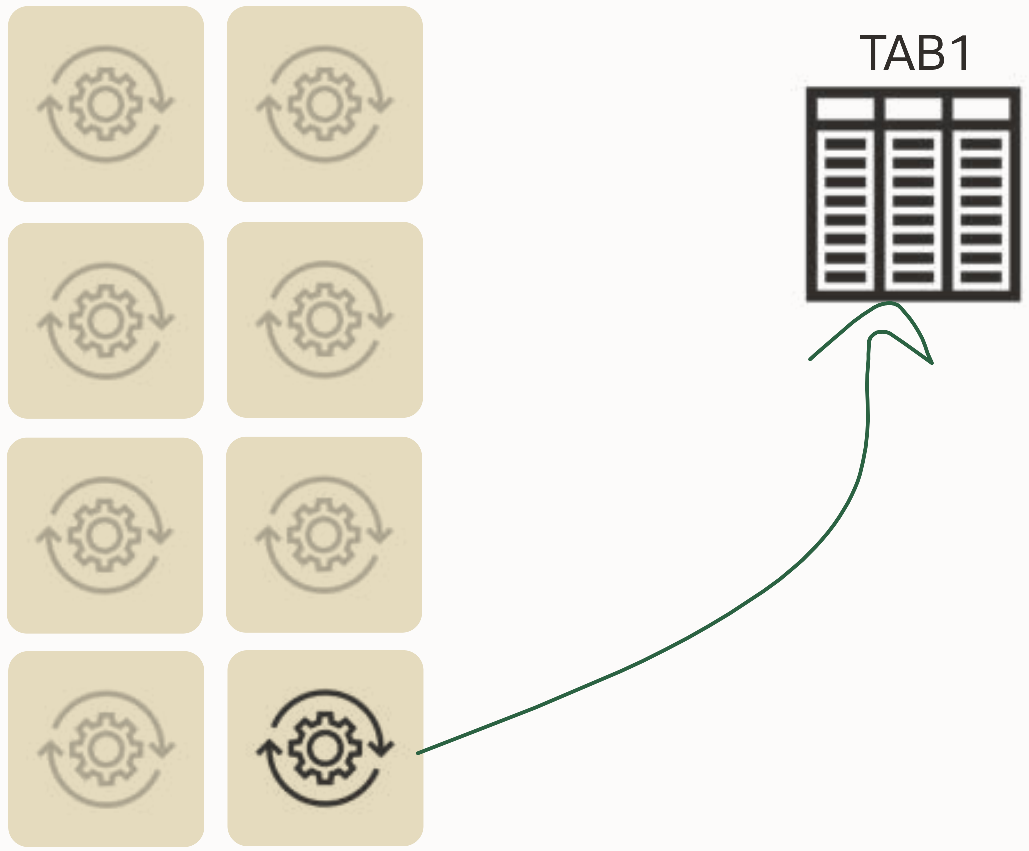
No, not possible.
So what's next?

LOB Export | Manipulating Statistics

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

LOB Export | Parallel Degree

Relief! Workers do PQ now!



```
Worker 2 Status:
  Process Name: DW01
  State: EXECUTING
  Object Schema: HUGO
  Object Name: TAB1
  Object Type: SCHEMA_EXPORT/...
  Completed Objects: 1
  Total Objects: 1
  Completed Rows: 85
  Worker Parallelism: 7
```

How about another approach …

LOB Export | ESTIMATE=BLOCKS

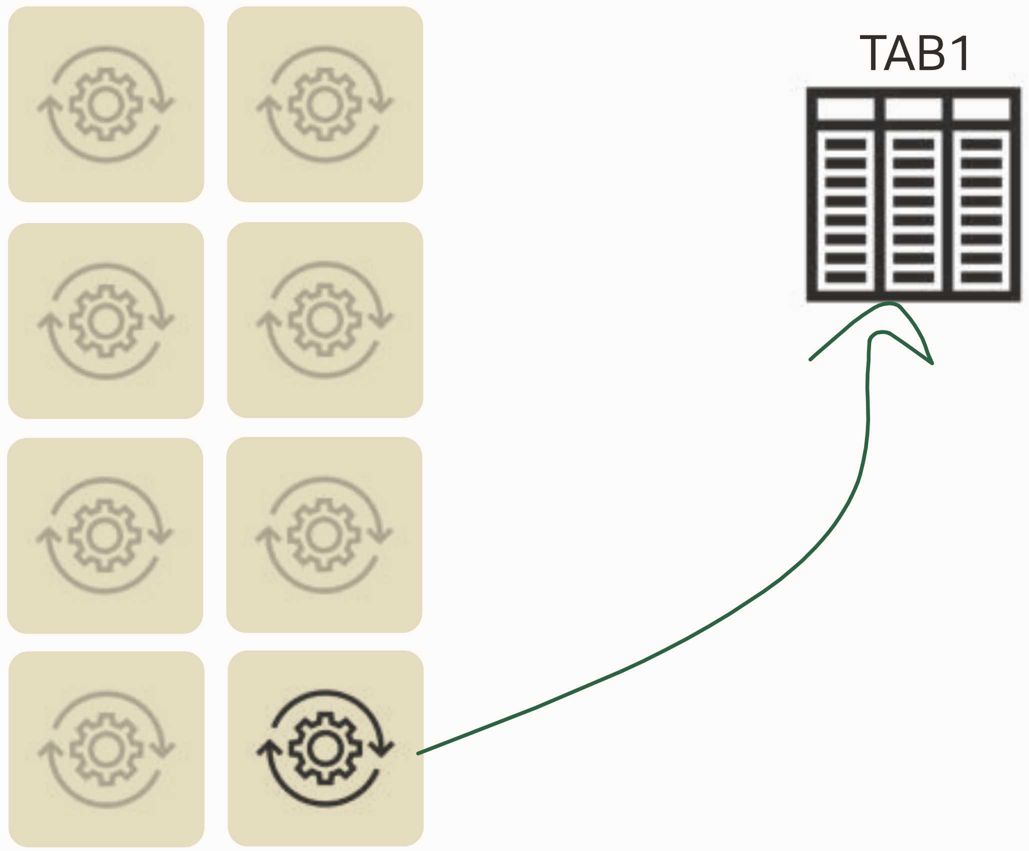
```
expdp hugo/oracle ESTIMATE=BLOCKS…
```

```
12-SEP-23 15:50:30.288: W-7 Startup took 0 seconds
12-SEP-23 15:50:31.409: W-1 Processing object type SCHEMA_EXPORT/TABLE/TABLE_DATA
12-SEP-23 15:50:31.735: W-1 .  estimated "HUGO"."TAB1”            10.24 GB
12-SEP-23 15:50:31.735: W-1 .  estimated "HUGO"."T1”                 11 MB
12-SEP-23 15:50:31.735: W-1 .  estimated "HUGO"."T4"                  7 MB
12-SEP-23 15:50:31.735: W-1 .  estimated "HUGO"."T2"                  4 MB
12-SEP-23 15:50:31.735: W-1 .  estimated "HUGO"."T5"                256 KB
12-SEP-23 15:50:31.735: W-1 .  estimated "HUGO"."T3”                 64 KB
.
.
.
```

Tech Tip: Make sure you are on 19.18 or later with the Data Pump Bundle Patch installed!

LOB Export | ESTIMATE=BLOCKS

Relief! Workers do PQ now!



```
Worker 2 Status:
  Process Name: DW01
  State: EXECUTING
  Object Schema: HUGO
  Object Name: TAB1
  Object Type: SCHEMA_EXPORT/...
  Completed Objects: 1
  Total Objects: 1
  Completed Rows: 85
  Worker Parallelism: 7
```

How do we get more workers to export data?

Boost parallelism by using partitioned tables

LOB Export | Which Approach is Better?

Faking Statistics

- Must be done for each table
- Requires testing to get best result
- Could be overwritten by stats gathering

ESTIMATE=BLOCKS

- Just one parameter for the whole export
- Estimate phase adds time to export
- Requires patch applied in 19c

We are working on an approach that combines the best of both. Stay tuned to the upgrade blog!

LOB Export | What if you still have BasicFiles LOBs?

Exporting

- Multiple Data Pump jobs in parallel exporting subsets of rows

```
expdp parallel=1 table=t1 query="where <subset 1>"
expdp parallel=1 table=t1 query="where <subset 2>"
expdp parallel=1 table=t1 query="where <subset 3>"
expdp parallel=1 table=t1 query="where <subset 4>"
```

Importing

- Convert to SecureFile LOBs

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

Pro Tip: Blog post with examples

Tips and tricks

if you remember only **one thing**

Install the Data Pump Bundle Patch

- Contains 166 bug fixes in 19.21.0
- Download from MOS 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

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"

Data Pump is hanging - what's going on?

- How to troubleshoot

Attach to a running job and use the interactive command mode

```
$ expdp user/password@alias ...

Export: Release 23.0.0.0.0 - Production on Tue Oct 31 14:56:06 2023
Version 23.3.0.23.09

Copyright (c) 1982, 2023, Oracle and/or its affiliates.  All rights reserved.
Connected to: Oracle Database 23c EE High Perf Release 23.0.0.0.0 - Production
31-OCT-23 14:56:13.420: Starting "SYSTEM"."SYS_EXPORT_FULL_01"
31-OCT-23 14:56:13.799: W-1 Startup on instance 1 took 0 seconds
31-OCT-23 14:56:30.550: W-2 Startup on instance 1 took 0 seconds
31-OCT-23 14:56:38.519: W-3 Startup on instance 1 took 0 seconds
31-OCT-23 14:56:38.529: W-4 Startup on instance 1 took 0 seconds
```

```
$ expdp user/password@alias attach=SYSTEM.SYS_EXPORT_FULL_01

Export> status

...

Worker 1 Status:
  Instance ID: 1
  Instance name: CDB23
  Host name: dbs23
  Object start time: Tuesday, 14 November, 2023 9:22:30
  Object status at: Tuesday, 14 November, 2023 9:30:35
  Process Name: DW00
  State: EXECUTING
  Object Schema: APPS
  Object Name: AP_INVOICE_DISTRIBUTIONS_PKG
  Object Type: DATABASE_EXPORT/SCHEMA/PACKAGE_BODIES/PACKAGE/PACKAGE_BODY
  Completed Objects: 1,938
  Worker Parallelism: 1
```

Monitor Progress of Data Pump Jobs

```
-- Assuming user performing operation is HUGO
-- What object types are left?
select unique object_path_seqno, object_type from hugo.sys_export_schema_01 where process_order > 0
AND processing_state = 'R' and processing_status = 'C';

-- What's left for the current object?
-- opject_path_seqno obtained from above query
select object_schema, object_name from hugo.sys_export_schema_01 where process_order > 0 and
processing_state = 'R' and processing_status = 'C' and object_path_seqno = 67;

-- Get metrics on exported/imported data - how many objects are already processed,
-- are still to be processed and are excluded from processing
select sum(dump_orig_length), processing_state from "HUGO"."SYS_EXPORT_SCHEMA_01" where
process_order > 0 and duplicate = 0 and object_type = 'TABLE_DATA' group by processing_state;
```

How to trace Data Pump jobs

- MOS Doc ID 286496.1

```
-- 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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exec dbms_workload_repository.create_snapshot;
@?/rdbms/admin/awrrpt
```

Data Pump Trace

Collect:

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

Thank You