12 Conventional and Direct Path Loads

SQL*Loader provides the option to load data using a conventional path load method, and a direct path load method.

- Data Loading Methods
  SQL*Loader can load data by using either a convention path load, or a direct path load.
- Loading ROWID Columns
  In both conventional path and direct path, you can specify a text value for a `ROWID` column.
- Conventional Path Loads
  Learn what a SQL*Loader conventional path load is, when and how to use it to pass data, and what restrictions apply to this feature.
- Direct Path Loads
  Learn what a SQL*Loader direct path load is, when and how to use it to pass data, and what restrictions apply to this feature.
- Automatic Parallel Load of Table Data with SQL*Loader
- Loading Modes and Options for Automatic Parallel Loads
  Learn about the loading modes and options for automatic parallel loads of sharded and non sharded tables for both conventional and direct path loads using SQL*Loader.
- Using Direct Path Load
  Learn how you can use the SQL*Loader direct path load method for loading data.
- Optimizing Performance of Manual Direct Path Loads
  If you choose to configure direct path loads manually, then learn how to enable your SQL*Loader direct path loads to run faster, and to use less space.
- Optimizing Direct Path Loads on Multiple-CPU Systems
  If you are performing direct path loads on a multiple-CPU system, then SQL*Loader uses multithreading by default. A multiple-CPU system in this case is defined as a single system that has two or more CPUs.
- Avoiding Index Maintenance
  For both the conventional path and the direct path, SQL*Loader maintains all existing indexes for a table.
- Direct Path Loads, Integrity Constraints, and Triggers
  There can be differences between how you set triggers with direct path loads, compared to conventional path loads
- Optimizing Performance of Direct Path Loads
  Learn how to enable your SQL*Loader direct path loads to run faster, and to use less space.
- General Performance Improvement Hints
  Learn how to enable general performance improvements when using SQL*Loader with parallel data loading.

Related Topics

- SQL*Loader Case Studies
  To learn how you can use SQL*Loader features, you can run a variety of case studies that Oracle provides.

12.1 Data Loading Methods

SQL*Loader can load data by using either a convention path load, or a direct path load.

A conventional path load runs SQL `INSERT` statements to populate tables in Oracle Database. A direct path load eliminates much of the Oracle Database overhead by formatting Oracle data blocks, and then writing the data blocks directly to the database files. A direct load does not compete with other users for database resources, so it can usually load data at near disk speed.

The tables that you want to be loaded must already exist in the database. SQL*Loader never creates tables. It loads existing tables that either already contain data, or that are empty.

The following privileges are required for a load:

- You must have `INSERT` privileges on the table to be loaded.
- You must have `DELETE` privileges on the table that you want to be loaded, when using the `REPLACE` or `TRUNCATE` option to empty old data from the table before loading the new data in its place.

Related Topics

- Conventional Path Load
  With conventional path load (the default), SQL*Loader uses the SQL `INSERT` statement and a bind array buffer to load data into database tables.
- Direct Path Loads
  Learn what a SQL*Loader direct path load is, when and how to use it to pass data, and what restrictions apply to this feature.

12.2 Loading ROWID Columns

In both conventional path and direct path, you can specify a text value for a `ROWID` column.

This is the same text you get when you perform a `SELECT ROWID FROM table_name` operation. The character string interpretation of the `ROWID` is converted into the `ROWID` type for a column in a table.

12.3 Conventional Path Loads

Learn what a SQL*Loader conventional path load is, when and how to use it to pass data, and what restrictions apply to this feature.

- Conventional Path Load
  With conventional path load (the default), SQL*Loader uses the SQL `INSERT` statement and a bind array buffer to load data into database tables.
- When to Use a Conventional Path Load
  To determine when you should use conventional path load instead of direct path load, review the options for your use case scenario.
- Conventional Path Load of a Single Partition
  SQL*Loader uses the partition-extended syntax of the `INSERT` statement.

12.3.1 Conventional Path Load

With conventional path load (the default), SQL*Loader uses the SQL `INSERT` statement and a bind array buffer to load data into database tables.

When SQL*Loader performs a conventional path load, it competes equally with all other processes for buffer resources. Using this method can slow the load significantly. Extra overhead is added as SQL statements are generated, passed to Oracle Database, and executed.

Oracle Database looks for partially filled blocks and attempts to fill them on each insert. Although appropriate during normal use, this method can slow bulk loads dramatically.

Related Topics

- Discontinued Conventional Path Loads
  In conventional path loads, if only part of the data is loaded before the data is discontinued, then only data processed up to the time of the last commit is loaded.

12.3.2 When to Use a Conventional Path Load

To determine when you should use conventional path load instead of direct path load, review the options for your use case scenario.

If load speed is most important to you, then you should use direct path load because it is faster than conventional path load. However, certain restrictions on direct path loads can require you to use a conventional path load. You should use a conventional path load in the following situations:

- When accessing an indexed table concurrently with the load, or when applying inserts or updates to a nonindexed table concurrently with the load

  Note: To use a direct path load (except for parallel loads), SQL*Loader must have exclusive write access to the table and exclusive read/write access to any indexes.
- When loading data into a clustered table

  Reason: A direct path load does not support loading of clustered tables.
- When loading a relatively small number of rows into a large indexed table

  Reason: During a direct path load, the existing index is copied when it is merged with the new index keys. If the existing index is very large and the number of new keys is very small, then the index copy time can offset the time saved by a direct path load.
- When loading a relatively small number of rows into a large table with referential and column-check integrity constraints

  Reason: Because these constraints cannot be applied to rows loaded on the direct path, they are disabled for the duration of the load. Then they are applied to the whole table when the load completes. The costs could outweigh the savings for a very large table and a small number of new rows.
- When loading records, and you want to ensure that a record is rejected under any of the following circumstances:
  - If the record causes an Oracle error upon insertion
  - If the record is formatted incorrectly, so that SQL*Loader cannot find field boundaries
  - If the record violates a constraint, or a record tries to make a unique index non-unique

12.3.3 Conventional Path Load of a Single Partition

SQL*Loader uses the partition-extended syntax of the `INSERT` statement.

By definition, a conventional path load uses SQL `INSERT` statements. During a conventional path load of a single partition, SQL*Loader uses the partition-extended syntax of the `INSERT` statement, which has the following form:

```
INSERT INTO TABLE T PARTITION (P) VALUES ...
```

The SQL layer of the Oracle kernel determines if the row being inserted maps to the specified partition. If the row does not map to the partition, then the row is rejected, and the SQL*Loader log file records an appropriate error message.

12.4 Direct Path Loads

Learn what a SQL*Loader direct path load is, when and how to use it to pass data, and what restrictions apply to this feature.

- About SQL*Loader Direct Path Load
  The SQL*Loader direct path load option uses the direct path API to pass the data to be loaded to the load engine in the server.
- Loading into Synonyms
  You can use SQL*Loader to load data into a synonym for a table during a direct path load, but the synonym must point directly either to a table, or to a view on a simple table.
- Field Defaults on the Direct Path
  Default column specifications defined in the database are not available when you use direct path loading.
- Integrity Constraints
  All integrity constraints are enforced during direct path loads, although not necessarily at the same time.
- When to Use a Direct Path Load
  Learn under what circumstances you should run SQL*Loader with direct path load.
- Restrictions on a Direct Path Load of a Single Partition
  When you want to use a direct path load of a single partition, the partition that you specify for direct path load must meet additional requirements.
- Restrictions on Using Direct Path Loads
  To use the direct path load method, your tables and segments must meet certain requirements. Some features are not available with Direct Path Loads.
- Advantages of a Direct Path Load
  Direct path loads typically are faster than using conventional path loads.
- Direct Path Load of a Single Partition or Subpartition
  During a direct path load of a single partition, SQL*Loader uses the partition-extended syntax of the `LOAD` statement.
- Direct Path Load of a Partitioned or Subpartitioned Table
  When loading a partitioned or subpartitioned table, SQL*Loader partitions the rows and maintains indexes (which can also be partitioned).

- Data Conversion During Direct Path Loads
  During a SQL*Loader direct path load, data conversion occurs on the client side, rather than on the server side.

12.4.1 About SQL*Loader Direct Path Load

The SQL*Loader direct path load option uses the direct path API to pass the data to be loaded to the load engine in the server.

When you use the direct path load feature of SQL*Loader, then instead of filling a bind array buffer and passing it to Oracle Database with a SQL `INSERT` statement, a direct path load uses the direct path API to pass the data to be loaded to the load engine in the server. The load engine builds a column array structure from the data passed to it.

The direct path load engine uses the column array structure to format Oracle Database data blocks, and to build index keys. The newly formatted database blocks are written directly to the database (multiple blocks per I/O request using asynchronous writes if the host platform supports asynchronous I/O).

Internally, multiple buffers are used for the formatted blocks. While one buffer is being filled, one or more buffers are being written if asynchronous I/O is available on the host platform. Overlapping computation with I/O increases load performance.

Related Topics

- Discontinued Direct Path Loads
  In a direct path load, the behavior of a discontinued load varies depending on the reason the load was discontinued.

12.4.2 Loading into Synonyms

You can use SQL*Loader to load data into a synonym for a table during a direct path load, but the synonym must point directly either to a table, or to a view on a simple table.

Note the following restrictions:

- Direct path mode cannot be used if the view is on a table that has either user-defined types, or XML data.
- In direct path mode, a view cannot be loaded using a SQL*Loader control file that contains SQL expressions.

12.4.3 Field Defaults on the Direct Path

Default column specifications defined in the database are not available when you use direct path loading.

Fields for which default values are desired must be specified with the `DEFAULTIF` clause. If a `DEFAULTIF` clause is not specified and the field is `NULL`, then a null value is inserted into the database.

12.4.4 Integrity Constraints

All integrity constraints are enforced during direct path loads, although not necessarily at the same time.

`NOT NULL` constraints are enforced during the SQL*Loader load. Records that fail these constraints are rejected.

UNIQUE constraints are enforced both during and after the load. A record that violates a UNIQUE constraint is not rejected (the record is not available in memory when the constraint violation is detected).

Integrity constraints that depend on other rows or tables, such as referential constraints, are disabled before the direct path load and must be reenabled afterwards. If REENABLE is specified, then SQL*Loader can reenable them automatically at the end of the load. When the constraints are reenabled, the entire table is checked. Any rows that fail this check are reported in the specified error log.

Related Topics

- Direct Path Loads, Integrity Constraints, and Triggers
  There can be differences between how you set triggers with direct path loads, compared to conventional path loads

12.4.5 When to Use a Direct Path Load

Learn under what circumstances you should run SQL*Loader with direct path load.

If you are not restricted by views, field defaults, or integrity constraints, then then you should use a direct path load in the following circumstances:

- You have a large amount of data to load quickly. A direct path load can quickly load and index large amounts of data. It can also load data into either an empty or nonempty table.
- You want to load data in parallel for maximum performance.

12.4.6 Restrictions on a Direct Path Load of a Single Partition

When you want to use a direct path load of a single partition, the partition that you specify for direct path load must meet additional requirements.

In addition to the previously listed restrictions, loading a single partition has the following restrictions:

- The table that the partition is a member of cannot have any global indexes defined on it.
- Enabled referential and check constraints on the table that the partition is a member of are not allowed.
- Enabled triggers are not allowed.

12.4.7 Restrictions on Using Direct Path Loads

To use the direct path load method, your tables and segments must meet certain requirements. Some features are not available with Direct Path Loads.

The following conditions must be satisfied for you to use the direct path load method:

- Tables that you want to load cannot be clustered.
- Tables that you want to load cannot have Oracle Virtual Private Database (VPD) policies active on INSERT.
- Segments that you want to load cannot have any active transactions pending.

  To check for active transactions, use the Oracle Enterprise Manager command MONITOR TABLE to find the object ID for the tables that you want to load. Then use the command MONITOR LOCK to see if there are any locks on the tables.

- For Oracle Database releases earlier than Oracle9*i*, you can perform a SQL*Loader direct path load only when the client and server are the same release. This restriction also means that you cannot perform a direct path load of Oracle9*i* data into an earlier Oracle Database release. For example, you cannot use direct path load to load data from Oracle Database 9*i* Release 1 (9.0.1) into an Oracle 8*i* (8.1.7) Oracle Database.

  Beginning with Oracle Database 9*i*, you can perform a SQL*Loader direct path load when the client and server are different releases. However, both releases must be at least Oracle Database 9i Release 1 (9.0.1), and the client release must be the same as or lower than the server release. For example, you can perform a direct path load from an Oracle Database 9*i* Release 1 (9.0.1) database into Oracle Database 9*i* Release 2 (9.2). However, you cannot use direct path load to load data from Oracle Database 10g into an Oracle Database 9*i* release.

The following features are not available with direct path load:

- Loading `BFILE` columns
- Use of `CREATE SEQUENCE` during the load. This is because in direct path loads there is no SQL being generated to fetch the next value, because direct path does not generate `INSERT` statements.

12.4.8 Advantages of a Direct Path Load

Direct path loads typically are faster than using conventional path loads.

A direct path load is faster than the conventional path for the following reasons:

- Partial blocks are not used, so no reads are needed to find them, and fewer writes are performed.
- SQL*Loader does not need to run any SQL `INSERT` statements; therefore, the processing load on Oracle Database is reduced.
- A direct path load calls on Oracle Database to lock tables and indexes at the start of the load, and release those locks when the load is finished. A conventional path load issues an Oracle Database call once for each array of rows to process a SQL `INSERT` statement.
- A direct path load uses multiblock asynchronous I/O for writes to the database files.
- During a direct path load, processes perform their own write I/O, instead of using the Oracle Database buffer cache. This process method minimizes contention with other Oracle Database users.
- The sorted indexes option available during direct path loads enables you to presort data using high-performance sort routines that are native to your system or installation.
- When a table that you specify to load is empty, the presorting option eliminates the sort and merge phases of index-building. The index is filled in as data arrives.
- Protection against instance failure does not require redo log file entries during direct path loads. Therefore, no time is required to log the load when:
  - Oracle Database has the SQL `NOARCHIVELOG` parameter enabled
  - The SQL*Loader `UNRECOVERABLE` clause is enabled
  - The object being loaded has the SQL `NOLOGGING` parameter set

Related Topics

- Instance Recovery and Direct Path Loads
  Because SQL*Loader writes directly to the database files, all rows inserted up to the last data save will automatically be present in the database files if the instance is restarted.

12.4.9 Direct Path Load of a Single Partition or Subpartition

During a direct path load of a single partition, SQL*Loader uses the partition-extended syntax of the `LOAD` statement.

When loading a single partition of a partitioned or subpartitioned table, SQL*Loader partitions the rows, and rejects any rows that do not map to the partition or subpartition specified in the SQL*Loader control file. Local index partitions that correspond to the data partition or subpartition being loaded are maintained by SQL*Loader. Global indexes are not maintained on single partition or subpartition direct path loads. During a direct path load of a single partition, SQL*Loader uses the partition-extended syntax of the `LOAD` statement, which has either of the following forms:

```
LOAD INTO TABLE T PARTITION (P) VALUES ...

LOAD INTO TABLE T SUBPARTITION (P) VALUES ...
```

While you are loading a partition of a partitioned or subpartitioned table, you are also allowed to perform DML operations on, and direct path loads of, other partitions in the table.

Although a direct path load minimizes database processing, to initialize and then finish the load, several calls to Oracle Database are required at the beginning and end of the load. Also, certain DML locks are required during load initialization. When the load completes, these DML locks are released. The following operations occur during the load:

- Index keys are built and put into a sort
- Space management routines are used to obtain new extents, when needed, and to adjust the upper boundary (high-water mark) for a data savepoint.

For more information about protecting data, see "Using Data Saves to Protect Against Data Loss.

Related Topics

- Using Data Saves to Protect Against Data Loss
  When you have a savepoint, if you encounter an instance failure during a SQL*Loader load, then use the `SKIP` parameter to continue the load.

12.4.10 Direct Path Load of a Partitioned or Subpartitioned Table

When loading a partitioned or subpartitioned table, SQL*Loader partitions the rows and maintains indexes (which can also be partitioned).

Note that a direct path load of a partitioned or subpartitioned table can be quite resource-intensive for tables with many partitions or subpartitions.

Note:

If you are performing a direct path load into multiple partitions and a space error occurs, then the load is rolled back to the last commit point. If there was no commit point, then the entire load is rolled back. This ensures that no data encountered after the space error is written out to a different partition.

You can use the `ROWS` parameter to specify the frequency of the commit points. If the `ROWS` parameter is not specified, then the entire load is rolled back.

12.4.11 Data Conversion During Direct Path Loads

During a SQL*Loader direct path load, data conversion occurs on the client side, rather than on the server side.

As an implication of client side data conversion, this means that NLS parameters in the database initialization parameter file (server-side language handle) will not be used. To override this behavior, you can specify a format mask in the SQL*Loader control file that is equivalent to the setting of the NLS parameter in the initialization parameter file, or you can set the appropriate environment variable. For example, to specify a date format for a field, you can either set the date format in the SQL*Loader control file, as shown in "Setting the Date Format in the SQL*Loader Control File"), or you can set an `NLS_DATE_FORMAT` environment variable, as shown in "Setting an `NLS_DATE_FORMAT` Environment Variable." .

Example 12-1 Setting the Date Format in the SQL*Loader Control File

```
LOAD DATA
INFILE 'data.dat'
INSERT INTO TABLE emp
FIELDS TERMINATED BY "|"
(
EMPNO NUMBER(4) NOT NULL,
ENAME CHAR(10),
JOB CHAR(9),
MGR NUMBER(4),
HIREDATE DATE 'YYYYMMDD',
SAL NUMBER(7,2),
COMM NUMBER(7,2),
DEPTNO NUMBER(2)
)
```

Example 12-2 Setting an `NLS_DATE_FORMAT` Environment Variable

On Unix Bourne or Korn shell:

```
% NLS_DATE_FORMAT='YYYYMMDD'
% export NLS_DATE_FORMAT
```

On Unix C shell (`csh`):

```
%setenv NLS_DATE_FORMAT='YYYYMMDD'
```

12.5 Automatic Parallel Load of Table Data with SQL*Loader

Starting with Oracle Database 23ai, you no longer need to divide data files into multiple smaller files for SQL*Loader direct path or conventional parallel loading. The SQL*Loader client can perform parallel loading automatically.
In releases before Oracle Database 23ai, enabling parallel loads with SQL*Loader (`sqlldr`) of large data files to reduce load times required you to break up a large data file into separate parts, and then run SQL*Loader multiple times for each section of the large data files that you wanted to load, using the `PARALLEL=TRUE` command option each time.

Automatic parallel loads simplify this process. Instead of preparing your large data files manually for parallel loads and setting the `PARALLEL` parameter, you can perform the same task automatically by running SQL*Loader with just one command, setting the degree of parallelism using the `DEGREE_OF_PARALLELISM` parameter. The `DEGREE_OF_PARALLELISM` parameter sets the number of `sqlldr` client loader threads.

Also, you can use the SQL*Loader Instant Client for Oracle Database 23ai to perform the same automatic parallel loads to earlier releases of Oracle Database, which makes this same Oracle Database 23ai capability available through the SQL*Loader client to your earlier release databases. Automatic parallel loading is supported for a single table only. Multiple `INTO` clauses are not supported.

To enable parallel loading of tables with SQL*Loader, set the SQL*Loader parameter `DEGREE_OF_PARALLELISM` to a numeric value to set the degree of parallel threads. For data file formats that can support being divided into multiple granules of data, such as `csv` files, the files will be divided for parallel reading and loading. If a large file cannot be split into multiple granules, but instead must be read by one reader, then that reader assigns records to multiple loaders for parallel loading. For example, it may not be possible to split a terabyte-size file that has a complex character set into multiple granules, so that file is read by one reader. However, that reader assigns records to multiple loaders, so the file is loaded in parallel. If files with complex character sets are manually divided into input multiple files, then they can be processed in parallel. Each file will be treated as one granule.

If you load a sharded table with SQL*Loader, then multiple threads are used to read input data files and load each record into the table on the appropriate shard.

When loading sharded tables in parallel, the SQL*Loader client automatically determines the correct shard to load for each input record, and assigns each record to the appropriate target loader thread. Both conventional and direct path can be used to load shards. If there are no indexes present on the table, then each sharded table can also be loaded using direct path with the existing `PARALLEL` option. For sharded tables, Oracle recommends that you let SQL*Loader set `DEGREE_OF_PARALLELISM`. Direct path can be used if no indexes are present, and `DEGREE_OF_PARALLELISM` is greater then the number of shards.

Example 12-3   Automatic Parallel Loading of a Single Table

Suppose you have a 30 GB data file, called `t.dat` that you want to load more quickly by using a direct path load with parallelism enabled.

In the following command, user `scott` starts SQL*Loader using the `DIRECT=TRUE` parameter option, and sets the number of parallel threads to 5 using `DEGREE_OF_PARALLELISM=5`:

```
sqlldr scott/tiger t.ctl direct=true degree_of_parallelism=5
```

The command starts five reader/loader threads, and the table input file is split into five granules for parallel reading and loading.

Example 12-4 Automatic Parallel Loading of a Sharded Table

Suppose you have a sharded table and you want to load a data file named `t.dat`.

The following is an example where the number of loader threads will default to the number of shards:

```
sqlldr scott/tiger t.ctl gsm_name=example.gsm.name gsm_host=example
gsm_port=4338
```

If the value of `DEGREE_OF_PARALLELISM` is greater than the number of shards, then each shard is loaded using multiple loader threads. If `PARALLEL=FALSE`, then the number of loader threads used will be trimmed to the number of shards.

Assuming the number of shards is 100, the following command results in SQL*Loader using 4 passes over data files to load all of the shards (this assumes the three required `gsm` parameters have been specified in the control file options clause):

```
 sqlldr scott/tiger t.ctl degree_of_parallelism=25
```

Assuming the number of shards is 10, the following command results in SQL*Loader using 2 threads for each shard's table, where the GSM host name (`gsm_host`) is *`example`*, the GSM name is `example.gsm.name`, and the GSM port number (`gsm_port`) is *`example-port-number`*

```
sqlldr scott/tiger t.ctl degree_of_parallelism=20 gsm_name=example.gsm.name
gsm_host=example gsm_port=example-port-number
```

To increase the read buffer when loading shards, you can use the SQL*Loader `READSIZE` parameter to set a higher buffer value.

Note:

When you run SQL*Loader with `PARALLEL` set to `TRUE` for sharded tables, index maintenance is not supported. The default is to support local index maintenance, in which case only 1 thread will be used per shard.

12.6 Loading Modes and Options for Automatic Parallel Loads

Learn about the loading modes and options for automatic parallel loads of sharded and non sharded tables for both conventional and direct path loads using SQL*Loader.

- Loading Modes for Automatic Parallel Loads
  Starting with Oracle Database 23ai, SQL*Loader uses three modes for parallel loads of data files.
- Non-Sharded Automatic Parallel Loading Modes for SQL*Loader
  Learn about how SQL*Loader processes non-sharded tables to obtain the fastest loads automatically for your data files.

- Sharded Automatic Parallel Loading Modes for SQL*Loader
  Automatic SQL*Loader parallel loads of sharded tables are performed automatically using the modes described here.

12.6.1 Loading Modes for Automatic Parallel Loads

Starting with Oracle Database 23ai, SQL*Loader uses three modes for parallel loads of data files.

In an automatic parallel direct path load, SQL*Loader automatically divides data files into granules, similar to the way that network traffic is divided into packets. SQL*Loader automatically divides input files into smaller granules for parallel loading, when possible, using parallel readers and loaders. SQL*Loader tracks each granule of data, and optimizes the transmission of that data from the source to the target system, based on the number of readers and the number of loaders, and the loading options available for the table data. The SQL*Loader log file records which modes are used, and how the readers performed the parallel loads.

You can use the SQL*Loader parameter CREDENTIAL to provide credentials to enable read access to object stores. Parallel loading from the object store is supported.

The `DEGREE_OF_PARALLELISM` parameter sets the number of `sqlldr` client loader threads.

SQL*Loader by default assumes `OPTIMIZE_PARALLEL=TRUE`. SQL*Loader defaults to the fastest possible mode for automatic parallel loads. The available modes also depend on whether the data are loaded to non-sharded or sharded tables.

The three modes of operation SQL*Loader uses are as follows:

- Mode One: Each thread of the SQL*Loader client is a reader and a loader. This mode is not available for sharded tables.
- Mode Two: One or more SQL*Loader readers assign records to loaders. When there are multiple readers, each data file is split into granules, and each granule is handled by a reader thread, which assigns the records to the appropriate loader thread. If it is not possible to break the file into multiple granules to read the file in parallel, then files are treated as one granule only. Records from each granule are loaded by multiple loader threads.
- Mode Three: Data files are not divided into granules. Instead, all threads read all the data, but only load selected records. When it is not possible to use one of the faster methods, SQL*Loader defaults to Mode Three.

12.6.2 Non-Sharded Automatic Parallel Loading Modes for SQL*Loader

Learn about how SQL*Loader processes non-sharded tables to obtain the fastest loads automatically for your data files.

> **Note:**
>
> Performance of automatic parallel loading should be similar to the previous method of manually splitting up files and issuing multiple concurrent direct path loads with `parallel=true`.

Mode One: Readers/Loaders (with granules)

With non-Sharded tables, when `OPTIMIZE_PARALLEL` is set to `TRUE`, each thread of the SQL*Loader client is a reader and a loader. SQL*Loader divides up data files into granules of data , and the threads parse and load these granules. This is the fastest method for parallel loading of non-sharded tables.

`DEGREE_OF_PARALLELISM` determines the number of reader/loader threads. The log file records these threads as `reader/loader` threads. `READER_COUNT` is ignored in this mode.

Mode Two: Separate Readers/Loaders (with separate granules)

For non-sharded tables, when you set `OPTIMIZE_PARALLEL` to `TRUE`, but Mode One cannot be used, the default is Mode Two. In Mode Two, there are *m* readers and *n* loaders. The value of m is determined by `READER_COUNT`, and the value of n is determined by the value for `DEGREE_OF_PARALLELISM`. Degree of parallelism is required to be specified only for non-sharded tables.

`DEGREE_OF_PARALLELISM` determines the number of loader threads. `READER_COUNT` determines the number of readers. This is the fastest mode when loading sharded tables in parallel.

In Mode Two, reader and loader threads appear separately in the log file, either as `reader` or as `loader` threads. When loading non-sharded tables, this is the non-optimized mode.

If the statistics in the log file show excess time for loaders waiting for readers, then increasing the reader count may speed up the load. If excess time for readers waiting for loaders, increasing the number of loaders may speed up the load. Increasing `READSIZE` may also improve mode 2 performance.

Mode Three Reader/Loaders reading all files (no granules)

If Mode One or Mode Two cannot be used, then SQL*Loader defaults to Mode Three. In this mode, `reader/loader` threads must read through and analyze all data files, and load records as required for the parallel load. This the least optimized mode of parallel processing. This mode is required when loading delimited `LOB`s, because SQL*Loader must track the position within the `LOBFILES` as it is processing records.

Example 12-5   Mode Two Nonsharded Parallel Load Log File

```
SQL*Loader: Release 23.0.0.0.0 - Development on Thu Sep 22 11:54:31 2022
Version 23.1.0.0.0

Control File:   fact_page.ctl
Data File:      /scratch/fact_page.dat
   Bad File:     fact_page.bad
   Discard File:  none specified

  (Allow all discards)

Number to load: ALL
Number to skip: 0
Errors allowed: 50
Continuation:    none specified
Path used:      Direct - with parallel option.

Load is UNRECOVERABLE; invalidation redo is produced.
```

```
Table L_FACT_PAGE, loaded from every logical record.
Insert option in effect for this table: APPEND TRAILING NULLCOLS option in
effect

Column Name                  Position    Len    Term   Encl    Datatype
--------------------         ----------  -----  ----   ----  ----------------------
PAGE_ID                      FIRST       50      |           CHARACTER
SESSION_ID                   NEXT        50      |           CHARACTER
IP_ID                        NEXT        50      |           CHARACTER
DATE_ID                      NEXT        *       |           DATE YYYY-MM-DD
SECOND_ID                    NEXT        50      |           CHARACTER
LOCATION_ID                  NEXT        50      |           CHARACTER
SERVER_ID                    NEXT        50      |           CHARACTER
REF_PAGE_ID                  NEXT        50      |           CHARACTER
RET_CODE_ID                  NEXT        50      |           CHARACTER
PAGE_KEY_ID                  NEXT        50      |           CHARACTER
PAGE_NAME                    NEXT        50      |           CHARACTER
REFER_PAGE_NAME              NEXT        50      |           CHARACTER
REFER_URL                    NEXT        250     |           CHARACTER
COUNT_1                      NEXT        50      |           CHARACTER
NUM_BYTES                    NEXT        50      |           CHARACTER
ENTRY_EXIT_FLAG              NEXT        50      |           CHARACTER
MEMBER_FLAG                  NEXT        50      |           CHARACTER
QUERY_ID                     NEXT        100     |           CHARACTER


   3 Total granules for all files to be loaded.


Table L_FACT_PAGE:
Reader/Loader: Thread 1
Granules/Files Assigned: 1
Rows Assigned: 3353354
Elapsed time reading input data:                     00:00:00.14
Elapsed time loading stream data:                    00:00:03.32
Average stream buffer size:                          497121
Total number of stream buffers loaded:               675

   3353354 Rows successfully loaded.
   0 Rows not loaded due to data errors.
   0 Rows not loaded because all WHEN clauses were failed.
   0 Rows not loaded because all fields were null.

   Date cache:
    Max Size:      1000
    Entries :         1
    Hits    :   3353353
    Misses  :         0

CPU time was:          00:00:10.03

Elapsed time loading stream data for this thread:    00:00:03.32
```

12.6.3 Sharded Automatic Parallel Loading Modes for SQL*Loader

Automatic SQL*Loader parallel loads of sharded tables are performed automatically using the modes described here.

Note:

Mode One is not available for sharded tables.

When loading shards, you must specify all three of the Oracle Global Service Manager shard director (`gsm`) parameters (`gsm_name`, `gsm_host` and `gsm_port`). The `DEGREE_OF_PARALLELISM` parameter is set automatically to the number of shards that are going to be loaded. The default is to load all shards. If SQL*Loader encounters a load problem with any individual shard, then SQL*Loader will continue to load the other shards. You can then review the log file to see which shards loaded successfully, and which shards failed, and resolve the issue. Use the `LOAD_SHARDS` parameter to load any shards that failed to load. SQL*Loader will ignore the shards that you do not list with `LOAD_SHARDS`. Setting `COMPRESS_STREAM=TRUE` can help speed up shard loading. For sharded tables, Oracle recommends that you let SQL*Loader set `DEGREE_OF_PARALLELISM`. Direct path can be used if no indexes are present, and `DEGREE_OF_PARALLELISM` is greater then the number of shards.

Mode Two: Reader/Loaders (with granules) for sharded tables

When `OPTIMIZE_PARALLEL` is set to `TRUE`, Mode Two is used. This is the fastest mode when loading sharded tables in parallel.

`DEGREE_OF_PARALLELISM` determines the number of loader threads. This option is set automatically to the number of shards that are to be loaded. The default is all shards. `READER_COUNT` determines the number of readers. The reader and loader threads appear separately in the log file, as `reader` or `loader` threads. When loading shards, you must specify `gsm_name`, `gsm_host` and `gsm_port`. If you set `DEGREE_OF_PARALLELISM` to a value lower than the number of shards, then SQL*Loader will perform multiple passes over the input data, until all shards are loaded. You can choose this option if the SQL*Loader client system cannot efficiently process a large number of threads.

If the statistics in the log file show excess time for loaders waiting for readers, then increasing the value of `READER_COUNT` may increase the load performance. If excess time for readers waiting for loaders, then increasing the number of loaders may increase the load performance. Increasing `READSIZE` may also improve Mode Two performance.

Mode Three Reader/Loaders reading all files (no granules) for sharded tables

If Mode Two cannot be used, then SQL*Loader defaults to Mode Three. In Mode Three, all `reader/loader` threads must read through and process all data files, and load records as required for the parallel load. This is the least optimized mode of parallel processing. This mode is required when loading delimited `LOB`s.

Example 12-6 Mode Two Sharded Parallel Load Log File

```
SQL*Loader: Release 23.0.0.0.0 - Development on Thu Jan 12 16:53:28 2023
Version 23.1.0.0.0

Copyright (c) 1982, 2023, Oracle and/or its affiliates.  All rights reserved.
```

```
Control File:   fact_page_shard.ctl
Data File:      /scratch/rphillip/fact_page.dat
   Bad File:     fact_page.bad
   Discard File:  none specified

  (Allow all discards)

Number to load: 1234
Number to skip: 0
Errors allowed: 50
Continuation:    none specified
Path used:      Direct

Table L_FACT_PAGE, loaded from every logical record.
Insert option in effect for this table: TRUNCATE TRAILING NULLCOLS option in
effect

Column Name           Position    Len   Term   Encl    Datatype
--------------------  ----------  ----- ----   ----  ---------------------
PAGE_ID               FIRST       50     |           CHARACTER
SESSION_ID            NEXT        50     |           CHARACTER
IP_ID                 NEXT        50     |           CHARACTER
DATE_ID               NEXT        *      |           DATE YYYY-MM-DD
SECOND_ID             NEXT        50     |           CHARACTER
LOCATION_ID           NEXT        50     |           CHARACTER
SERVER_ID             NEXT        50     |           CHARACTER
REF_PAGE_ID           NEXT        50     |           CHARACTER
RET_CODE_ID           NEXT        50     |           CHARACTER
PAGE_KEY_ID           NEXT        50     |           CHARACTER
PAGE_NAME             NEXT        50     |           CHARACTER
REFER_PAGE_NAME       NEXT        50     |           CHARACTER
REFER_URL             NEXT        250    |           CHARACTER
COUNT_1               NEXT        50     |           CHARACTER
NUM_BYTES             NEXT        50     |           CHARACTER
ENTRY_EXIT_FLAG       NEXT        50     |           CHARACTER
MEMBER_FLAG           NEXT        50     |           CHARACTER
QUERY_ID              NEXT        100    |           CHARACTER

   4 Total granules for all files to be loaded.


Loading the following shards (all):
shpool%1
shpool%11
shpool%21
shpool%31
shpool%41


Table L_FACT_PAGE:
Reader: Thread 2
Granules/Files Assigned: 1
Rows Assigned: 231
Elapsed time reading input data:                     00:00:00.04
```

```
   0 Rows not loaded due to data errors.
   0 Rows not loaded because all WHEN clauses were failed.
   0 Rows not loaded because all fields were null.

CPU time was:         00:00:00.03


Table L_FACT_PAGE:
Reader: Thread 1
Granules/Files Assigned: 1
Rows Assigned: 825
Elapsed time reading input data:                      00:00:00.04

   0 Rows not loaded due to data errors.
   0 Rows not loaded because all WHEN clauses were failed.
   0 Rows not loaded because all fields were null.

CPU time was:         00:00:00.05


Table L_FACT_PAGE:
Reader: Thread 4
Granules/Files Assigned: 1
Rows Assigned: 0
Elapsed time reading input data:                      00:00:00.01

   0 Rows not loaded due to data errors.
   0 Rows not loaded because all WHEN clauses were failed.
   0 Rows not loaded because all fields were null.

CPU time was:         00:00:00.03


Table L_FACT_PAGE:
Reader: Thread 3
Granules/Files Assigned: 1
Rows Assigned: 178
Elapsed time reading input data:                      00:00:00.02

   0 Rows not loaded due to data errors.
   0 Rows not loaded because all WHEN clauses were failed.
   0 Rows not loaded because all fields were null.

CPU time was:         00:00:00.03


Table L_FACT_PAGE:
Load Thread For Shard: shpool%41
   206 Rows successfully loaded.
   0 Rows not loaded due to data errors.
   0 Rows not loaded because all WHEN clauses were failed.
   0 Rows not loaded because all fields were null.

   Date cache:
    Max Size:      1000
    Entries :         1
    Hits    :       205
    Misses  :         0

   Partition L_FACT_PAGE_P11: 104 Rows loaded.
   Partition L_FACT_PAGE_P12: 102 Rows loaded.

CPU time was:         00:00:00.02

Elapsed time loading stream data for this thread:     00:00:00.01
Average stream buffer size:                           19969
Total number of stream buffers loaded:                1


Table L_FACT_PAGE:
Load Thread For Shard: shpool%21
   198 Rows successfully loaded.
   0 Rows not loaded due to data errors.
   0 Rows not loaded because all WHEN clauses were failed.
   0 Rows not loaded because all fields were null.

   Date cache:
    Max Size:      1000
    Entries :         1
    Hits    :       197
    Misses  :         0

   Partition L_FACT_PAGE_P7: 91 Rows loaded.
   Partition L_FACT_PAGE_P8: 107 Rows loaded.

CPU time was:         00:00:00.02

Elapsed time loading stream data for this thread:     00:00:00.01
Average stream buffer size:                           19077
Total number of stream buffers loaded:                1


Table L_FACT_PAGE:
Load Thread For Shard: shpool%1
   284 Rows successfully loaded.
   0 Rows not loaded due to data errors.
   0 Rows not loaded because all WHEN clauses were failed.
   0 Rows not loaded because all fields were null.

   Date cache:
    Max Size:      1000
    Entries :         1
    Hits    :       283
    Misses  :         0

   Partition L_FACT_PAGE_P1: 87 Rows loaded.
   Partition L_FACT_PAGE_P2: 104 Rows loaded.
   Partition L_FACT_PAGE_P3: 93 Rows loaded.

CPU time was:         00:00:00.02

Elapsed time loading stream data for this thread:     00:00:00.01
```

```
Average stream buffer size:                         27499
Total number of stream buffers loaded:              1


Table L_FACT_PAGE:
Load Thread For Shard: shpool%31
   203 Rows successfully loaded.
   0 Rows not loaded due to data errors.
   0 Rows not loaded because all WHEN clauses were failed.
   0 Rows not loaded because all fields were null.

   Date cache:
    Max Size:      1000
    Entries :         1
    Hits    :       202
    Misses  :         0

   Partition L_FACT_PAGE_P10: 109 Rows loaded.
   Partition L_FACT_PAGE_P9: 94 Rows loaded.

CPU time was:         00:00:00.02

Elapsed time loading stream data for this thread:     00:00:00.00
Average stream buffer size:                         19714
Total number of stream buffers loaded:              1


Table L_FACT_PAGE:
Load Thread For Shard: shpool%11
   343 Rows successfully loaded.
   0 Rows not loaded due to data errors.
   0 Rows not loaded because all WHEN clauses were failed.
   0 Rows not loaded because all fields were null.

   Date cache:
    Max Size:      1000
    Entries :         1
    Hits    :       342
    Misses  :         0

   Partition L_FACT_PAGE_P4: 102 Rows loaded.
   Partition L_FACT_PAGE_P5: 127 Rows loaded.
   Partition L_FACT_PAGE_P6: 114 Rows loaded.

CPU time was:         00:00:00.02

Elapsed time loading stream data for this thread:     00:00:00.00
Average stream buffer size:                         33089
Total number of stream buffers loaded:              1


Table L_FACT_PAGE:
Main Thread
Total Granules/Files Assigned: 4
   0 Rows not loaded due to data errors.
   0 Rows not loaded because all WHEN clauses were failed.
   0 Rows not loaded because all fields were null.

1234 Total rows for all shards successfully loaded.

Bind array size not used in direct path.
Column array  rows :    5000
Stream buffer bytes:  512000
Read   buffer bytes:41943040

Total logical records skipped:          0
Total logical records read:          1234
Total logical records rejected:         0
Total logical records discarded:        0
Direct path multithreading optimization is disabled

Run began on Thu Jan 12 16:53:28 2023
Run ended on Thu Jan 12 16:53:38 2023

Elapsed time was:     00:00:09.76
CPU time was:         00:00:00.30

Elapsed time for loader threads waiting for records:  00:00:00.30
Elapsed time for reader threads waiting for loaders:  00:00:00.30
Elapsed time reading input data:                      00:00:00.11
Elapsed time loading stream data:                     00:00:00.03
Average stream buffer size:                           23869
Total number of stream buffers loaded:                5



The following shards were successfully loaded:
Load successful for shard: shpool%1
Load successful for shard: shpool%11
Load successful for shard: shpool%21
Load successful for shard: shpool%31
Load successful for shard: shpool%41
```

Related Topics

- Using Oracle Data Pump to Migrate to a Sharded Database in *Oracle Globally Distributed Database Guide*

12.7 Using Direct Path Load

Learn how you can use the SQL*Loader direct path load method for loading data.

- Setting Up for Direct Path Loads
  To create the necessary views required to prepare the database for direct path loads, you must run the setup script `catldr.sql`.
- Specifying a Direct Path Load
  To start SQL*Loader in direct path load mode, set the `DIRECT` parameter to `TRUE` on the command line, or in the parameter file.

- Building Indexes
  You can improve performance of direct path loads by using temporary storage. After each block is formatted, the new index keys are put in a sort (temporary) segment.
- Indexes Left in an Unusable State
  SQL*Loader leaves indexes in an Index Unusable state when the data segment being loaded becomes more up-to-date than the index segments that index it.
- Preventing Data Loss with Data Saves
  You can use data saves to protect against loss of data due to instance failure.
- Data Recovery During Direct Path Loads
  SQL*Loader provides full support for data recovery when using the direct path load method.
- Loading Long Data Fields
  You can load data that is longer than SQL*Loader's maximum buffer size can load on the direct path by using large object types (LOBs).
- Loading Data As PIECED
  The `PIECED` parameter can be used to load data in sections, if the data is in the last column of the logical record.
- Auditing SQL*Loader Operations That Use Direct Path Mode
  You can perform auditing on SQL*Loader direct path loads to monitor and record selected user database actions.

12.7.1 Setting Up for Direct Path Loads

To create the necessary views required to prepare the database for direct path loads, you must run the setup script `catldr.sql`.

You only need to run `catldr.sql` once for each database to which you plan to run direct loads. You can run this script during database installation if you know then that you will be doing direct loads.

12.7.2 Specifying a Direct Path Load

To start SQL*Loader in direct path load mode, set the `DIRECT` parameter to `TRUE` on the command line, or in the parameter file.

For example, to configure the parameter file to start SQL*Loader in direct path load mode, include the following line in the parameter file:

```
DIRECT=TRUE
```

Related Topics

- Minimizing Time and Space Required for Direct Path Loads
  You can control the time and temporary storage used during direct path loads.
- Optimizing Direct Path Loads on Multiple-CPU Systems
  If you are performing direct path loads on a multiple-CPU system, then SQL*Loader uses multithreading by default. A multiple-CPU system in this case is defined as a single system that has two or more CPUs.

12.7.3 Building Indexes

You can improve performance of direct path loads by using temporary storage. After each block is formatted, the new index keys are put in a sort (temporary) segment.

The old index and the new keys are merged at load finish time to create the new index. The old index, sort (temporary) segment, and new index segment all require storage until the merge is complete. Then the old index and temporary segment are removed.

During a conventional path load, every time a row is inserted the index is updated. This method does not require temporary storage space, but it does add processing time.

- Improving Performance
  To improve performance of SQL*Loader direct loads on systems with limited memory, use the `SINGLEROW` parameter.
- Calculating Temporary Segment Storage Requirements
  To estimate the amount of temporary segment space needed during direct path loads for storing new index keys, use this formula.

12.7.3.1 Improving Performance

To improve performance of SQL*Loader direct loads on systems with limited memory, use the `SINGLEROW` parameter.

> **Note:**
>
> If, during a direct load, you have specified that you want the data to be presorted, and the existing index is empty, then a temporary segment is not required, and no merge occurs—the keys are put directly into the index.
>
> See Optimizing Performance of Direct Path Loads

When multiple indexes are built, the temporary segments corresponding to each index exist simultaneously, in addition to the old indexes. The new keys are then merged with the old indexes, one index at a time. As each new index is created, the old index and the corresponding temporary segment are removed.

Related Topics

- Understanding the SINGLEROW Parameter
  When using SQL*Loader for direct path loads for small loads, or on systems with limited memory, consider using the `SINGLEROW` control file parameter.
- Estimate Index Size and Set Storage Parameters
- Automatic Parallel Load of Table Data with SQL*Loader

12.7.3.2 Calculating Temporary Segment Storage Requirements

To estimate the amount of temporary segment space needed during direct path loads for storing new index keys, use this formula.

To estimate the amount of temporary segment space needed for storing the new index keys (in bytes), use the following formula:

```
1.3 * key_storage
```

In this formula, key storage is defined as follows, where *`number_rows`* is the number of rows, *`sum_of_column_sizes`* is the sum of the column sizes, and *`number_of_columns`* is the number of columns in the index:

```
key_storage = (number_rows) *
( 10 + sum_of_column_sizes + number_of_columns )
```

The columns included in this formula are the columns in the index. There is one length byte per column, and 10 bytes per row are used for a `ROWID`, and additional overhead.

The constant, 1.3, reflects the average amount of extra space needed for sorting. This value is appropriate for most randomly ordered data. If the data arrives in exactly opposite order, then twice the key-storage space is required for sorting, and the value of this constant would be 2.0. That is the worst case.

If the data is fully sorted, then only enough space to store the index entries is required, and the value of this constant would be 1.0.

Related Topics

- Presorting Data for Faster Indexing
  You can improve the performance of SQL*Loader direct path loads by presorting your data on indexed columns.

12.7.4 Indexes Left in an Unusable State

SQL*Loader leaves indexes in an Index Unusable state when the data segment being loaded becomes more up-to-date than the index segments that index it.

Any SQL statement that tries to use an index that is in an Index Unusable state returns an error. The following conditions cause a direct path load to leave an index or a partition of a partitioned index in an Index Unusable state:

- SQL*Loader runs out of space for the index and cannot update the index.
- The data is not in the order specified by the `SORTED INDEXES` clause.
- There is an instance failure, or the Oracle shadow process fails while building the index.
- There are duplicate keys in a unique index.
- Data savepoints are being used, and the load fails or is terminated by a keyboard interrupt after a data savepoint occurred.

To determine if an index is in an Index Unusable state, you can execute a simple query:

```
SELECT INDEX_NAME, STATUS
   FROM USER_INDEXES
   WHERE TABLE_NAME = 'tablename';
```

If you are not the owner of the table, then search `ALL_INDEXES` or `DBA_INDEXES` instead of `USER_INDEXES`.

To determine if an index partition is in an unusable state, you can execute the following query:

```
SELECT INDEX_NAME,
       PARTITION_NAME,
       STATUS FROM USER_IND_PARTITIONS
       WHERE STATUS != 'VALID';
```

If you are not the owner of the table, then search `ALL_IND_PARTITIONS` and `DBA_IND_PARTITIONS` instead of `USER_IND_PARTITIONS`.

12.7.5 Preventing Data Loss with Data Saves

You can use data saves to protect against loss of data due to instance failure.

- Using Data Saves to Protect Against Data Loss
  When you have a savepoint, if you encounter an instance failure during a SQL*Loader load, then use the `SKIP` parameter to continue the load.
- Using the ROWS Parameter
  The `ROWS` parameter determines when data saves occur during a direct path load.
- Data Save Versus Commit
  In a conventional load, `ROWS` is the number of rows to read before a commit operation. A direct load data save is similar to a conventional load commit, but it is not identical.

12.7.5.1 Using Data Saves to Protect Against Data Loss

When you have a savepoint, if you encounter an instance failure during a SQL*Loader load, then use the `SKIP` parameter to continue the load.

All data loaded up to the last savepoint is protected against instance failure.

To continue the load after an instance failure, determine how many rows from the input file were processed before the failure, then use the `SKIP` parameter to skip those processed rows.

If there are any indexes on the table, then before you continue the load, drop those indexes, and then recreate them after the load. See "Data Recovery During Direct Path Loads" for more information about media and instance recovery.

Note:

Indexes are not protected by a data save, because SQL*Loader does not build indexes until after data loading completes. (The only time indexes are built during the load is when presorted data is loaded into an empty table, but these indexes are also unprotected.)

Related Topics

- Data Recovery During Direct Path Loads
  SQL*Loader provides full support for data recovery when using the direct path load method.

12.7.5.2 Using the ROWS Parameter

The `ROWS` parameter determines when data saves occur during a direct path load.

The value you specify for `ROWS` is the number of rows you want SQL*Loader to read from the input file before saving inserts in the database.

A data save is an expensive operation. The value for `ROWS` should be set high enough so that a data save occurs once every 15 minutes or longer. The intent is to provide an upper boundary (high-water mark) on the amount of work that is lost when an instance failure occurs during a long-running direct path load. Setting the value of `ROWS` to a small number adversely affects performance and data block space utilization.

12.7.5.3 Data Save Versus Commit

In a conventional load, `ROWS` is the number of rows to read before a commit operation. A direct load data save is similar to a conventional load commit, but it is not identical.

The similarities are as follows:

- A data save will make the rows visible to other users.
- Rows cannot be rolled back after a data save.

The major difference is that in a direct path load data save, the indexes will be unusable (in Index Unusable state) until the load completes.

12.7.6 Data Recovery During Direct Path Loads

SQL*Loader provides full support for data recovery when using the direct path load method.

There are two main types of recovery:

- Media - recovery from the loss of a database file. You must be operating in `ARCHIVELOG` mode to recover after you lose a database file.
- Instance - recovery from a system failure in which in-memory data was changed but lost due to the failure before it was written to disk. The Oracle database can always recover from instance failures, even when redo logs are not archived.

- Media Recovery and Direct Path Loads
  If redo log file archiving is enabled (you are operating in `ARCHIVELOG` mode), then SQL*Loader logs loaded data when using the direct path, making media recovery possible.
- Instance Recovery and Direct Path Loads
  Because SQL*Loader writes directly to the database files, all rows inserted up to the last data save will automatically be present in the database files if the instance is restarted.

12.7.6.1 Media Recovery and Direct Path Loads

If redo log file archiving is enabled (you are operating in `ARCHIVELOG` mode), then SQL*Loader logs loaded data when using the direct path, making media recovery possible.

If redo log archiving is not enabled (you are operating in `NOARCHIVELOG` mode), then media recovery is not possible.

To recover a database file that was lost while it was being loaded, use the same method that you use to recover data loaded with the conventional path:

1. Restore the most recent backup of the affected database file.
2. Recover the tablespace using the RMAN `RECOVER` command.

Related Topics

- Performing Complete Recovery of a Tablespace in *Oracle Database Backup and Recovery User's Guide*

12.7.6.2 Instance Recovery and Direct Path Loads

Because SQL*Loader writes directly to the database files, all rows inserted up to the last data save will automatically be present in the database files if the instance is restarted.

Changes do not need to be recorded in the redo log file to make instance recovery possible.

If an instance failure occurs, then the indexes being built may be left in an Index Unusable state. Indexes that are Unusable must be rebuilt before you can use the table or partition. See "Indexes Left in an Unusable State" for information about how to determine if an index has been left in Index Unusable state.

Related Topics

- Indexes Left in an Unusable State
  SQL*Loader leaves indexes in an Index Unusable state when the data segment being loaded becomes more up-to-date than the index segments that index it.

12.7.7 Loading Long Data Fields

You can load data that is longer than SQL*Loader's maximum buffer size can load on the direct path by using large object types (LOBs).

In considering how to load long data fields, note the following:

- To improve performance for loading long data fields as LOBs, Oracle recommends that you use a large `STREAMSIZE` value.
- As an alternative to LOBs, you can also load data that is longer than the maximum buffer size by using the `PIECED` parameter. However, for this scenario, Oracle highly recommends that you use LOBs instad of `PIECED`.

Related Topics

- Loading LOBs with SQL*Loader
  Find out which large object types (LOBs) SQL*Loader can load, and see examples of how to load LOB Data.
- Specifying the Number of Column Array Rows and Size of Stream Buffers
  The number of column array rows determines the number of rows loaded before the stream buffer is built.

12.7.8 Loading Data As PIECED

The `PIECED` parameter can be used to load data in sections, if the data is in the last column of the logical record.

Declaring a column as `PIECED` informs the direct path loader that a `LONG` field might be split across multiple physical records (pieces). In such cases, SQL*Loader processes each piece of the `LONG` field as it is found in the physical record. All the pieces are read before the record is processed. SQL*Loader makes no attempt to materialize the `LONG` field before storing it; however, all the pieces are read before the record is processed.

The following restrictions apply when you declare a column as `PIECED`:

- This option is only valid on the direct path.
- Only one field per table may be `PIECED`.
- The `PIECED` field must be the last field in the logical record.
- The `PIECED` field may not be used in any `WHEN`, `NULLIF`, or `DEFAULTIF` clauses.
- The `PIECED` field's region in the logical record must not overlap with any other field's region.
- The `PIECED` corresponding database column may not be part of the index.
- It may not be possible to load a rejected record from the bad file if it contains a `PIECED` field.

  For example, a `PIECED` field could span three records. SQL*Loader loads the piece from the first record and then reuses the buffer for the second buffer. After loading the second piece, the buffer is reused for the third record. If an error is discovered, then only the third record is placed in the bad file because the first two records no longer exist in the buffer. As a result, the record in the bad file would not be valid.

12.7.9 Auditing SQL*Loader Operations That Use Direct Path Mode

You can perform auditing on SQL*Loader direct path loads to monitor and record selected user database actions.

SQL*Loader uses unified auditing, in which all audit records are centralized in one place.

To set up unified auditing you create a unified audit policy, or alter an existing policy. An audit policy is a named group of audit settings that enable you to audit a particular aspect of user behavior in the database. To create the policy, use the SQL `CREATE AUDIT POLICY` statement.

After creating the audit policy, use the `AUDIT` and `NOAUDIT` SQL statements to, respectively, enable and disable the policy.

Related Topics

- CREATE AUDIT POLICY (Unified Auditing)
- Auditing Oracle SQL*Loader Direct Load Path Events

12.8 Optimizing Performance of Manual Direct Path Loads

If you choose to configure direct path loads manually, then learn how to enable your SQL*Loader direct path loads to run faster, and to use less space.

- Minimizing Time and Space Required for Direct Path Loads
  You can control the time and temporary storage used during direct path loads.
- Preallocating Storage for Faster Loading
  SQL*Loader automatically adds extents to the table if necessary, but this process takes time. For faster loads into a new table, allocate the required extents when the table is created.
- Presorting Data for Faster Indexing
  You can improve the performance of SQL*Loader direct path loads by presorting your data on indexed columns.
- Infrequent Data Saves
  Frequent data saves resulting from a small `ROWS` value adversely affect the performance of a direct path load.
- Minimizing Use of the Redo Log
  One way to speed a direct load dramatically is to minimize use of the redo log.
- Specifying the Number of Column Array Rows and Size of Stream Buffers
  The number of column array rows determines the number of rows loaded before the stream buffer is built.
- Specifying a Value for DATE_CACHE
  To improve performance where the same date or timestamp is used many times during a direct path load, you can use the SQL*Loader date cache.

12.8.1 Minimizing Time and Space Required for Direct Path Loads

You can control the time and temporary storage used during direct path loads.

To minimize time:

- Preallocate storage space
- Presort the data
- Perform infrequent data saves
- Minimize use of the redo log
- Specify the number of column array rows and the size of the stream buffer
- Specify a date cache value
- Set `DB_UNRECOVERABLE_SCN_TRACKING=FALSE`. Unrecoverable (nologging) direct writes are tracked in the control file by periodically storing the SCN and Time of the last direct write. If these updates to the control file are adversely affecting performance, then setting the `DB_UNRECOVERABLE_SCN_TRACKING` parameter to `FALSE` may improve performance.

To minimize space:

- When sorting data before the load, sort data on the index that requires the most temporary storage space
- Avoid index maintenance during the load

12.8.2 Preallocating Storage for Faster Loading

SQL*Loader automatically adds extents to the table if necessary, but this process takes time. For faster loads into a new table, allocate the required extents when the table is created.

To calculate the space required by a table, see the information about managing database files in the *Oracle Database Administrator's Guide.* Then use the `INITIAL` or `MINEXTENTS` clause in the SQL `CREATE TABLE` statement to allocate the required space.

Another approach is to size extents large enough so that extent allocation is infrequent.

12.8.3 Presorting Data for Faster Indexing

You can improve the performance of SQL*Loader direct path loads by presorting your data on indexed columns.

- Advantages of Presorting Data
  Learn about how presorting enables you to increase load performance with SQL*Loader
- SORTED INDEXES Clause
  The `SORTED INDEXES` clause identifies the indexes on which the data is presorted.
- Unsorted Data
  If you specify an index in the `SORTED INDEXES` clause, and the data is not sorted for that index, then the index is left in an Index Unusable state at the end of the load.
- Multiple-Column Indexes
  If you specify a multiple-column index in the `SORTED INDEXES` clause, then the data should be sorted so that it is ordered first on the first column in the index, next on the second column in the index, and so on.
- Choosing the Best Sort Order
  For the best overall performance of direct path loads, you should presort the data based on the index that requires the most temporary segment space.

12.8.3.1 Advantages of Presorting Data

Learn about how presorting enables you to increase load performance with SQL*Loader

Presorting minimizes temporary storage requirements during the load. Presorting also enables you to take advantage of high-performance sorting routines that are optimized for your operating system or application.

If the data is presorted, and the existing index is not empty, then presorting minimizes the amount of temporary segment space needed for the new keys. The sort routine appends each new key to the key list. Instead of requiring extra space for sorting, only space for the keys is needed. To calculate the amount of storage needed, use a sort factor of 1.0 instead of 1.3. For more information about estimating storage requirements, refer to "Temporary Segment Storage Requirements."

If presorting is specified, and the existing index is empty, then maximum efficiency is achieved. The new keys are simply inserted into the index. Instead of having a temporary segment and new index existing simultaneously with the empty, old index, only the new index exists. As a result, temporary storage is not required during the load, and time is saved.

Related Topics

- Calculating Temporary Segment Storage Requirements
  To estimate the amount of temporary segment space needed during direct path loads for storing new index keys, use this formula.

12.8.3.2 SORTED INDEXES Clause

The `SORTED INDEXES` clause identifies the indexes on which the data is presorted.

This clause is allowed only for direct path loads. See case study 6, Loading Data Using the Direct Path Load Method, for an example. (See SQL*Loader Case Studies for information on how to access case studies.)

Generally, you specify only one index in the `SORTED INDEXES` clause, because data that is sorted for one index is not usually in the right order for another index. When the data is in the same order for multiple indexes, however, all indexes can be specified at once.

All indexes listed in the `SORTED INDEXES` clause must be created before you start the direct path load.

12.8.3.3 Unsorted Data

If you specify an index in the `SORTED INDEXES` clause, and the data is not sorted for that index, then the index is left in an Index Unusable state at the end of the load.

The data is present, but any attempt to use the index results in an error. Any index that is left in an Index Unusable state must be rebuilt after the load.

12.8.3.4 Multiple-Column Indexes

If you specify a multiple-column index in the `SORTED INDEXES` clause, then the data should be sorted so that it is ordered first on the first column in the index, next on the second column in the index, and so on.

For example, if the first column of the index is city, and the second column is last name; then the data should be ordered by name within each city, as in the following list:

```
Albuquerque      Adams
Albuquerque      Hartstein
Albuquerque      Klein
...          ...
Boston           Andrews
Boston           Bobrowski
Boston           Heigham
...              ...
```

12.8.3.5 Choosing the Best Sort Order

For the best overall performance of direct path loads, you should presort the data based on the index that requires the most temporary segment space.

For example, if the primary key is one numeric column, and the secondary key consists of three text columns, then you can minimize both sort time and storage requirements by presorting on the secondary key.

To determine the index that requires the most storage space, use the following procedure:

1. For each index, add up the widths of all columns in that index.
2. For a single-table load, pick the index with the largest overall width.
3. For each table in a multiple-table load, identify the index with the largest overall width. If the same number of rows are to be loaded into each table, then again pick the index with the largest overall width. Usually, the same number of rows are loaded into each table.
4. If a different number of rows are to be loaded into the indexed tables in a multiple-table load, then multiply the width of each index identified in Step 3 by the number of rows that are to be loaded into that index, and pick the index with the largest result.

12.8.4 Infrequent Data Saves

Frequent data saves resulting from a small `ROWS` value adversely affect the performance of a direct path load.

A small `ROWS` value can also result in wasted data block space because the last data block is not written to after a save, even if the data block is not full.

Because direct path loads can be many times faster than conventional loads, the value of `ROWS` should be considerably higher for a direct load than it would be for a conventional load.

During a data save, loading stops until all of SQL*Loader's buffers are successfully written. You should select the largest value for `ROWS` that is consistent with safety. It is a good idea to determine the average time to load a row by loading a few thousand rows. Then you can use that value to select a good value for `ROWS`.

For example, if you can load 20,000 rows per minute, and you do not want to repeat more than 10 minutes of work after an interruption, then set `ROWS` to be 200,000 (20,000 rows/minute * 10 minutes).

12.8.5 Minimizing Use of the Redo Log

One way to speed a direct load dramatically is to minimize use of the redo log.

There are three ways to do this. You can disable archiving, you can specify that the load is unrecoverable, or you can set the SQL `NOLOGGING` parameter for the objects being loaded. This section discusses all methods.

- Disabling Archiving
  If archiving is disabled, then direct path loads do not generate full image redo.

- Specifying the SQL*Loader UNRECOVERABLE Clause
  To save time and space in the redo log file, use the SQL*Loader `UNRECOVERABLE` clause in the control file when you load data.
- Setting the SQL NOLOGGING Parameter
  If a data or index segment has the SQL `NOLOGGING` parameter set, then full image redo logging is disabled for that segment (invalidation redo is generated).

12.8.5.1 Disabling Archiving

If archiving is disabled, then direct path loads do not generate full image redo.

Use the SQL `ARCHIVELOG` and `NOARCHIVELOG` parameters to set the archiving mode.

Related Topics

- Managing Archived Redo Log Files in *Oracle Database Administrator's Guide*

12.8.5.2 Specifying the SQL*Loader UNRECOVERABLE Clause

To save time and space in the redo log file, use the SQL*Loader `UNRECOVERABLE` clause in the control file when you load data.

An unrecoverable load does not record loaded data in the redo log file; instead, it generates invalidation redo.

The `UNRECOVERABLE` clause applies to all objects loaded during the load session (both data and index segments). Therefore, media recovery is disabled for the loaded table, although database changes by other users may continue to be logged.

Note:

Because the data load is not logged, you may want to make a backup of the data after loading.

If media recovery becomes necessary on data that was loaded with the `UNRECOVERABLE` clause, then the data blocks that were loaded are marked as logically corrupted.

To recover the data, drop and re-create the data. It is a good idea to do backups immediately after the load to preserve the otherwise unrecoverable data.

By default, a direct path load is `RECOVERABLE`.

The following is an example of specifying the `UNRECOVERABLE` clause in the control file:

```
UNRECOVERABLE
LOAD DATA
INFILE 'sample.dat'
INTO TABLE emp
(ename VARCHAR2(10), empno NUMBER(4));
```

12.8.5.3 Setting the SQL NOLOGGING Parameter

If a data or index segment has the SQL `NOLOGGING` parameter set, then full image redo logging is disabled for that segment (invalidation redo is generated).

Use of the `NOLOGGING` parameter allows a finer degree of control over the objects that are not logged.

12.8.6 Specifying the Number of Column Array Rows and Size of Stream Buffers

The number of column array rows determines the number of rows loaded before the stream buffer is built.

The `STREAMSIZE` parameter specifies the size (in bytes) of the data stream sent from the client to the server.

Use the `COLUMNARRAYROWS` parameter to specify a value for the number of column array rows. Note that when `VARRAY`s are loaded using direct path, the `COLUMNARRAYROWS` parameter defaults to 100 to avoid client object cache thrashing.

Use the `STREAMSIZE` parameter to specify the size for direct path stream buffers.

The optimal values for these parameters vary, depending on the system, input data types, and Oracle column data types used. When you are using optimal values for your particular configuration, the elapsed time in the SQL*Loader log file should go down.

Note:

You should monitor process paging activity, because if paging becomes excessive, then performance can be significantly degraded. You may need to lower the values for `READSIZE`, `STREAMSIZE`, and `COLUMNARRAYROWS` to avoid excessive paging.

It can be particularly useful to specify the number of column array rows and size of the stream buffer when you perform direct path loads on multiple CPU systems.

Related Topics

- Optimizing Direct Path Loads on Multiple-CPU Systems
  If you are performing direct path loads on a multiple-CPU system, then SQL*Loader uses multithreading by default. A multiple-CPU system in this case is defined as a single system that has two or more CPUs.
- COLUMNARRAYROWS
  The `COLUMNARRAYROWS` command-line parameter for SQL*Loader specifies the number of rows to allocate for direct path column arrays.
- STREAMSIZE
  The `STREAMSIZE` SQL*Loader command-line parameter specifies the size (in bytes) of the data stream sent from the client to the server.

12.8.7 Specifying a Value for DATE_CACHE

To improve performance where the same date or timestamp is used many times during a direct path load, you can use the SQL*Loader date cache.

If you are performing a direct path load in which the same date or timestamp values are loaded many times, then a large percentage of total load time can end up being used for converting date and timestamp data. This is especially true if multiple date columns are being loaded. In such a case, it may be possible to improve performance by using the SQL*Loader date cache.

The date cache reduces the number of date conversions done when many duplicate values are present in the input data. It enables you to specify the number of unique dates anticipated during the load.

The date cache is enabled by default. To completely disable the date cache, set it to 0.

The default date cache size is 1000 elements. If the default is used and the number of unique input values loaded exceeds 1000, then the date cache is automatically disabled for that table. This prevents excessive and unnecessary lookup times that could affect performance. However, if instead of using the default, you specify a nonzero value for the date cache and it is exceeded, then the date cache is *not* disabled. Instead, any input data that exceeded the maximum is explicitly converted using the appropriate conversion routines.

The date cache can be associated with only one table. No date cache sharing can take place across tables. A date cache is created for a table only if all of the following conditions are true:

- The `DATE_CACHE` parameter is not set to 0
- One or more date values, timestamp values, or both are being loaded that require data type conversion in order to be stored in the table
- The load is a direct path load

Date cache statistics are written to the log file. You can use those statistics to improve direct path load performance as follows:

- If the number of cache entries is less than the cache size and there are no cache misses, then the cache size could safely be set to a smaller value.
- If the number of cache hits (entries for which there are duplicate values) is small and the number of cache misses is large, then the cache size should be increased. Be aware that if the cache size is increased too much, then it may cause other problems, such as excessive paging or too much memory usage.
- If most of the input date values are unique, then the date cache will not enhance performance and therefore should not be used.

> **Note:**
>
> Date cache statistics are *not* written to the SQL*Loader log file if the cache was active by default and disabled because the maximum was exceeded.

If increasing the cache size does not improve performance, then revert to the default behavior or set the cache size to 0. The overall performance improvement also depends on the data types of the other columns being loaded. Improvement will be greater for cases in which the total number of date columns loaded is large compared to other types of data loaded.

Related Topics

- DATE_CACHE
  The `DATE_CACHE` command-line parameter for SQL*Loader specifies the date cache size (in entries).

12.9 Optimizing Direct Path Loads on Multiple-CPU Systems

If you are performing direct path loads on a multiple-CPU system, then SQL*Loader uses multithreading by default. A multiple-CPU system in this case is defined as a single system that has two or more CPUs.

Multithreaded loading means that, when possible, conversion of the column arrays to stream buffers and stream buffer loading are performed in parallel. This optimization works best when:

- Column arrays are large enough to generate multiple direct path stream buffers for loads
- Data conversions are required from input field data types to Oracle column data types

  The conversions are performed in parallel with stream buffer loading.

The status of this process is recorded in the SQL*Loader log file, as shown in the following log portion example:

```
Total stream buffers loaded by SQL*Loader main thread:         47
Total stream buffers loaded by SQL*Loader load thread:        180
Column array rows:                                           1000
Stream buffer bytes:                                       256000
```

In this example, the SQL*Loader load thread has offloaded the SQL*Loader main thread, allowing the main thread to build the next stream buffer while the load thread loads the current stream on the server.

The goal is to have the load thread perform as many stream buffer loads as possible. This can be accomplished by increasing the number of column array rows, decreasing the stream buffer size, or both. You can monitor the elapsed time in the SQL*Loader log file to determine whether your changes are having the desired effect. For more information, see "Specifying the Number of Column Array Rows and Size of Stream Buffers". See Specifying the Number of Column Array Rows and Size of Stream Buffers for more information.

On single-CPU systems, optimization is turned off by default. When the server is on another system, performance may improve if you manually turn on multithreading.

To turn the multithreading option on or off, use the `MULTITHREADING` parameter at the SQL*Loader command line or specify it in your SQL*Loader control file.

Related Topics

- Specifying the Number of Column Array Rows and Size of Stream Buffers
  The number of column array rows determines the number of rows loaded before the stream buffer is built.
- Direct Path Load Interface

12.10 Avoiding Index Maintenance

For both the conventional path and the direct path, SQL*Loader maintains all existing indexes for a table.

To avoid index maintenance, use one of the following methods:

- Drop the indexes before beginning of the load.
- Mark selected indexes or index partitions as Index Unusable before beginning the load and use the `SKIP_UNUSABLE_INDEXES` parameter.
- Use the `SKIP_INDEX_MAINTENANCE` parameter (direct path only, use with caution).

By avoiding index maintenance, you minimize the amount of space required during a direct path load, in the following ways:

- You can build indexes one at a time, reducing the amount of sort (temporary) segment space that would otherwise be needed for each index.

- Only one index segment exists when an index is built, instead of the three segments that temporarily exist when the new keys are merged into the old index to make the new index.

Avoiding index maintenance is quite reasonable when the number of rows to be loaded is large compared to the size of the table. But if relatively few rows are added to a large table, then the time required to resort the indexes may be excessive. In such cases, it is usually better to use the conventional path load method, or to use the `SINGLEROW` parameter of SQL*Loader. For more information, see SINGLEROW Option.

12.11 Direct Path Loads, Integrity Constraints, and Triggers

There can be differences between how you set triggers with direct path loads, compared to conventional path loads

With the conventional path load method, arrays of rows are inserted with standard SQL `INSERT` statements; integrity constraints and insert triggers are automatically applied. But when you load data with the direct path, SQL*Loader disables some integrity constraints and all database triggers.

- Integrity Constraints
  During a direct path load with SQL*Loader, some integrity constraints are automatically disabled, while others are not.
- Database Insert Triggers
  Table insert triggers are also disabled when a direct path load begins.
- Permanently Disabled Triggers and Constraints
  SQL*Loader needs to acquire several locks on the table to be loaded to disable triggers and constraints.
- Increasing Performance with Concurrent Conventional Path Loads
  If triggers or integrity constraints pose a problem, but you want faster loading, then you should consider using concurrent conventional path loads.

12.11.1 Integrity Constraints

During a direct path load with SQL*Loader, some integrity constraints are automatically disabled, while others are not.

To better understand the concepts behind how integrity constraints enforce the business rules associated with a database, and to understand the different techniques you can use to prevent the entry of invalid information into tables, refer to "Data Integrity."

- Enabled Constraints
  During direct path load, some constraints remain enabled.
- Disabled Constraints
  During a direct path load, some constraints are disabled.
- Reenable Constraints
  When a SQL*Loader load completes, the integrity constraints will be reenabled automatically if the `REENABLE` clause is specified.

Related Topics

- Data Integrity

12.11.1.1 Enabled Constraints

During direct path load, some constraints remain enabled.

During a direct path load, the constraints that remain enabled are as follows:

- NOT NULL
- UNIQUE
- PRIMARY KEY (unique-constraints on not-null columns)

NOT NULL constraints are checked at column array build time. Any row that violates the NOT NULL constraint is rejected.

Even though UNIQUE constraints remain enabled during direct path loads, any rows that violate those constraints are loaded anyway (this is different than in conventional path in which such rows would be rejected). When indexes are rebuilt at the end of the direct path load, UNIQUE constraints are verified and if a violation is detected, then the index will be left in an Index Unusable state. See Indexes Left in an Unusable State.

12.11.1.2 Disabled Constraints

During a direct path load, some constraints are disabled.

During a direct path load, the following constraints are automatically disabled by default:

- CHECK constraints
- Referential constraints (FOREIGN KEY)

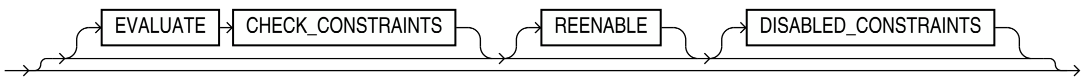
You can override the automatic disabling of CHECK constraints by specifying the EVALUATE CHECK_CONSTRAINTS clause. SQL*Loader will then evaluate CHECK constraints during a direct path load. Any row that violates the CHECK constraint is rejected. The following example shows the use of the EVALUATE CHECK_CONSTRAINTS clause in a SQL*Loader control file:

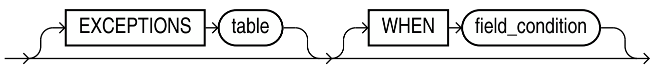
```
LOAD DATA
INFILE *
APPEND
INTO TABLE emp
EVALUATE CHECK_CONSTRAINTS
FIELDS TERMINATED BY ',' OPTIONALLY ENCLOSED BY '"'
(c1 CHAR(10) ,c2)
BEGINDATA
Jones,10
Smith,20
Brown,30
Taylor,40
```

12.11.1.3 Reenable Constraints

When a SQL*Loader load completes, the integrity constraints will be reenabled automatically if the REENABLE clause is specified.

The syntax for the REENABLE clause is as follows:





The optional parameter `DISABLED_CONSTRAINTS` is provided for readability. If the `EXCEPTIONS` clause is included, then the exceptions table (default name: `EXCEPTIONS`) must already exist, and you must be able to insert into it. This table contains the `ROWID` values for all rows that violated one of the integrity constraints. It also contains the name of the constraint that was violated.

For instructions on how to create the exceptions table, see `exceptions_clause` under `constraint` in *Oracle Database SQL Language Reference*.

The SQL*Loader log file describes the constraints that were disabled, the ones that were reenabled, and what error, if any, prevented reenabling or validating of each constraint. It also contains the name of the exceptions table specified for each loaded table.

If the `REENABLE` clause is not used, then the constraints must be reenabled manually, at which time all rows in the table are verified. If the Oracle database finds any errors in the new data, then error messages are produced. The names of violated constraints and the ROWIDs of the bad data are placed in an exceptions table, if one is specified.

If the `REENABLE` clause is used, then SQL*Loader automatically reenables the constraint and verifies all new rows. If no errors are found in the new data, then SQL*Loader automatically marks the constraint as validated. If any errors *are* found in the new data, then error messages are written to the log file and SQL*Loader marks the status of the constraint as `ENABLE NOVALIDATE`. The names of violated constraints and the ROWIDs of the bad data are placed in an exceptions table, if one is specified.

Note:

Normally, when a table constraint is left in an `ENABLE NOVALIDATE` state, new data can be inserted into the table but no new invalid data may be inserted. However, SQL*Loader direct path load does not enforce this rule. Thus, if subsequent direct path loads are performed with invalid data, then the invalid data will be inserted but the same error reporting and exception table processing as described previously will take place. In this scenario the exception table may contain duplicate entries if it is not cleared out before each load. Duplicate entries can easily be filtered out by performing a query such as the following:

```
SELECT UNIQUE * FROM exceptions_table;
```

Note:

Because referential integrity must be reverified for the entire table, performance may be improved by using the conventional path, instead of the direct path, when a small number of rows are to be loaded into a very large table.

Related Topics

- constraint in *Oracle Database SQL Language Reference*

12.11.2 Database Insert Triggers

Table insert triggers are also disabled when a direct path load begins.

After the rows are loaded and indexes rebuilt, any triggers that were disabled are automatically reenabled. The log file lists all triggers that were disabled for the load. There should not be any errors reenabling triggers.

Unlike integrity constraints, insert triggers are not reapplied to the whole table when they are enabled. As a result, insert triggers do *not* fire for any rows loaded on the direct path. When using the direct path, the application must ensure that any behavior associated with insert triggers is carried out for the new rows.

- Replacing Insert Triggers with Integrity Constraints
  Applications commonly use insert triggers to implement integrity constraints.
- When Automatic Constraints Cannot Be Used
  Sometimes an insert trigger cannot be replaced with Oracle's automatic integrity constraints.
- Preparation of Database Triggers
  Before you can use either the insert triggers or automatic constraints method, you must prepare the Oracle Database table
- Using an Update Trigger
  Generally, you can use a database update trigger to duplicate the effects of an insert trigger.
- Duplicating the Effects of Exception Conditions
  If the insert trigger can raise an exception, then more work is required to duplicate its effects.
- Using a Stored Procedure
  If using an insert trigger raises exceptions, then consider using a stored procedure to duplicate the effects of an insert trigger.

12.11.2.1 Replacing Insert Triggers with Integrity Constraints

Applications commonly use insert triggers to implement integrity constraints.

Most of the triggers that these application insert are simple enough that they can be replaced with Oracle's automatic integrity constraints.

12.11.2.2 When Automatic Constraints Cannot Be Used

Sometimes an insert trigger cannot be replaced with Oracle's automatic integrity constraints.

For example, if an integrity check is implemented with a table lookup in an insert trigger, then automatic check constraints cannot be used, because the automatic constraints can only reference constants and columns in the current row. This section describes two methods for duplicating the effects of such a trigger.

12.11.2.3 Preparation of Database Triggers

Before you can use either the insert triggers or automatic constraints method, you must prepare the Oracle Database table

Use the following general guidelines to prepare the table:

1. Before the load, add a 1-byte or 1-character column to the table that marks rows as "old data" or "new data."
2. Let the value of null for this column signify "old data" because null columns do not take up space.

3. When loading, flag all loaded rows as "new data" with SQL*Loader's `CONSTANT` parameter.

After following this procedure, all newly loaded rows are identified, making it possible to operate on the new data without affecting the old rows.

12.11.2.4 Using an Update Trigger

Generally, you can use a database update trigger to duplicate the effects of an insert trigger.

This method is the simplest. It can be used whenever the insert trigger does not raise any exceptions.

1. Create an update trigger that duplicates the effects of the insert trigger.

   Copy the trigger. Change all occurrences of "*new*.column_name" to "*old*.column_name".
2. Replace the current update trigger, if it exists, with the new one.
3. Update the table, changing the "new data" flag to null, thereby firing the update trigger.
4. Restore the original update trigger, if there was one.

Depending on the behavior of the trigger, it may be necessary to have exclusive update access to the table during this operation, so that other users do not inadvertently apply the trigger to rows they modify.

12.11.2.5 Duplicating the Effects of Exception Conditions

If the insert trigger can raise an exception, then more work is required to duplicate its effects.

Raising an exception would prevent the row from being inserted into the table. To duplicate that effect with an update trigger, it is necessary to mark the loaded row for deletion.

The "new data" column cannot be used as a delete flag, because an update trigger cannot modify the columns that caused it to fire. So another column must be added to the table. This column marks the row for deletion. A null value means the row is valid. Whenever the insert trigger would raise an exception, the update trigger can mark the row as invalid by setting a flag in the additional column.

In summary, when an insert trigger can raise an exception condition, its effects can be duplicated by an update trigger, provided:

- Two columns (which are usually null) are added to the table
- The table can be updated exclusively (if necessary)

12.11.2.6 Using a Stored Procedure

If using an insert trigger raises exceptions, then consider using a stored procedure to duplicate the effects of an insert trigger.

The following procedure always works, but it is more complex to implement. It can be used when the insert trigger raises exceptions. It does not require a second additional column; and, because it does not replace the update trigger, it can be used without exclusive access to the table.

1. Create a stored procedure that duplicates the effects of the insert trigger:
   a. Declare a cursor for the table, selecting all new rows.
   b. Open the cursor and fetch rows, one at a time, in a processing loop.
   c. Perform the operations contained in the insert trigger.

   d. If the operations succeed, then change the "new data" flag to null.
   e. If the operations fail, then change the "new data" flag to "bad data."
2. Run the stored procedure using an administration tool, such as SQL*Plus.
3. After running the procedure, check the table for any rows marked "bad data."
4. Update or remove the bad rows.
5. Reenable the insert trigger.

12.11.3 Permanently Disabled Triggers and Constraints

SQL*Loader needs to acquire several locks on the table to be loaded to disable triggers and constraints.

If a competing process is enabling triggers or constraints at the same time that SQL*Loader is trying to disable them for that table, then SQL*Loader may not be able to acquire exclusive access to the table.

SQL*Loader attempts to handle this situation as gracefully as possible. It attempts to reenable disabled triggers and constraints before exiting. However, the same table-locking problem that made it impossible for SQL*Loader to continue may also have made it impossible for SQL*Loader to finish enabling triggers and constraints. In such cases, triggers and constraints will remain disabled until they are manually enabled.

Although such a situation is unlikely, it is possible. The best way to prevent it is to ensure that no applications are running that could enable triggers or constraints for the table while the direct load is in progress.

If a direct load is terminated due to failure to acquire the proper locks, then carefully check the log. It will show every trigger and constraint that was disabled, and each attempt to reenable them. Any triggers or constraints that were not reenabled by SQL*Loader should be manually enabled with the `ENABLE` clause of the `ALTER TABLE` statement described in *Oracle Database SQL Language Reference.*

12.11.4 Increasing Performance with Concurrent Conventional Path Loads

If triggers or integrity constraints pose a problem, but you want faster loading, then you should consider using concurrent conventional path loads.

That is, use multiple load sessions executing concurrently on a multiple-CPU system. Split the input data files into separate files on logical record boundaries, and then load each such input data file with a conventional path load session. The resulting load has the following attributes:

- It is faster than a single conventional load on a multiple-CPU system, but probably not as fast as a direct load.
- Triggers fire, integrity constraints are applied to the loaded rows, and indexes are maintained using the standard DML execution logic.

12.12 Optimizing Performance of Direct Path Loads

Learn how to enable your SQL*Loader direct path loads to run faster, and to use less space.

- Restrictions on Automatic and Manual Parallel Direct Path Loads
  When you use the SQL*Loader client to perform direct path loads in parallel manually, be aware of the restrictions listed here.

- About SQL*Loader Parallel Data Loading Models
  There are three basic models of concurrency that you can use to minimize the elapsed time required for data loading.
- Concurrent Conventional Path Loads
  This topic describes using concurrent conventional path loads.
- Intersegment Concurrency with Direct Path
  Intersegment concurrency can be used for concurrent loading of different objects.
- Intrasegment Concurrency with Direct Path
  SQL*Loader permits multiple, concurrent sessions to perform a direct path load into the same table, or into the same partition of a partitioned table.
- Restrictions on Manual Parallel Direct Path Loads
  When you configure parallel direct path loads manually, review and be aware of the restrictions enforced on manual parallel direct path loads.
- Initiating Multiple SQL*Loader Sessions Manually
  If you choose to initiate direct path parallel loads of data manually, then for all sessions executing a direct load on the same table, you must set `PARALLEL` to `TRUE`.
- Parameters for Manual Parallel Direct Path Loads
  When you perform parallel direct path loads manually, there are options available for specifying attributes of the temporary segment that the loader allocates.
- Enabling Constraints After a Parallel Direct Path Load
  Constraints and triggers must be enabled manually after all data loading is complete.
- PRIMARY KEY and UNIQUE KEY Constraints
  This topic describes using the PRIMARY KEY and UNIQUE KEY constraints.

12.12.1 Restrictions on Automatic and Manual Parallel Direct Path Loads

When you use the SQL*Loader client to perform direct path loads in parallel manually, be aware of the restrictions listed here.

Note:

Starting with the SQL*Loader client for Oracle Database 23ai, the SQL*Loader client can support direct path loads from any Oracle Database release starting with Oracle Database 12c Release 2 (12.2). This capability is available in the SQL*Loader Instant Client for Release 23ai. Generally speaking, you should use the automatic parallel direct path load procedure. Except where noted, the restrictions listed here apply to both manual and automatic parallel loading.

If you intend to perform parallel direct path loads, then the following restrictions are enforced:

- Global indexes are not maintained by the load. By default, local indexes are maintained.
- You cannot specify `ROWS` for the parallel load. If you attempt to do so, then SQL*Loader returns the error " SQL*Loader-826: ROWS parameter is not supported for parallel direct path loading using `degree_of_parallelism` parameter".
- Primary Key values in tables cannot be specified as `NULL`.

Note:

If you use Automatic Parallel Direct Path Loading, then can use the `TRUNCATE` or `REPLACE` load options, which will be performed at the start of the load.

SQL*Loader automatically disables the following restraints and triggers before the load begins and re-enables them after the load completes:

- Referential integrity constraints
- Triggers
- `CHECK` constraints, unless the `ENABLE_CHECK_CONSTRAINTS` control file option is used

12.12.2 About SQL*Loader Parallel Data Loading Models

There are three basic models of concurrency that you can use to minimize the elapsed time required for data loading.

The concurrency models are:

- Concurrent conventional path loads
- Intersegment concurrency with the direct path load method
- Intrasegment concurrency with the direct path load method

Starting with Oracle Database 21c, you can use the SQL*Loader parameter CREDENTIAL to provide credentials to enable read access to object stores. Parallel loading from the object store is supported.

In addition, starting with Oracle Database 23ai, you can enable automatic parallel loads of sharded and non-sharded tables for both conventional and direct path loads using SQL*Loader.

Related Topics

- Automatic Parallel Load of Table Data with SQL*Loader

12.12.3 Concurrent Conventional Path Loads

This topic describes using concurrent conventional path loads.

Using multiple conventional path load sessions executing concurrently is discussed in Increasing Performance with Concurrent Conventional Path Loads, you can use this technique to load the same or different objects concurrently with no restrictions.

12.12.4 Intersegment Concurrency with Direct Path

Intersegment concurrency can be used for concurrent loading of different objects.

You can apply this technique to concurrent direct path loading of different tables, or to concurrent direct path loading of different partitions of the same table.

When you direct path load a single partition, consider the following items:

- Local indexes can be maintained by the load.
- Global indexes cannot be maintained by the load.

- Referential integrity and `CHECK` constraints must be disabled.
- Triggers must be disabled.
- The input data should be partitioned (otherwise many records will be rejected, which adversely affects performance).

12.12.5 Intrasegment Concurrency with Direct Path

SQL*Loader permits multiple, concurrent sessions to perform a direct path load into the same table, or into the same partition of a partitioned table.

Multiple SQL*Loader sessions improve the performance of a direct path load given the available resources on your system.

This method of data loading is enabled by setting both the `DIRECT` and the `PARALLEL` parameters to `TRUE`, and is often referred to as a parallel direct path load.

It is important to realize that parallelism is user managed. Setting the `PARALLEL` parameter to `TRUE` only allows multiple concurrent direct path load sessions.

12.12.6 Restrictions on Manual Parallel Direct Path Loads

When you configure parallel direct path loads manually, review and be aware of the restrictions enforced on manual parallel direct path loads.

The following restrictions are enforced on manual parallel direct path loads:

- Neither local nor global indexes can be maintained by the load.
- Rows can only be appended. `REPLACE`, `TRUNCATE`, and `INSERT` cannot be used (this is due to the individual loads not being coordinated in manual parallel direct path loads). If you must truncate a table before a parallel load, then you must do it manually.

Additionally, the following objects must be disabled on parallel direct path loads. You do not have to take any action to disable them. SQL*Loader disables them before the load begins and re-enables them after the load completes:

- Referential integrity constraints
- Triggers
- CHECK constraints, unless the `ENABLE_CHECK_CONSTRAINTS` control file option is used

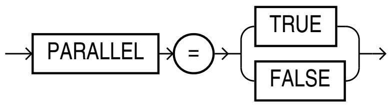
If a manual parallel direct path load is being applied to a single partition, then you should partition the data first (otherwise, the overhead of record rejection due to a partition mismatch slows down the load).

12.12.7 Initiating Multiple SQL*Loader Sessions Manually

If you choose to initiate direct path parallel loads of data manually, then for all sessions executing a direct load on the same table, you must set `PARALLEL` to `TRUE`.

Syntax

When you set `PARALLEL` to `TRUE`, each SQL*Loader session takes a different data file as input. Syntax:



`PARALLEL` can be specified either on the command line, or in a parameter file. It can also be specified in the control file with the `OPTIONS` clause.

For example, to start three SQL*Loader direct path load sessions on the same table, you would execute each of the following commands at the operating system prompt. After entering each command, you will be prompted for a password.

```
sqlldr USERID=scott CONTROL=load1.ctl DIRECT=TRUE PARALLEL=TRUE
sqlldr USERID=scott CONTROL=load2.ctl DIRECT=TRUE PARALLEL=TRUE
sqlldr USERID=scott CONTROL=load3.ctl DIRECT=TRUE PARALLEL=TRUE
```

The previous commands must be executed in separate sessions, or if permitted on your operating system, as separate background jobs. Note the use of multiple control files. For manual parallel direct path loads, using multiple control files enables you to be flexible in specifying the files that you want to use for the direct path load.

Note:

Indexes are not maintained during a parallel load. Any indexes must be created or re-created manually after the load completes. You can use the parallel index creation or parallel index rebuild feature to speed the building of large indexes after a parallel load.

When you perform a manual parallel load, SQL*Loader creates temporary segments for each concurrent session, and then merges the segments upon completion of the load. The segment created from the merge is then added to the existing segment in the database above the segment's high-water mark. The last extent used of each segment for each loader session is trimmed of any free space before being combined with the other extents of the SQL*Loader session.

12.12.8 Parameters for Manual Parallel Direct Path Loads

When you perform parallel direct path loads manually, there are options available for specifying attributes of the temporary segment that the loader allocates.

The loader options are specified with the `FILE` and `STORAGE` parameters. These parameters are valid only for manual parallel loads.

- Using the FILE Parameter to Specify Temporary Segments
  To allow for maximum I/O throughput, Oracle recommends that each concurrent direct path load session use files located on different disks.

12.12.8.1 Using the FILE Parameter to Specify Temporary Segments

To allow for maximum I/O throughput, Oracle recommends that each concurrent direct path load session use files located on different disks.

In the SQL*Loader control file, use the `FILE` parameter of the `OPTIONS` clause to specify the file name of any valid data file in the tablespace of the object (table or partition) being loaded.

For example:

```
LOAD DATA
INFILE 'load1.dat'
INSERT INTO TABLE emp
OPTIONS(FILE='/dat/data1.dat')
(empno POSITION(01:04) INTEGER EXTERNAL NULLIF empno=BLANKS
...
```

You could also specify the `FILE` parameter on the command line of each concurrent SQL*Loader session, but then it would apply globally to all objects being loaded with that session.

- Using the FILE Parameter
  This topic describes using the FILE parameter.
- Using the STORAGE Parameter
  You can use the `STORAGE` parameter to specify the storage attributes of the temporary segments allocated for a parallel direct path load.

12.12.8.1.1 Using the FILE Parameter

This topic describes using the FILE parameter.

The `FILE` parameter in the Oracle database has the following restrictions for parallel direct path loads:

- **For nonpartitioned tables:** The specified file must be in the tablespace of the table being loaded.
- **For partitioned tables, single-partition load:** The specified file must be in the tablespace of the partition being loaded.
- **For partitioned tables, full-table load:** The specified file must be in the tablespace of all partitions being loaded; that is, all partitions must be in the same tablespace.

12.12.8.1.2 Using the STORAGE Parameter

You can use the `STORAGE` parameter to specify the storage attributes of the temporary segments allocated for a parallel direct path load.

If the `STORAGE` parameter is not used, then the storage attributes of the segment containing the object (table, partition) being loaded are used. Also, when the `STORAGE` parameter is not specified, SQL*Loader uses a default of 2 KB for `EXTENTS`.

For example, the following `OPTIONS` clause could be used to specify `STORAGE` parameters:

```
OPTIONS (STORAGE=(INITIAL 100M NEXT 100M PCTINCREASE 0))
```

You can use the `STORAGE` parameter only in the SQL*Loader control file, and not on the command line. Use of the `STORAGE` parameter to specify anything other than `PCTINCREASE` of 0, and `INITIAL` or `NEXT` values is strongly discouraged and may be silently ignored.

12.12.9 Enabling Constraints After a Parallel Direct Path Load

Constraints and triggers must be enabled manually after all data loading is complete.

Because each SQL*Loader session can attempt to reenable constraints on a table after a direct path load, there is a danger that one session may attempt to reenable a constraint before another session is finished loading data. In this case, the first session to complete the load will be unable to enable the constraint because the remaining sessions possess share locks on the table.

Because there is a danger that some constraints might not be reenabled after a direct path load, you should check the status of the constraint after completing the load to ensure that it was enabled properly.

12.12.10 PRIMARY KEY and UNIQUE KEY Constraints

This topic describes using the PRIMARY KEY and UNIQUE KEY constraints.

`PRIMARY KEY` and `UNIQUE KEY` constraints create indexes on a table when they are enabled, and subsequently can take a significantly long time to enable after a direct path loading session if the table is very large. You should consider enabling these constraints manually after a load (and not specifying the automatic enable feature). This enables you to manually create the required indexes in parallel to save time before enabling the constraint.

12.13 General Performance Improvement Hints

Learn how to enable general performance improvements when using SQL*Loader with parallel data loading.

If you have control over the format of the data to be loaded, then you can use the following hints to improve load performance:

- Make logical record processing efficient.
  - Use one-to-one mapping of physical records to logical records (avoid using `CONTINUEIF` and `CONCATENATE`).
  - Make it easy for the software to identify physical record boundaries. Use the file processing option string `"FIX nnn"` or `"VAR"`. If you use the default (stream mode), then on most platforms (for example, UNIX and NT) the loader must scan each physical record for the record terminator (newline character).
- Make field setting efficient.

  Field setting is the process of mapping fields in the data file to their corresponding columns in the table being loaded. The mapping function is controlled by the description of the fields in the control file. Field setting (along with data conversion) is the biggest consumer of CPU cycles for most loads.
  - Avoid delimited fields; use positional fields. If you use delimited fields, then the loader must scan the input data to find the delimiters. If you use positional fields, then field setting becomes simple pointer arithmetic (very fast).
  - Do not trim whitespace if you do not need to (use `PRESERVE BLANKS`).

- Make conversions efficient.

  SQL*Loader performs character set conversion and data type conversion for you. Of course, the quickest conversion is no conversion.

  - Use single-byte character sets if you can.
  - Avoid character set conversions if you can. SQL*Loader supports four character sets:
    - Client character set (`NLS_LANG` of the client `sqlldr` process)
    - Data file character set (usually the same as the client character set)
    - Database character set
    - Database national character set

    Performance is optimized if all character sets are the same. For direct path loads, it is best if the data file character set and the database character set are the same. If the character sets are the same, then character set conversion buffers are not allocated.
- Use direct path loads.
- Use the `SORTED INDEXES` clause.
- Avoid unnecessary `NULLIF` and `DEFAULTIF` clauses. Each clause must be evaluated on each column that has a clause associated with it for every row loaded.
- Use parallel direct path loads and parallel index creation when you can.
- Be aware of the effect on performance when you have large values for both the `CONCATENATE` clause and the `COLUMNARRAYROWS` clause.

Related Topics

- Using CONCATENATE to Assemble Logical Records