Visual Guide to Data Loading with Vertica

Choosing a Load Method

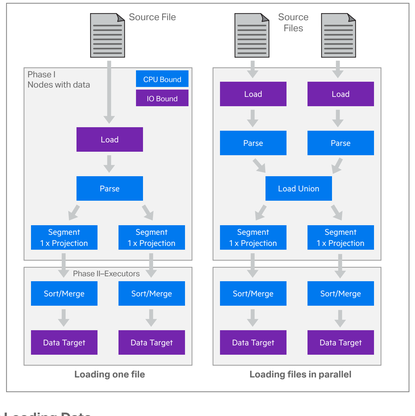
Depending on what data you are loading, the COPY statement includes several load options.

Load Method	Description
AUTO	This is the default load method. If you do not specify a load option explicitly, COPY uses the AUTO method to load data into WOS (Write Optimized Store) in memory. The default method is good for smaller bulk loads (< 100MB). Once the WOS is full, COPY continues loading directly to ROS (Read Optimized Store) on disk. ROS data is sorted and encoded.
DIRECT	Use the DIRECT parameter to to load data directly into ROS containers, bypassing loading data into WOS. The DIRECT option is best suited for large data loads (100MB or more). Using DIRECT to load many smaller data sets results in many ROS containers, which have to be combined later.
TRICKLE	Use the TRICKLE option to load data incrementally after you complete your initial bulk load. Trickle loading loads data into the WOS. If the WOS becomes full, an error occurs and the entire data load is rolled back. Use this option only when you have a finely-tuned load and moveout process at your site, and you are confident that the WOS can hold the data you are loading. This option is more efficient than AUTO when loading data into partitioned tables.
COPY PARSERS	By default, COPY uses the DELIMITER parser to load raw data into the database. Raw input data must be in UTF-8, delimited text format. COPY parsers include: `DELIMITED` `NATIVE BINARY` `NATIVE VARCHAR` `FIXED-WIDTH` `ORC` `PARQUET`

Understanding how the COPY command works

Vertica's bulk loader (COPY) will automatically create separate worker threads to process a single file. This means that a file will be read very quickly by multiple, parallel readers. In addition, Vertica will try to divide the work across all of the CPU cores and nodes, in the cluster, for multiple files. This significantly reduces the task of optimizing most bulk/trickle load tasks.

However, in some instances, it may be wise to manually divide the COPY workload across all of your nodes. In the case, put the data files where they are accessible from the target nodes. Then run multiple, parallel COPY statements for each node. A good place to start is to create a single COPY running for each node. You may add additional COPY statements, for each node, to improve bulk loading throughout. However, be cautious with the number of parallel COPY statements executing by monitoring system resource (CPU, memory, disk I/O, and network) utilization. You don't want to create a lot of resource contention.



Bulk Loading Data

There are different methods for bulk loading data into a Vertica database using the COPY statement. In its basic form, use COPY as follows:

```
COPY target-table FROM data-source
```

The COPY statement loads data from a file stored on the host or client (or in a data stream) into a database table. You can pass the COPY statement many different parameters to define various options such as:

- The format of the incoming data
- Metadata about the data load
- Which parser COPY should use
- Load data over parallel load streams
- How to transform data as it is loaded
- How to handle errors

Vertica's hybrid storage model provides a great deal of flexibility for loading and managing data.

For more information on data loading refer to the Vertica documentation online at **my.vertica.com/docs**

Column Delimiter Options

The default COPY delimiter is a '|' vertical bar. The DELIMITER is a single ASCII character used to separate columns within each record of a file. Between two delimiters, COPY interprets all string data in load files as characters.

Change default to comma delimiter.
```
COPY mytable FROM STDIN DELIMITER ',';
```

Specify TAB character column delimiter.
```
COPY mytable FROM STDIN DELIMITER E'\t';
```

Specify any ASCII character as delimiter character.
```
COPY mytable FROM STDIN DELIMITER E'\x1E';
```

Specify any ASCII character as record delimiter.
```
COPY mytable FROM STDIN DELIMITER ','
RECORD TERMINATOR E'\n';
```

Delimiting Characters (ENCLOSED BY)
The COPY ENCLOSED BY parameter lets you set an ASCII character to delimit characters to embed in string values.
```
COPY mytable FROM STDIN DELIMITER
E'\t' ENCLOSED BY '"';
```

Capturing Load Rejections and Exceptions

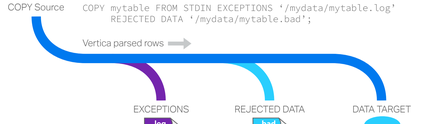
Loading data with COPY has two main phases: parsing and loading. Rejected data is created whenever COPY cannot parse a row of data. Other problems can occur during the load phase, but such problems are not considered rejections.

Saving Rejected Rows (REJECTED DATA and EXCEPTIONS)

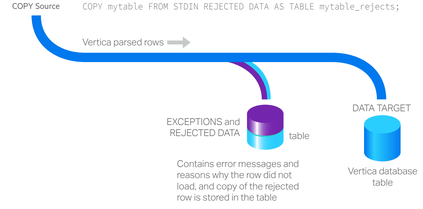
The COPY statement automatically saves a copy of each rejected row in a rejected-data file. COPY also saves a corresponding explanation of why the rejection occurred in an exceptions file. By default, Vertica saves both files in a database catalog subdirectory, called CopyErrorLogs, as listed in this example:

```
vdb_node001_catalog\CopyErrorLogs\trans-STDIN-copy-from-rejected-data.1
vdb_node001_catalog\CopyErrorLogs\trans-STDIN-copy-from-exceptions.1
```

Use the REJECTED DATA reject_file and EXCEPTIONS except_file parameters to save one, or both, files to a location of your choice. The rejections file includes rejected rows, while the exceptions file contains a description of why each row was rejected.



Use the REJECTED DATA AS TABLE reject_table clause. Saving rejected rows to a reject_table also retains the exception descriptions.

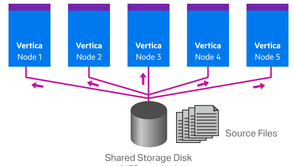


Data Loading by Example

For loading initial data sets, it is important to review the rejected rows before loading many terabytes of data. Try to correct the rejected rows as much as possible for subsequent data loads. Even a handful of rejected row may cause the COPY statement to slow down when compared to zero rejected rows. Corrections are typically done by either modifying the source data files (typically by creating an external (Shell, Python, etc.) script to fix a specific formatting problem) or by modifying the COPY statement parameters to understand/accept the rejected row.

Load Compressed File
Load a single, gzipped CSV (with pipe delimiter) file on a single node:
```
COPY schema-name.taget-table FROM '/path/on/node/file.gz' ON node0001
 GZIP DIRECT;
```

Load Multiple Files from Shared Device
Load multiple CSV (with tab delimiter) files from a shared storage device (connected to all nodes):
```
COPY schema-name.target-table FROM '/shared/path/*.csv' ON ANY NODE
  UNCOMPRESSED DELIMITER E'\t' DIRECT;
```



Using a wildcard with the ON ANY NODE clause expands the file list on the initiator node. This command then distributes the individual files among all nodes, so that the COPY workload is evenly distributed across the cluster.

Load Specific Columns
Load specific columns, in a specific order, from a CSV (with comma delimiter) file, on a single node:
```
COPY schema-name.target-table (c, a, b) FROM '/path/on/node/file.csv'
ON node0001 UNCOMPRESSED DELIMITER ',' DIRECT;
```

Skip Lines in Load
Skip a header (first line) in a CSV file. This prevents Vertica from rejecting the line.

```
COPY schema-name.target-table FROM '/path/on/node/file.csv' SKIP 1
DIRECT;
```

Transform Data During Load
Transform data, at load time, using fillers from a CSV (with pipe delimiter) file on a single node, This transforms column C into a TIMESTAMP datatype from a string like '06 Jul 2006.' Any expressions can be applied to transform a column at load time, which saves a lot of post-processing time and effort.
```
COPY schema-name.target-table (a, b, c_temp FILLER VARCHAR, c AS
  TO_TIMESTAMP(c_temp, 'DD Mon YYYY')) FROM '/path/on/node/file.csv'
  ON node0001 UNCOMPRESSED DIRECT;
```

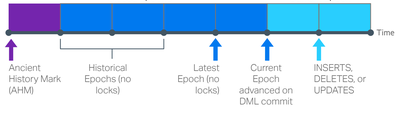
Combine Columns
This combines columns A and B into a single VARCHAR:
```
COPY schema-name.target-table (a_temp FILLER VARCHAR, b_temp FILLER
INTEGER, a AS CONCAT(CONCAT(a_temp, '-'), b_temp::VARCHAR)) FROM
'/path/on/node/file.csv' ON node0001 UNCOMPRESSED DIRECT;
```

Vertica Transaction Model

AHM: The Ancient History Mark epoch prior to which historical data can be purged from physical storage.

Epoch: A 64-bit number representing a logical timestamp for data in Vertica. Every row has an implicitly stored column recording the committed epoch.

The epoch advances when the logical state of the system changes or when data is committed with DML operations (INSERT, UPDATE, MERGE, COPY, or DELETE). The EPOCHS system table contains the date and time of each closed epoch and corresponding epoch number.



Using COPY Interactively

You can also use commands such as the following interactively by piping a text file to vsql and executing a COPY (or COPY FROM LOCAL) statement with the standard input stream as the input file. For example:

```
$ cat myfile.txt | vsql -c "COPY mytable FROM STDIN DELIMITER '|' DIRECT";
$ cat myfile.txt | vsql -c "COPY mytable FROM LOCAL STDIN DELIMITER '|' DIRECT";
```

Vertica Flex Tables

Flex tables simplify data loading by allowing you to browse semi-structured data without having to create a schema or column definitions. Flex tables support full SQL functionality. Formats supported include: Avro Data, CEF, CSV, Delimited, and JSON.

Source Data Example
The flex table feature loads JSON or delimited files without the need to define each column and data type. In this example, a simple CSV file will be used, create the file as follows and save as /source/cities.csv.

```
City,State,Zip,Population
Boston,MA,02108,655884
Chicago,IL,60601,2722389
Seattle,WA,98101,668342
Dallas,TX,75201,1281047
New York,NY,10001,8491079
```

Create Flex Table and Load the Data
Create the flex table and name it cities_flex. Note, column names and types are not necessary with flex tables.

```
create flexible table cities_flex();
copy cities_flex from
'/source/cities.csv' parser
fdelimitedparser (delimiter=',');
```

Query the cities_flex table, specifying column names from original CSV source file.

```
select city,state from cities_flex;
   city    | state
-----------+-------
 Boston    | MA
 Chicago   | IL
 Seattle   | WA
 Dallas    | TX
 New York  | NY
(5 rows)
```

To view actual raw contents, run the following:

```
select * from cities_flex;
```

Use the MapToString() function to view the contents in JSON text format.

```
select maptostring(__raw__) from
cities_flex limit 1;
```

Build Flex Table View
Compute the flex table keys and build a view in single statement. The new view name is cities_flex_view.

```
select
compute_flextable_keys_and_build_vie
w('cities_flex');
```

Adjust Data Types
The Zip and Population columns can be updated in from the default varchar() data type to int.

```
update cities_flex_keys set
data_type_guess = 'int' where
key_name='Zip';
update cities_flex_keys set
data_type_guess = 'int' where
key_name='Population';
commit;
```

Verify the updated columns and adjusted data types.

```
select * from cities_flex_keys;

  key_name   | frequency | data_type_guess
-------------+-----------+-----------------
 City        |         6 | varchar(20)
 State       |         5 | varchar(20)
 Zip         |         5 | int
 Population  |         5 | int
(4 rows)
```

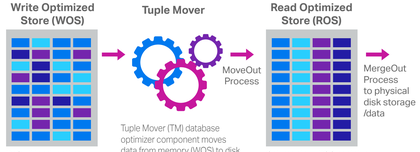
Refresh the cities_flex_view with new data types.

```
select
build_flextable_view('cities_flex');
```

Materialize the Flex Table
Materialize the flex table and all columns into a persistent Vertica table specifiy column names or entire table.

```
create table cities as select * from
cities_flex_view;
```

Vertica Storage Architecture



Default load method for COPY. Once WOS is full, COPY continues loading directly to ROS stored on disk.

Tuple Mover (TM) database optimizer component moves data from memory (WOS) to disk (ROS). Runs in background performing automatic tasks. Default Moveout from WOS to ROS is 5 minutes. Mergeout combines ROS containers to reduce data fragmentation on disk, by default every 10 minutes.

Column store, ROS container set of rows stored for particular group of files. Created by Moveout or COPY DIRECT operations. Monitor ROS and WOS storage containers in the STORAGE_CONTAINERS system table.

Hybrid Storage Architecture

User Privileges for COPY

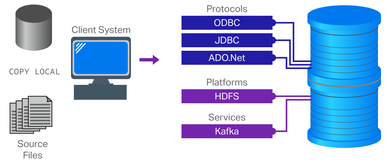
Privileges
You must connect to the Vertica database as a superuser, or, as a non-superuser, have a user-accessible storage location, and applicable READ or WRITE privileges granted to the storage location from which files are read or written to. COPY LOCAL users must have INSERT privileges to copy data from the STDIN pipe, as well as USAGE privileges on the schema.

The following permissions are required to COPY FROM STDIN:

```
INSERT privilege on table
USAGE privilege on schema
```

Client Connection Methods for Loading

You can load data into your Vertica database through client connections from other databases or sources. Common ETL tools connect to Vertica and useful for data loading.



Client Connection and Loading Best Practices
- Native connection load balancing is a feature built into the Vertica server and client libraries. Load balancing spreads the CPU and memory overhead caused by client connections across the hosts in the database. Native connection load balancing only has an effect when it is enabled by both the server and the client.
- Pushdown optimization (source side, target side, and full)
- Writing bulk data to disk directly with COPY using DIRECT option
- Avoid single row INSERTs for best performancev

Monitoring Loads and Reporting

Using the LOAD_STREAMS System Table
Vertica includes a set of system tables that include monitoring information. The LOAD_STREAMS system table includes information about load stream metrics from COPY and COPY FROM VERTICA statements.

To view all table columns:
```
select * from load_streams;
```

Using the STREAM NAME Parameter
Using the STREAM NAME parameter as part of the COPY statement labels COPY streams explicitly so they are easier to identify in the LOAD_STREAMS system table.

To use the STREAM NAME parameter:
```
COPY mytable FROM myfile DELIMITER '|' DIRECT STREAM NAME 'My stream name';
```

The LOAD_STREAMS system table includes stream names for every COPY statement that takes more than 1 second to run. The 1-second duration includes the time to plan and execute the statement.

Vertica maintains system table metrics until they reach a designated size quota (in kilobytes). The quota is set through internal processes and cannot be set or viewed directly.

Other LOAD_STREAMS Columns for COPY Metrics
These LOAD_STREAMS system table column values depend on the load status:

```
ACCEPTED_ROW_COUNT
REJECTED_ROW_COUNT
PARSE_COMPLETE_PERCENT
SORT_COMPLETE_PERCENT
```

When a COPY statement using the DIRECT option is in progress, the ACCEPTED_ROW_COUNT value can increase to the maximum number of rows in the input file as the rows are being parsed.

If COPY reads input data from multiple named pipes, the PARSE_COMPLETE_PERCENT value will remain at zero (0) until all named pipes return an EOF. While COPY awaits an EOF from multiple pipes, it can appear to be hung. However, before canceling the COPY statement, check your system CPU and disk accesses to see if any activity is in progress.

In a typical load, the PARSE_COMPLETE_PERCENT value can either increase slowly to 100%, or jump to 100% quickly. If you are loading from named pipes or STDIN, the SORT_COMPLETE_PERCENT value is 0. Once PARSE_COMPLETE_PERCENT reaches 100%, SORT_COMPLETE_PERCENT increases to 100%. Depending on the data sizes, a significant lag can occur between the time PARSE_COMPLETE_PERCENT reaches 100% and the time SORT_COMPLETE_PERCENT begins to increase. This example sets the VSQL expanded display, and then selects various columns of data from the LOAD_STREAMS system table:

```
=> \pset expanded
Expanded display is on.
=> SELECT stream_name, table_name, load_start, accepted_row_count,
   rejected_row_count, read_bytes, unsorted_row_count,
   sorted_row_count, sort_complete_percent FROM load_streams;
-[ RECORD 1 ]----------+--------------------------
stream_name            | fact-13
table_name             | fact
load_start             | 2010-12-28 15:07:41.132053
accepted_row_count     | 900
rejected_row_count     | 100
read_bytes             | 11975
input_file_size_bytes  | 0
parse_complete_percent | 0
unsorted_row_count     | 3600
sorted_row_count       | 3600
sort_complete_percent  | 100
```