



# A FRAMEWORK FOR MIGRATING YOUR DATA WAREHOUSE TO GOOGLE BIGQUERY

**Vladimir Stoyak**

Principal Consultant for Big Data, Certified Google Cloud Platform  
Qualified Developer

The purpose of this document is to provide a framework and help guide you through the process of migrating a data warehouse to Google BigQuery. It highlights many of the areas you should consider when planning for and implementing a migration of this nature, and includes an example of a migration from another cloud data warehouse to BigQuery. It also outlines some of the important differences between BigQuery and other database solutions, and addresses the most frequently asked questions about migrating to this powerful database.

Note: This document does not claim to provide any benchmarking or performance comparisons between platforms, but rather highlights areas and scenarios where BigQuery is the best option.

# TABLE OF CONTENTS

<b>PRE-MIGRATION</b>	<b>3</b>
MAIN MOTIVATORS	3
DEFINING MEASURABLE MIGRATION GOALS	4
PERFORMANCE	4
INFRASTRUCTURE, LICENSE AND MAINTENANCE COSTS	5
USABILITY AND FUNCTIONALITY	5
DATABASE MODEL REVIEW AND ADJUSTMENTS	6
DATA TRANSFORMATION	7
CONTINUOUS DATA INGESTION	7
REPORTING, ANALYTICS AND BI TOOLSET	8
CAPACITY PLANNING	8
<b>MIGRATION</b>	<b>8</b>
STAGING REDSHIFT DATA IN S3	9
REDSHIFT CLI CLIENT INSTALL	9
TRANSFERRING DATA TO GOOGLE CLOUD STORAGE	9
DATA LOAD	10
ORIGINAL STAR SCHEMA MODEL	11
BIG FAT TABLE	13
DATE PARTITIONED FACT TABLE	15
DIMENSION TABLES	17
SLOWLY CHANGING DIMENSIONS (SCD)	17
FAST CHANGING DIMENSIONS (FCD)	18
<b>POST-MIGRATION</b>	<b>18</b>
MONITORING	18
STACKDRIVER	18
AUDIT LOGS	19
QUERY EXPLAIN PLAN	20

## PRE-MIGRATION

### MAIN MOTIVATORS

Having a clear understanding of main motivators for the migration will help structure the project, set priorities and migration goals, and provide a basis for assessing the success of the project at the end.

Google BigQuery is a lightning-fast analytics database. Customers find BigQuery's performance liberating, allowing them to experiment with enormous datasets without compromise and to build complex analytics applications such as reporting and data warehousing.

Here are some of the main reasons that users find migrating to BigQuery an attractive option:

- BigQuery is a fully managed, no-operations data warehouse. The concept of hardware is completely abstracted away from the user.
- BigQuery enables extremely fast analytics on a petabyte scale through its unique architecture and capabilities.
- BigQuery eliminates the need to forecast and provision storage and compute resources in advance. All the resources are allocated dynamically based on usage.
- BigQuery provides a unique 'pay as you go' model for your data warehouse and allows you to move away from a CAPEX-based model.
- BigQuery charges separately for data storage and query processing enabling an optimal cost model, unlike solutions where processing capacity is allocated (and charged) as a function of allocated storage.
- BigQuery employs a columnar data store, which enables the highest data compression and minimizes data scanning in common data warehouse deployments.
- BigQuery provides support for streaming data ingestions directly through an API or by using [Google Cloud Dataflow](#).
- BigQuery has native integrations with many third-party reporting and BI providers such as Tableau, MicroStrategy, Looker, and so on.

And some scenarios where BigQuery might not be a good fit:

- BigQuery is not an OLTP database. It performs full column scans for all columns in the context of the query. It can be very expensive to perform a single row read similar to primary key access in relational databases with BigQuery.
- BigQuery was not built to be a transactional store. If you are looking to implement locking, multi-row/table transactions, BigQuery may not be the right platform.

- BigQuery does not support primary keys and referential integrity. During the migration the data model should be flattened out and denormalized before storing it in BigQuery to take full advantage of the engine.
- BigQuery is a massively scalable distributed analytics engine where querying smaller datasets is overkill because in these cases, you cannot take full advantage of its highly distributed computational and I/O resources.

## DEFINING MEASURABLE MIGRATION GOALS

Before an actual migration to BigQuery most companies will identify a “lighthouse project” and build a proof of concept (PoC) around BigQuery to demonstrate its value. Explicit success criteria and clearly measurable goals have to be defined at the very beginning, even if it’s only a PoC of a full-blown production system implementation. It’s easy to formulate such goals generically for a production migration as something like: “to have a new system that is equal to or exceeds performance and scale of the current system and costs less”. But it’s better to be more specific. PoC projects are smaller in scope so they require very specific success criteria.

As a guideline, measurable metrics in at least the following three categories have to be established and observed throughout the migration process: performance, infrastructure/license/maintenance costs, and usability/functionality.

## PERFORMANCE

In an analytical context, performance has a direct effect on productivity, because running a query for hours means days of iterations between business questions. It is important to build a solution that scales well not only in terms of data volume but, in the quantity and complexity of the queries performed.

For queries, BigQuery uses the notion of ‘slots’ to allocate query resources during query execution. A ‘slot’ is simply a unit of analytical computation (i.e. a chunk of infrastructure) pertaining to a certain amount of CPU and RAM. All projects, by default, are allocated 2,000 slots on a best effort basis. As the use of BigQuery and the consumption of the service goes up, the allocation limit is dynamically raised. This method serves most customers very well, but in rare cases where a higher number of slots is required, or/and reserved slots are needed due to strict SLAs, a new flat-rate billing model might be a better option as it allows you to choose the specific slot allocation required.

To monitor slot usage per project, use BigQuery integration with Stackdriver. This captures slot availability and allocations over time for each project. However, there is no easy way to look at resource usage on a per query basis. To measure per query usage and identify problematic loads, you might need to cross-reference slot usage metrics with the query history and query execution.

## INFRASTRUCTURE, LICENSE AND MAINTENANCE COSTS

In the case of BigQuery, Google provides a fully managed serverless platform that eliminates hardware, software and maintenance costs as well as efforts spent on detailed capacity planning thanks to embedded scalability and a utility billing model - services are billed based on the volume of data stored and amount of data processed.

It is important to pay attention to the following specifics of BigQuery billing:

- Storage is billed separately from processing so working with large amounts of “cold” data (rarely accessed) is very affordable.
- Automatic pricing tiers for storage (short term and long term) eliminate the need of commitment to and planning for volume discounts – they are automatic.
- Processing cost is ONLY for data scanned, so selecting the minimum amount of columns required to produce results will minimize the processing costs thanks to columnar storage. This is why explicitly selecting required columns instead of “\*” can make a big processing cost (and performance) difference.
- Likewise, implementing appropriate partitioning techniques in BigQuery will result in less data scanned and lower processing costs (in addition to better performance). This is especially important since BigQuery doesn’t utilize the concept of indexes that’s common to relational databases.
- There is an extra charge if a streaming API is used to ingest data into BigQuery in real time.
- Cost control tools such as “Billing Alerts” and “Custom Quotas” and alerting or limiting resource usage per project or user might come in handy (<https://cloud.google.com/bigquery/cost-controls>)

Learning from early adoption, in addition to usage-based billing, Google is introducing a new pricing model where customers can choose a fixed billing model for data processing. And, although it seems like usage-based billing might still be a better option for most of the use cases and clients, receiving a predictable bill at the end of the month is attractive to some organizations.

## USABILITY AND FUNCTIONALITY

There may be some functional differences when migrating to a different platform, however in many cases there are workarounds and specific design considerations that can be adopted to address these.

BigQuery launched support for standard SQL, which is compliant with the SQL 2011 standard and has extensions that support querying nested and repeated data.

It is worth exploring some additional SQL language/engine specifics and some additional functions:

- Analytic/window functions
- JSON parsing
- Working with arrays
- Correlated subqueries
- Temporary SQL/Javascript user defined functions
- Inequality predicates in joins
- Table name wildcards and table suffixes

In addition, BigQuery support for querying data directly from Google Cloud Storage and Google Drive. It supports AVRO, JSON NL, CSV files as well as Google Cloud Datastore backup, Google Sheets (first tab only). Federated datasources should be considered in the following cases:

- Loading and cleaning your data in one pass by querying the data from a federated data source (a location external to BigQuery) and writing the cleaned result into BigQuery storage.
- Having a small amount of frequently changing data that you join with other tables. As a federated data source, the frequently changing data does not need to be reloaded every time it is updated.

## **DATABASE MODEL REVIEW AND ADJUSTMENTS**

It's important to remember that a "lift and shift" approach prioritizes ease and speed of migration over long-term performance and maintainability benefits. This can be a valid approach if it's an organization's priority and incremental improvements can be applied over time. However, it might not be optimal from a performance and cost standpoint. ROI on optimization efforts can be almost immediate. In many cases data model adjustments have to be made to some degree.

While migrating to BigQuery the following are worthwhile considering:

- Limiting the number of columns in the context of the query and specifically avoid things like "select \* from table".
- Limiting complexity of joins, especially with high cardinality join keys. Some extra denormalization might come in handy and greatly improve query performance with minimal impact on storage cost and changes required to implement them.
- Making use of structured data types.
- Introducing table decorators, table name filters in queries and structuring data around manual or automated date partitioning.

- Making use of retention policies on Dataset level or set partition expiration date -time\_partitioning\_expiration flag.
- Batching DML statements like insert,update and delete.
- Limiting data scanned through use of partitioning (there is only date partition supported at the moment but multiple tables and table name selectors can somewhat overcome this limitation).

## DATA TRANSFORMATION

Exporting data from the source system into a flat file and then loading it into BigQuery might not always work. In some cases the transformation process should take place before loading data into BigQuery due to some data type constraints, changes in data model, etc. For example, WebUI does not allow any parsing (i.e. date string format), type casting, etc. and source data should be fully compatible with target schema.

If any transformation is required, the data can potentially be loaded into a temporary staging table in BigQuery with subsequent processing steps that would take staged data, and transform/parse it using built-in functions or custom JavaScript UDFs and loaded it into target schema.

If more complex transformations are required, Google Cloud Dataflow (<https://cloud.google.com/dataflow/>) or Google Dataproc (<https://cloud.google.com/dataproc/>) can be used as an alternative to custom coding. Here is a good tutorial demonstrating how to use Google Cloud Dataflow to analyze logs collected and exported by [Google Cloud Logging](#).

## CONTINUOUS DATA INGESTION

Initial data migration is not the only process. And once the migration is completed, changes will have to be made in the data ingestion process for new data to flow into the new system. Having a clear understanding of how the data ingestion process is currently implemented and how to make it work in a new environment is one of the important planning aspects.

When considering loading data to BigQuery, there are a few options available:

- Bulk loading from AVRO/JSON/CSV on GCS. There are some difference of what format is best for what, more information available from (<https://cloud.google.com/bigquery/loading-data>)
- Using the BigQuery API (<https://cloud.google.com/bigquery/loading-data-post-request>)
- Streaming Data into BigQuery using one of the [API Client Libraries](#) or [Google Cloud Dataflow](#)

- Using BigQuery to load uncompressed files. This is significantly faster than compressed files due to parallel load operations, but because uncompressed files are larger in size, using them can lead to bandwidth limitations and higher storage costs.
- Loading Avro file, which does not require you to manually define schemas. The schema will be inherited from the datafile itself.

## REPORTING, ANALYTICS AND BI TOOLSET

Reporting, visualization and BI platform investments in general are significant. Although some improvements might be needed to avoid bringing additional dependencies and risks into the migration project (BI/ETL tools replacement), keeping existing end user tools is a common preference.

There is a growing list of vendors that provide native connection to BigQuery (<https://cloud.google.com/bigquery/partners/>). However if native support is not yet available for the BI layer in use, then some third-party connectors (such as Simba <https://cloud.google.com/bigquery/partners/simba-beta-drivers> in Beta) might be required as there is no native ODBC/JDBC support yet.

## CAPACITY PLANNING

Identifying queries, concurrent users, data volumes processed, and usage pattern is important to understand. Normally migrations start from identifying and building a PoC from the most demanding area where the impact will be well visible.

As access to big data is being democratized with better user interfaces, standard SQL support and faster queries, it makes the reporting/data mining self-serviced and variability of analysis much wider. This shifts the attention from boring administrative and maintenance tasks to what really matters to the business: generating insights and intelligence from the data. As a result, the focus for organizations is in expanding capacity in business analysis, developing expertise in data modeling, data science, machine learning and statistics, etc.

BigQuery removes the need for capacity planning in most cases. Storage is virtually infinitely scalable and data processing compute capacity allocation is done automatically by the platform as data volumes and usage grow.

## MIGRATION

To test a simple “Star Schema” to BigQuery migration scenario we will be loading a [SSB sample schema](#) into Redshift and then performing ETL into BigQuery. This schema was generated based on the [TPC-H benchmark](#) with some data warehouse specific adjustments.

## STAGING REDSHIFT DATA IN S3

### REDSHIFT CLI CLIENT INSTALL

In order not to depend on a connection with a local workstation while loading data, an EC2 micro instance was launched so we could perform data load steps described in <http://snowplowanalytics.com/blog/2013/02/20/transferring-data-from-s3-to-redshift-at-the-command-line/>

We also needed to download the client from <http://www.xigole.com/software/jisql/build/jisql-2.0.11.zip>

The client requires the following environment variables to store AWS access credentials

- export ACCESS-KEY=
- export SECRET-ACCESS-KEY=
- export USERNAME=
- export PASSWORD=

Once RedShift CLI client is installed and access credentials are specified, we need to

- create source schema in RedShift
- load SSB data into RedShift
- Export data to S3

Here are some of the files and scripts needed

<https://gist.github.com/anonymous/657b5175b978cdc7dd0cba2b0d44ef77>

After executing the scripts in the above link, you will have an export of your Redshift tables in S3.

## TRANSFERRING DATA TO GOOGLE CLOUD STORAGE

Once the export is created you can use GCP Storage Transfer utility to move files from S3 to Cloud Storage (<https://cloud.google.com/storage/transfer/>). In addition to WebUI you can create and initiate transfer using Google API Client library for the language of your choice or REST API. If you are transferring less than 1TB of data then the [gsutil](#) command-line tool can also be used to transfer data between Cloud Storage and other locations.

Cloud Storage Transfer Service has options that make data transfers and synchronization between data sources and data sinks easier.

For example, you can:

- Schedule one-time transfers or recurring transfers.
- Schedule periodic synchronization from data source to data sink with

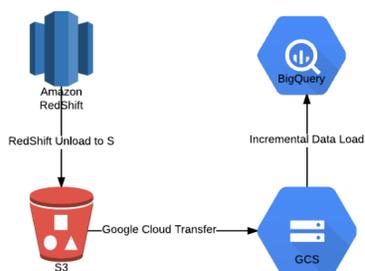
advanced filters based on file creation dates, file-name filters, and the times of day you prefer to import data.

- Delete source objects after transferring them.

For subsequent data synchronizations, data should ideally be pushed directly from the source into GCP. If for legacy reasons data must be staged in AWS S3 the following approaches can be used to load data into BigQuery on an ongoing basis assuming:

- Policy on S3 bucket is set to create a SQS message on object creation. In GCP we can use Dataflow and create custom unbounded source to subscribe to SQS messages and read and stream newly created objects into BigQuery
- Alternatively a policy to execute the AWS Lambda function on the new S3 object can be used to read the newly created object and load it into BigQuery. Here ([https://github.com/vstoyak/GCP/blob/master/RedShift2BigQuery\\_lambda.js](https://github.com/vstoyak/GCP/blob/master/RedShift2BigQuery_lambda.js)) is a simple Node.js Lambda function implementing automatic data transfer into BigQuery triggered on every new RedShift dump saved to S3. It implements a pipeline with the following steps:
  - Triggered on new RedShift dump saved to S3 bucket
  - Initiates Async Google Cloud Transfer process to move new data file from S3 to Google Cloud Storage
  - Initiates Async BigQuery load job for transferred data files

Automated RedShift to BigQuery Data Pipeline



## DATA LOAD

Once we have data files transferred to Google Cloud Storage they are ready to be loaded into BigQuery.

Unless you are loading AVRO files, BigQuery currently does not support schema creation out of JSON datafile so we need to create tables in BigQuery using the following schemas <https://gist.github.com/anonymous/8c0ece715c6a72ff6258e25cb84045c8> When creating tables in BigQuery using the above schemas, you can

load data at the same time. To do so you need to point the BigQuery import tool to the location of datafiles on Cloud Storage. Please note that since there will be multiple files created for each table when exporting from RedShift, you will need to specify wildcards when pointing to the location of corresponding datafiles.

One caveat here is that BigQuery data load interfaces are rather strict in what formats they accept and unless all types are fully compatible, properly quoted and formatted, the load job will fail with very little indication as to where the problematic row/column is in the source file.

There is always an option to load all fields as STRING and then do the transformation into target tables using default or user defined functions. Another approach would be to rely on Google Cloud Dataflow (<https://cloud.google.com/dataflow/>) for the transformation or ETL tools such as Talend or Informatica.

For help with automation of data migration from RedShift to BigQuery you can also look at BigShift utility (<https://github.com/iconara/bigshift>). BigShift follows the same steps dumping RedShift tables into S3, moving them over to Google Cloud Storage and then loading them into BigQuery. In addition, it implements automatic schema creation on the BigQuery side and implements type conversion, cleansing in case the source data does not fit perfectly into formats required by BigQuery (data type translation, timestamp reformatting, quotes are escaped, and so on). You should review and evaluate the limitations of BigShift before using the software and make sure it fits what you need.

## ORIGINAL STAR SCHEMA MODEL

We have now loaded data from RedShift using a simple “lift & shift” approach. No changes are really required and you can start querying and joining tables “as-is” using Standard SQL. Query optimizer will insure that the query is executed in most optimal stages, but you have to ensure that “Legacy SQL” is unchecked in Query Options.

### QUERY 1

Query complete (3.3s, 17.9 GB processed) , Cost: ~8.74¢

```
SELECT
    sum(lo_extendedprice*lo_discount) as revenue
FROM
    ssb.lineorder,ssb.dwdate
WHERE
    lo_orderdate = d_datekey
    AND d_year = 1997
    AND lo_discount between 1 and 3
    AND lo_quantity < 24;
```

### QUERY 2

Query complete (8.1s, 17.9 GB processed) , Cost: ~8.74¢

```
SELECT
    sum(lo_revenue) ,
    d_year,
    p_brand1
FROM
    ssb.lineorder,
    Ssb.dwdate,
    Ssb.part,
    ssb.supplier
WHERE
    lo_orderdate = d_datekey
    and lo_partkey = p_partkey
    and lo_suppkey = s_suppkey
    and p_category = 'MFGR#12'
    and s_region = 'AMERICA'
GROUP BY
    d_year,
    p_brand1
ORDER BY
    d_year,
    p_brand1;
```

### QUERY 3

Query complete (10.7s, 18.0 GB processed) , Cost: ~8.79¢

```
SELECT
    c_city,
    s_city,
    d_year,
    sum(lo_revenue) as revenue
FROM
    ssb.customer,
    ssb.lineorder,
    ssb.supplier,
    ssb.dwdate
WHERE
    lo_custkey = c_custkey
    AND lo_suppkey = s_suppkey
    AND lo_orderdate = d_datekey
    AND (c_city='UNITED KI1' OR c_city='UNITED KI5')
    AND (s_city='UNITED KI1' OR s_city='UNITED KI5')
    AND d_yearmonth = 'Dec1997'
GROUP BY
    c_city,
```

```

        s_city,
        d_year
ORDER BY
        d_year ASC
        revenue DESC;

```

## BIG FAT TABLE

Above model and queries were executed “as-is” without making any modification from standard “Star Schema” model. However, to take advantage of BigQuery some changes to the model might be beneficial and can also simplify query logic and make queries and results more readable.

To do this we will flatten out “Star Schema” into a big fat table using the following query, setting it as a batch job and materializing query results into a new table (lineorder\_denorm\_records). Note that rather than denormalizing joined tables into columns we rely on RECORD types and ARRAYS supported by BigQuery.

The following query will collapse all dimension tables into fact table.

Query complete (178.9s elapsed, 73.6 GB processed) , Cost: 35.94¢

```

SELECT
    t1.*,
    t2 as customer,
    t3 as supplier,
    t4 as part,
    t5 as dwdate
FROM
    ssb.lineorder t1
    JOIN ssb.customer t2 ON (t1.lo_custkey = t2.c_
    custkey)
    JOIN ssb.supplier t3 ON (t1.lo_suppkey = t3.s_
    suppkey)
    JOIN ssb.part t4 ON (t1.lo_partkey = t4.p_partkey)
    JOIN ssb.dwdate t5 ON (t1.lo_orderdate = t5.d_
    datekey);

```

To get an idea of table sizes in BigQuery before and after changes the following query will calculate space used by each table in a dataset:

```

select
    table_id,
    ROUND(sum(size_bytes)/pow(10,9),2) as size_gb

```

```

from
  ssb.__TABLES__
GROUP BY
  table_id
ORDER BY
  size_gb;

```

Row	table_id	size_gb
1	dwdate	0.0
2	supplier	0.09
3	part	0.14
4	customer	0.31
5	lineorder	78.54
6	lineorder_denorm_	330.74

Once “Star Schema” was denormalized into big fat table we can repeat our queries and look at how they performed in comparison with “lift & shift” approach and how much the cost to process will change.

#### QUERY 1

Query complete (3.8s, 17.9 GB processed) , Cost: 8.74¢

```

SELECT
  sum(lo_extendedprice*lo_discount) as revenue
FROM
  ssb.lineorder_denorm_records
WHERE
  dwdate.d_year = 1997
  AND lo_discount between 1 and 3
  AND lo_quantity < 24;

```

#### QUERY 2

Query complete (6.6s, 24.9 GB processed) , Cost: 12.16¢

```

SELECT
  sum(lo_revenue),
  dwdate.d_year,
  part.p_brand1
FROM
  ssb.lineorder_denorm_records
WHERE
  part.p_category = 'MFGR#12'
  AND supplier.s_region = 'AMERICA'

```

```

GROUP BY
    ddate.d_year,
    part.p_brand1
ORDER BY
    ddate.d_year,
    part.p_brand1;

```

### QUERY 3

Query complete (8.5s, 27.4 GB processed) , Cost: 13.23¢

```

SELECT
    customer.c_city,
    supplier.s_city,
    ddate.d_year,
    SUM(lo_revenue) AS revenue
FROM
    ssb.lineorder_denorm_records
WHERE
    (customer.c_city='UNITED KI1'
     OR customer.c_city='UNITED KI5')
    AND (supplier.s_city='UNITED KI1'
        OR supplier.s_city='UNITED KI5')
    AND ddate.d_yearmonth = 'Dec1997'
GROUP BY
    customer.c_city,
    supplier.s_city,
    ddate.d_year
ORDER BY
    ddate.d_year ASC,
    revenue DESC;

```

We can see some improvement in response time after denormalization, but these might not be enough to justify a significant increase in stored data size (~80GB “star schema” VS ~330GB for big fat table) and data processed on per query level (for Q3 it is 18.0 GB processed at a cost ~8.79¢ for “star schema” VS 24.5 GB processed at a cost: 13.23¢ for big fat table).

### DATE PARTITIONED FACT TABLE

Above was an extreme case in which all dimensions were collapsed into what is known as a fact table. However, in real life we could have used a combination of both approaches, collapsing some dimensions into the fact table and leaving some as standalone tables.

For instance, it makes perfect sense for the date/time dimension directly being collapsed into the fact table, and converting the fact table into a date partitioned table. For this specific demonstration case we will leave the rest of dimensions intact.

To achieve it, we need to:

1. create date-partitioned table  

```
bq mk --time_partitioning_type=DAY ssb.lineorder_
denorm_records_p
```
2. Extract list of day keys in the dataset  

```
bq query 'SELECT d_datekey FROM ssb.dwdate ORDER BY
d_datekey' >partitions.txt
```
3. Create partitioned by joining fact table with dwdate dimension using the following script to loop through available partition keys  

```
for i in `cat partitions.txt`
do
    bq query \
    --allow_large_results \
    --replace \
    --noflatten_results \
    --destination_table 'ssb.lineorder_denorm_
records_p${i}' \
    'bq query --use_legacy_sql=false 'SELECT
t1.*,t5 as dwdate FROM ssb.lineorder t1 JOIN
ssb.dwdate t5 ON (t1.lo_orderdate = t5.d_
datekey) WHERE t5.d_datekey='${i}
done
```

Once partitioning is done we can query all partition from ssb.lineorder\_denorm\_records\_p table as the following

```
SELECT partition_id from [ssb.lineorder_denorm_
records_p$__PARTITIONS_SUMMARY__];
```

And we can also run count across all partitions to see how the data is distributed across partitions

```
SELECT
    dwdate.d_datekey,
    COUNT(*) rows
FROM
    ssb.lineorder_denorm_records_p
GROUP BY
    dwdate.d_datekey
ORDER BY
    dwdate.d_datekey;
```

Now, let's rewrite Query# 3 taking advantage of partitioning as the following

### QUERY 3

Query complete (4.9s, 312 MB processed), Cost: 0.15¢

```
SELECT
  c_city,
  s_city,
  dwdate.d_year,
  SUM(lo_revenue) AS revenue
FROM
  ssb.lineorder_denorm_records_p,
  ssb.supplier,
  ssb.customer
WHERE
  lo_custkey = c_custkey
  AND lo_suppkey = s_suppkey
  AND (c_city='UNITED KI1'
       OR c_city='UNITED KI5')
  AND (s_city='UNITED KI1'
       OR s_city='UNITED KI5')
  AND lineorder_denorm_records_p._PARTITIONTIME
  BETWEEN TIMESTAMP ("1992-01-01")
  AND TIMESTAMP ("1992-01-31")
GROUP BY
  c_city,
  s_city,
  dwdate.d_year
ORDER BY
  dwdate.d_year ASC,
  revenue DESC;
```

Now, with the use of date-based partitions, we see that query response time is improved and the the amount of data processed is reduced significantly.

## DIMENSION TABLES

### SLOWLY CHANGING DIMENSIONS (SCD)

SCDs are the dimensions that evolve over time. In some cases only most recent state is important (Type1) in some other situations before and after states are kept (Type3) and in many cases the whole history should be preserved (Type2) to report accurately on historical data.

For this exercise let's look at how to implement most widely used Type2 SCD. Type2 for which an entire history of updates should be preserved, is really easy to implement in BigQuery. All you need to do is to add one SCD metadata field called "startDate" to table schema and implement SCD updates as straight additions to

existing table with startDate set to current date. No complex DMLs are required. And due to “scale out” nature of BigQuery and the fact that it does full table scans rather than relying on indexes, to get the most recent version of the dimension table is very easy using correlated subqueries and saving it as a View

```
SELECT
  s_suppkey,
  s_name,
  s_phone,
  startDate
FROM
  ssb.supplier_scd s1
WHERE
  startDate = (
    SELECT
      MAX(startDate)
    FROM
      ssb.supplier_scd s2
    WHERE
      s1.s_suppkey=s2.s_suppkey)
```

## FAST CHANGING DIMENSIONS (FCD)

FCDs are dimensions that are being updated at a much faster pace. And although these are more complex to implement in conventional data warehouse due to the high frequency of changes and rapid table growth, implementing them in BigQuery is no different from SCD.

## POST-MIGRATION

### MONITORING

#### STACKDRIVER

Recently Google added BigQuery support as one of the resources in Stackdriver. It allows you to report on the most important project and dataset level metrics summarized below. In addition to that, Stackdriver allows setting threshold, change rate, and metric presence based alerts on any of these metric with triggering different forms of notification.

The following area are currently supported:

- Processed data (data scanned)
- Aggregates of query Time statistics
- Computation slot allocation and usage
- Number and size of each table in a dataset
- Number of bytes and rows uploaded for each table in a dataset

And here are some of the current limitations of Stackdriver integration:

- BigQuery resources are not yet supported by Stackdriver Grouping making it hard to set threshold based alerts based on custom groupings of BigQuery resources.
- Long Running Query report or similar resources used per query views are not available from Stackdriver making it harder to troubleshoot, identify problematic queries and automatically react to them.
- There are Webhooks notifications for BigQuery Alerts in Stackdriver, “Custom Quotas” and “Billing Alerts” in GCP console, but I have not found an easy way to implement per-query actions.
- On the Alert side I think it might be useful to be able to send messages to Cloud Function (although general Webhooks are supported already) and PubSub.
- Streamed data is a billable usage and seeing this stat would be useful.

#### AUDIT LOGS

Stackdriver integration is extremely valuable to get understanding on per project BigQuery usage, but many times we need to dig deeper and understand platform usage on a more granular level such as individual department or user levels.

BigQuery Audit (<https://cloud.google.com/bigquery/audit-logs>) log is a valuable source for such information and can answer many questions such as:

- who are the users running the queries
- how much data is being processed per query or by an individual user in a day or a month.
- what is the cost per department processing data
- what are the long running queries or queries processing too much data

To make this type of analysis easier, GCP Cloud Logging comes with the ability to save audit log data into BigQuery. Once configured entries will be persisted into day-partitioned table in BigQuery and the following query can be used to get per user number of queries and estimated processing charges

```
SELECT
  protoPayload.authenticationInfo.principalEmail User,
  ROUND((total_bytes*5)/1000000000000, 2) Total_Cost_
  For_User,
  Query_Count
FROM (
  SELECT
    protoPayload.authenticationInfo.principalEmail,
    SUM(protoPayload.serviceData.jobCompletedEvent.
    job.jobStatistics.totalBilledBytes) AS total_bytes,
    COUNT(protoPayload.authenticationInfo.
```

```
principalEmail) AS query_count,
FROM
  TABLE_DATE_RANGE(AuditLogs.cloudaudit_googleapis_
com_data_access_, DATE_ADD(CURRENT_TIMESTAMP(), -7, 'DAY'),
CURRENT_TIMESTAMP())
WHERE
  protoPayload.serviceData.jobCompletedEvent.
eventName = 'query_job_completed'
GROUP BY
  protoPayload.authenticationInfo.principalEmail)
ORDER BY
  2 DESC
```

#### QUERY EXPLAIN PLAN

Query's execution plan (<https://cloud.google.com/bigquery/query-plan-explanation>) is another important tool to get familiar with. It is available through the BigQuery web UI or the API after a query completes.

In addition to similar information available from Audit Logs on who was running the query, how long the query took and volume of data scanned, it goes deeper and makes the following useful information available:

- priority of the query (batch VS interactive)
- whether the cache was used
- what columns and tables were referenced without a need to parse query string
- stages of query execution, records IN/OUT for each stage as well as wait/read/compute/write ratios

Unfortunately this information is only available through Web UI on per query basis which makes it hard to analyze this information across multiple queries.

One option is to use API where it is relatively easy to write a simple agent that would periodically retrieve query history and save it to BigQuery for subsequent analysis. Here is a simple Node.js script <https://gist.github.com/anonymous/ca36a117e418b88fe2cf1f28e628def8>

## OTHER USEFUL TOOLS

- Streak BigQuery Developer Tools provides graphing, timestamp conversions, queries across datasets, etc. - [https://chrome.google.com/webstore/detail/streak-bigquery-developer/lfmljpmipdibdhhbmmaadmhpaldcihg?utm\\_source=gmail](https://chrome.google.com/webstore/detail/streak-bigquery-developer/lfmljpmipdibdhhbmmaadmhpaldcihg?utm_source=gmail)
- BigQuery Mate provides improvements for BQ WebUI such as cost estimates, styling, parameterized queries, etc.- [https://chrome.google.com/webstore/detail/bigquery-mate/nepgdloeceldecnoaaegljlichnfognh?utm\\_source=gmail](https://chrome.google.com/webstore/detail/bigquery-mate/nepgdloeceldecnoaaegljlichnfognh?utm_source=gmail)
- Save BigQuery to GitHub - [https://chrome.google.com/webstore/detail/save-bigquery-to-github/heeofgmoliomldhghlgeikfklacpnad?utm\\_source=gmail](https://chrome.google.com/webstore/detail/save-bigquery-to-github/heeofgmoliomldhghlgeikfklacpnad?utm_source=gmail)



## ABOUT THE AUTHOR

Vladimir Stoyak

*Principal Consultant for Big Data, Certified Google Cloud Platform Qualified Developer*

Vladimir Stoyak is a principal consultant for big data. Vladimir is a certified Google Cloud Platform Qualified Developer, and Principal Consultant for Pythian's Big Data team. He has more than 20 years of expertise working in Big Data and machine learning technologies including Hadoop, Kafka, Spark, Flink, Hbase, and Cassandra. Throughout his career in IT, Vladimir has been involved in a number of startups. He was Director of Application Services for Fusepoint, which was recently acquired by CenturyLink. He also founded AlmaLOGIC Solutions Incorporated, an e-Learning analytics company.

## ABOUT PYTHIAN

Pythian is a global IT services company that helps businesses become more competitive by using technology to reach their business goals. We design, implement, and manage systems that directly contribute to revenue and business success. Our services deliver increased agility and business velocity through IT transformation, and high system availability and performance through operational excellence. Our highly skilled technical teams work as an integrated extension of our clients' organizations to deliver continuous transformation and uninterrupted operational excellence using our expertise in databases, cloud, DevOps, big data, advanced analytics, and infrastructure management.

Pythian, The Pythian Group, "love your data", pythian.com, and Adminiscope are trademarks of The Pythian Group Inc. Other product and company names mentioned herein may be trademarks or registered trademarks of their respective owners. The information presented is subject to change without notice. Copyright © <year> The Pythian Group Inc. All rights reserved.