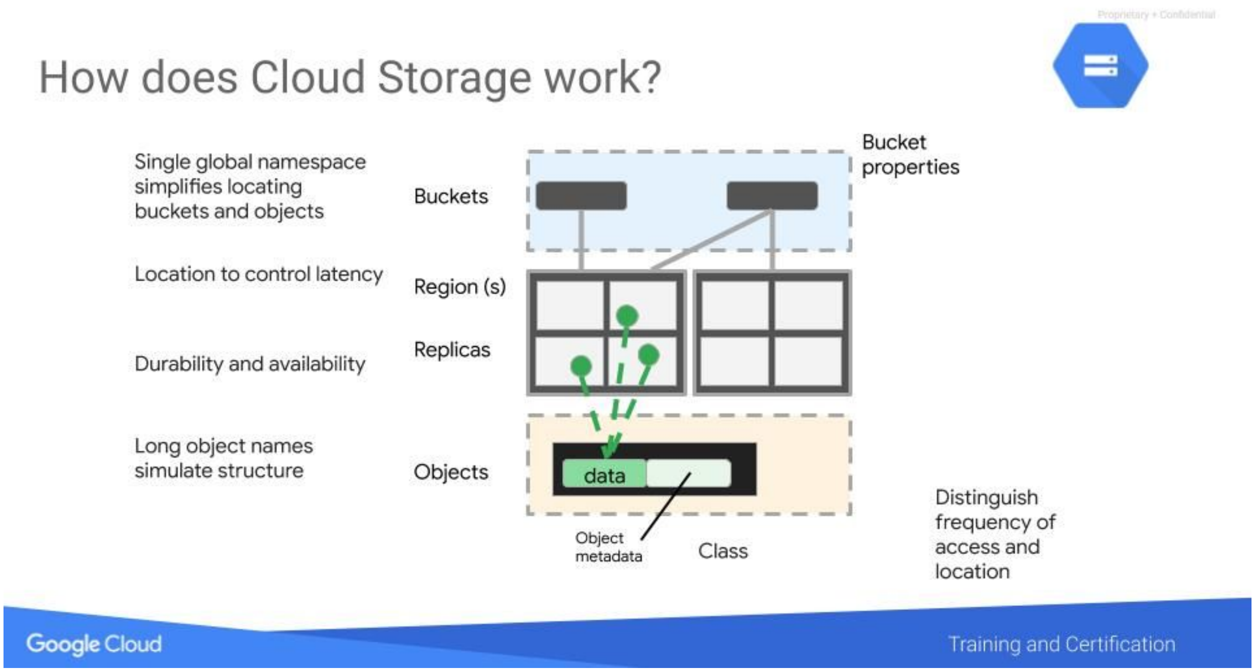
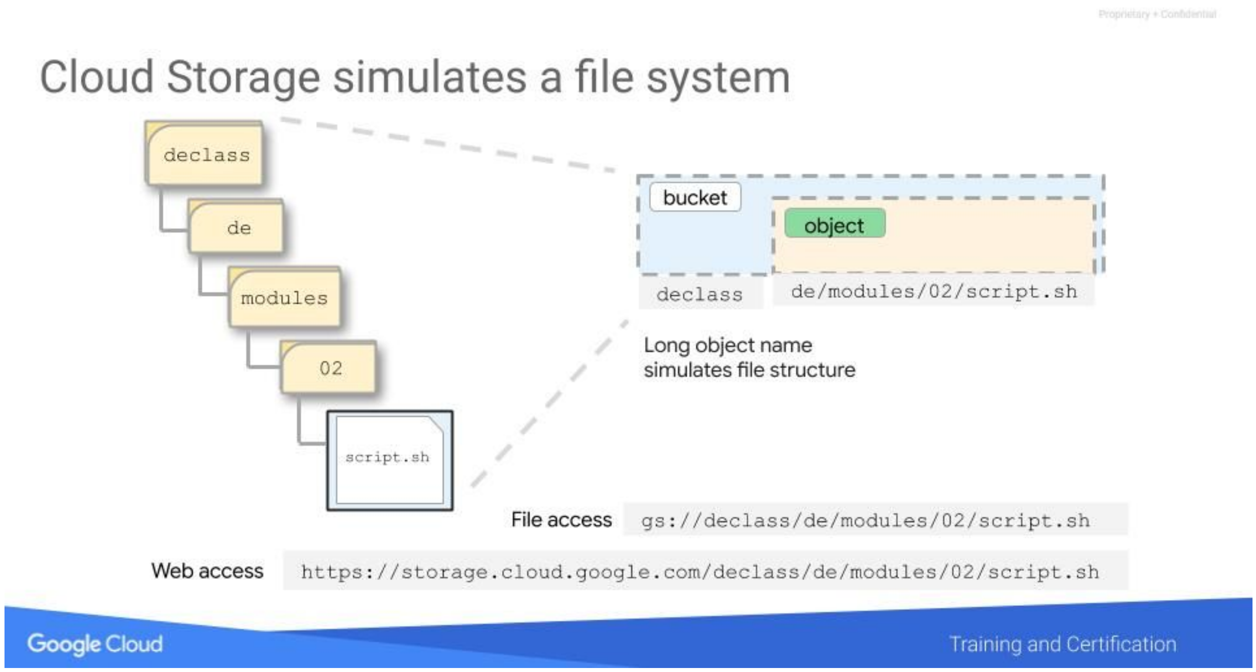
Cloud Dataproc Storage Services:
Cloud Storage, Cloud Bigtable, BigQuery



Cloud Storage is an object store. A lot of its amazing properties have to do with the fact of what's missing -- that it is not a file system.

A global namespace for buckets simplifies locating a specific bucket. Buckets are either multi-regional or regional. Objects within a bucket are replicated across zones.

That gives the objects durability and availability that are not possible in a physical storage device like a disk. Objects have several properties, among them is "class" which declares the frequency of anticipated access of the object. This allows the Cloud Storage service to distinguish between types of objects and internally manage them to service levels.

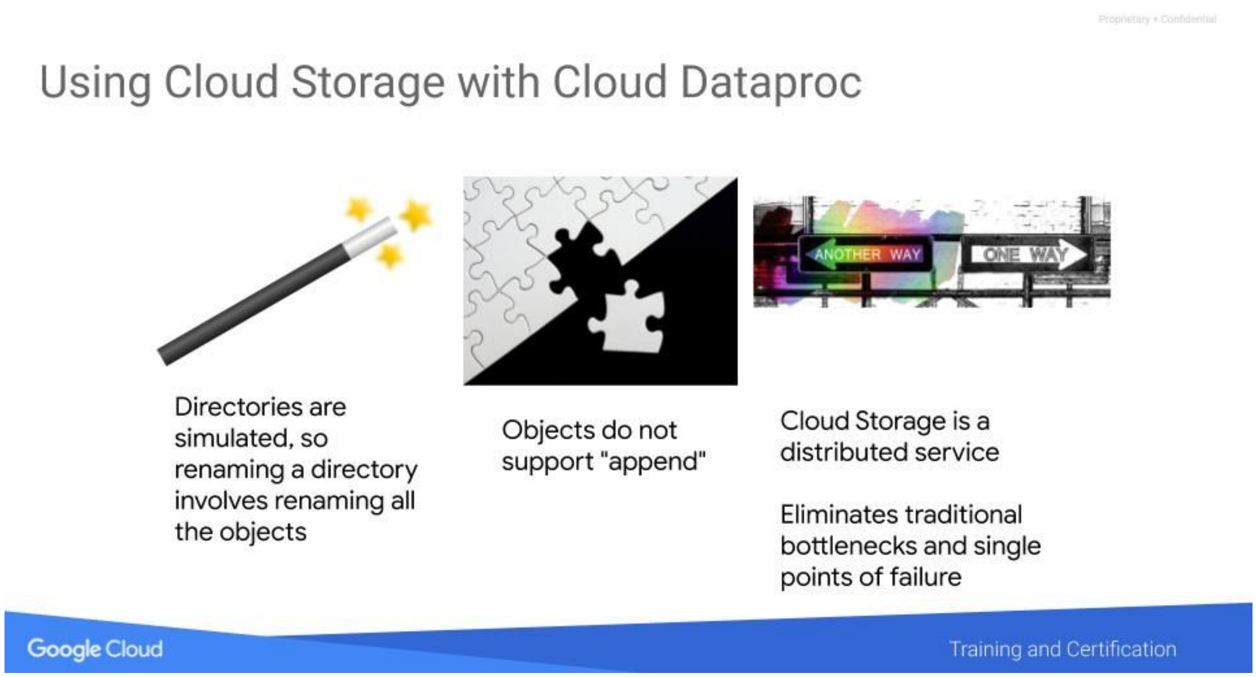


Cloud Storage simulates a file system by enabling forward slashes to be used as part of the object name. In the example above, the object is named "de/modules/02/script.sh" And because of the consistent use of slashes in the name, it is possible to simulate a file in a directory.

This allows objects to be addressed using file access and web access protocols.

The simulation does not work identically to a file system. For example, when you move a "file" like script.sh from one directory to another, what is really happening is the object is being renamed. This makes Cloud Storage faster for some operations and slower for others when compared with a file system.

https://storage.cloud.google.com uses TLS (HTTPS) to transport your data which protects credentials as well as data in transit. Avoid the use of sensitive information as part of bucket or object names.



Directories are simulated, so renaming a directory involves renaming all the objects.
Objects are not files, so they don't support "append".
Cloud Storage is a distributed service. That means it eliminates traditional file system bottlenecks and Single Points of Failure (SPoFs).

Latency is higher for data in Cloud Storage than HDFS on a Persistent Disk in the cluster.
Throughput for processing data in Cloud storage is higher than throughput for HDFS on Persistent disk in the cluster.

Cloud Storage is very good at bulk and parallel operations on larger objects. So for performance, keep these in mind:

- Avoid small reads
- Use large block/file sizes where possible
- Avoid iterating over many nested directories in a single job

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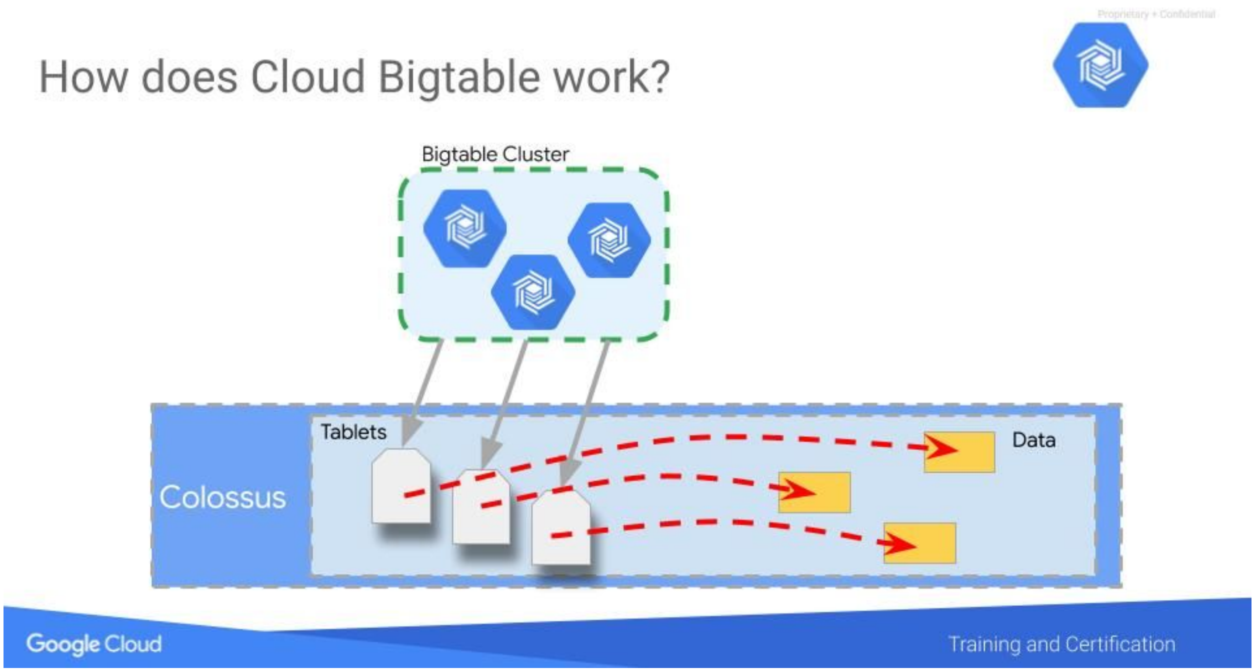
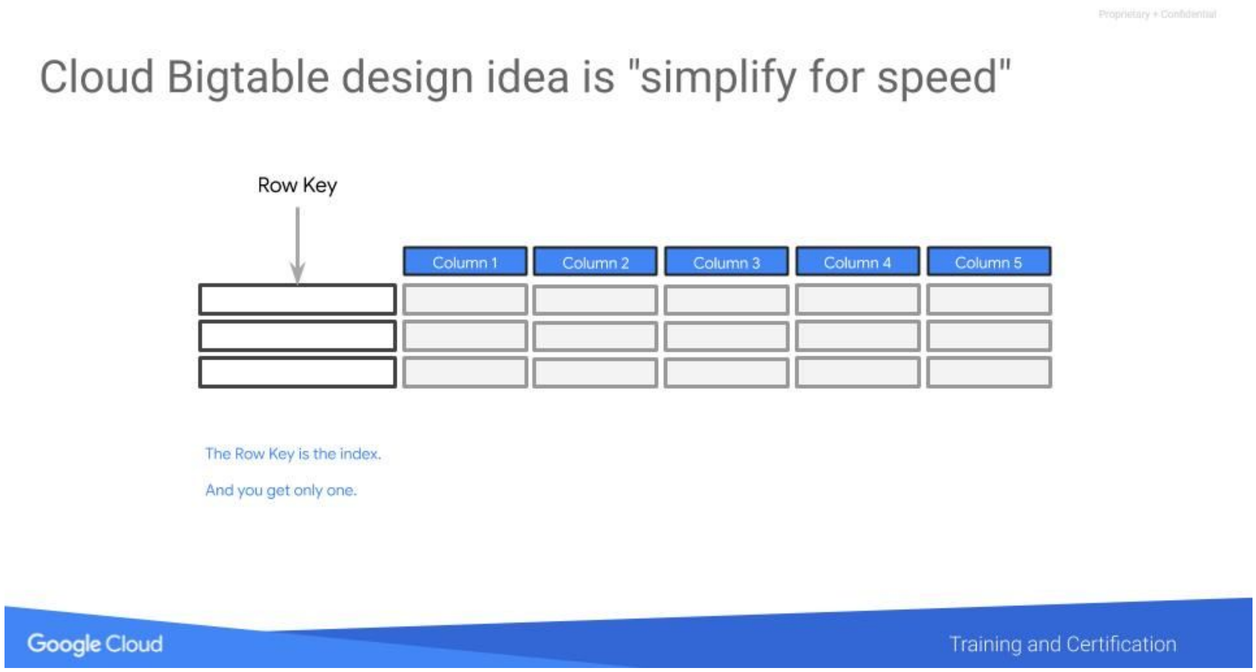


Cloud Bigtable stores data in a file system called Colossus. Colossus also contains data structures called Tablets that are used to identify and manage the data. And metadata about the Tablets is what is stored on the VMs in the Bigtable cluster itself.

This design provides amazing qualities to Cloud Bigtable. It has three levels of operation. It can manipulate the actual data. It can manipulate the Tablets that point to and describe the data. Or it can manipulate the metadata that points to the Tablets. Rebalancing tablets from one node to another is very fast, because only the pointers are updated.

Cloud Bigtable is a learning system. It detects "hot spots" where a lot of activity is going through a single Tablet and splits the Tablet in two. It can also rebalance the processing by moving the pointer to a Tablet to a different VM in the cluster. So its best use case is with big data -- above 300 GB -- and very fast access but constant use over a longer period of time. This gives Cloud Bigtable a chance to learn about the traffic pattern and rebalance the Tablets and the processing.

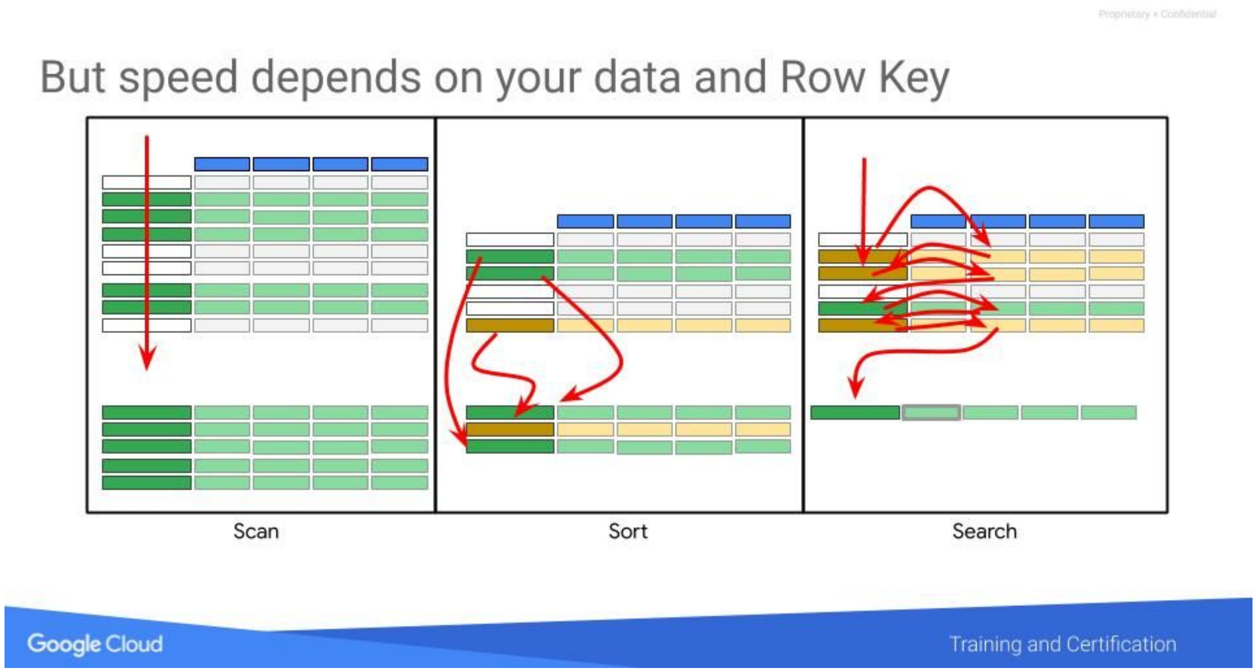
When a node is lost in the cluster, no data is lost. And recovery is fast because only the metadata needs to be copied to the replacement node.
Colossus provides better durability than the default 3 replicas provided by HDFS.



Cloud Bigtable stores data in tables. And to begin with, it is just a table with rows and columns. However, unlike other table-based data systems like spreadsheets and SQL databases, Cloud Bigtable has only one index.
That index is called the Row Key. There are no alternate indexes or secondary indexes. And when data is entered, it is organized lexicographically by the Row Key.

The design principle of Cloud Bigtable is speed through simplification. If you take a traditional table, and simplify the controls and operations you allow yourself to perform on it then you can optimize for those specific tasks.
It is the same idea behind RISC (Reduced Instruction Set Computing). Simplify the operations. And when you don't have to account for variations, you can make those that remain very fast.

In Cloud Bigtable, the first thing we must abandon in our design is SQL. This is a standard of all the operations a database can perform. And to speed things up we will drop most of them and build up from a minimal set of operations. That is why Cloud Bigtable is called a NoSQL database.



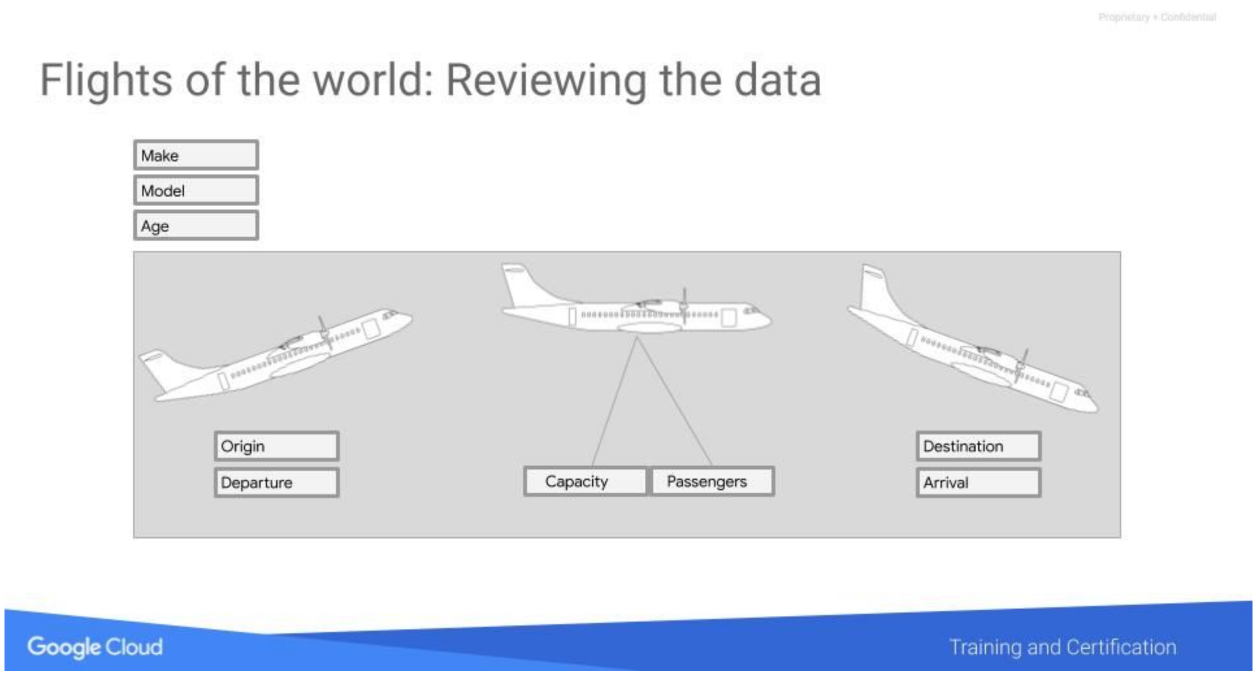
The green items are the results you want to produce from the query. In the best case you are going to scan the Row Key one time, from the top-down. And you will find all the data you want to retrieve in adjacent and contiguous rows. You might have to skip some rows. But the query takes a single scan through the index from top-down to collect the result set.

The second instance is sorting. You are still only looking at the Row Key. In this case the yellow line contains data that you want, but it is out of order. You can collect the data in a single scan, but the solution set will be disorderly. So you have to take the extra step of sorting the intermediate results to get the final results. Now think about this. What does the additional sorting operation do to timing? It introduces a couple of variables. If the solution set is only a few rows, then the sorting operation will be quick. But if the solution set is huge, the sorting will take more time. The size of the solution set becomes a factor in timing. The orderliness of the original data is another factor. If most of the rows are already in order, there will be less manipulation required than if there are many rows out of order. The orderliness of the original data becomes a factor in timing. So introducing sorting means that the time it takes to produce the result is much more variable than scanning.

The third instance is searching. In this case, one of the columns contains critical data. You can't tell whether a row is a member of the solution set or not without examining the data contained in the critical column. The Row Key is no longer sufficient. So now you are bouncing back and forth between Row Key and column contents. There are many approaches to searching. You could divide it up into multiple steps, one scan through the Row Keys and subsequent scans through the columns, and then perhaps a final sort to get the data in the order you want. And it gets much more complicated if there are multiple columns containing critical information. And it gets more complicated if the conditions of solution set membership involve logic such as a value in one column AND a value in another column, or a value in one column OR a value in another column. However, any algorithm or strategy you use to produce the result is going to be slower and more variable than scanning or sorting.

What is the lesson from this exploration? That to get the best performance with the design of the Cloud Bigtable service, you need to get your data in order first, if possible, and you need to select or construct a Row Key that minimizes sorting and searching and turns your most common queries into scans.

Not all data and not all queries are good use cases for the efficiency that the Cloud Bigtable service offers. But when it is a good match, Cloud Bigtable is so consistently fast that it is magical.



Each entry records the occurrence of one flight.

The data include city of origin and the date and time of departure, and destination city and date and time of arrival.
Each airplane has a maximum capacity, and related to this is the number of passengers that were actually aboard each flight.
Finally, there is information about the aircraft itself, including the manufacturer, called the make, the model number, and the current age of the aircraft at the time of the flight.

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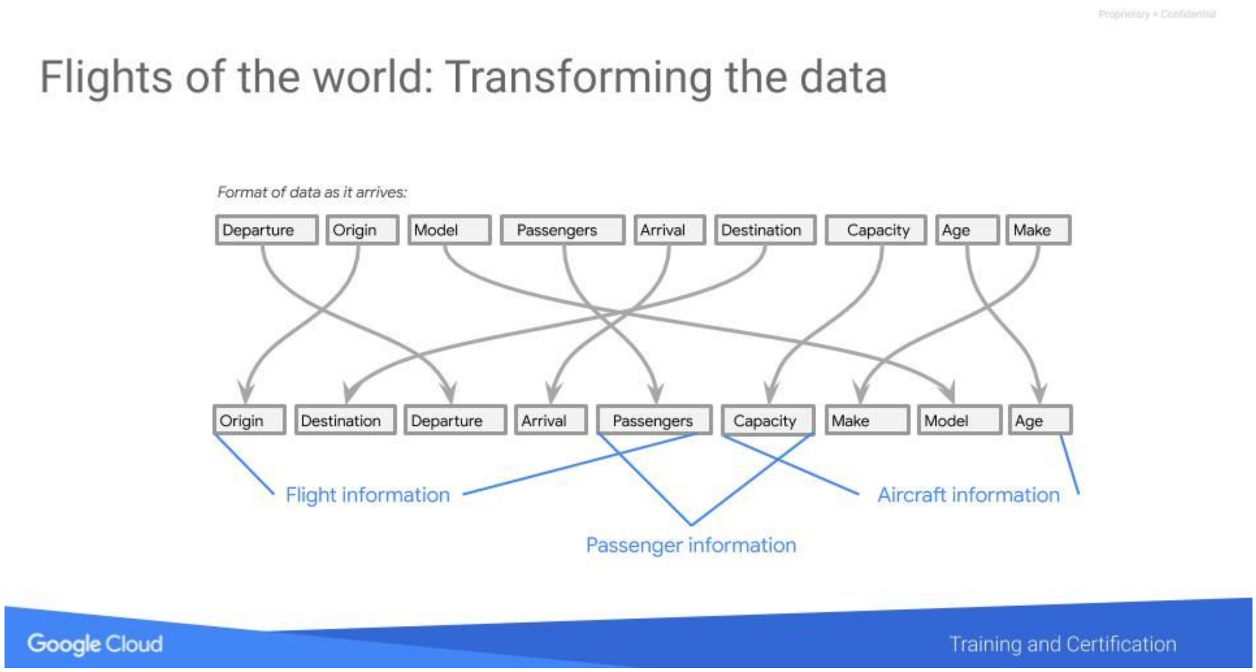
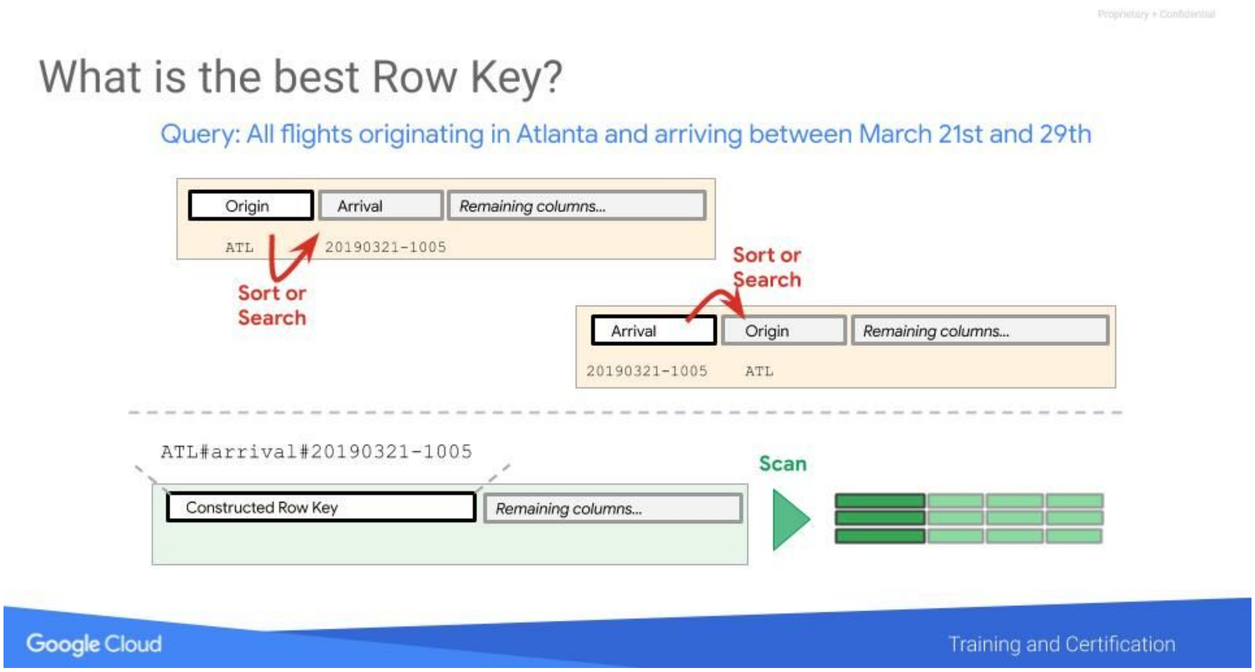


Often the data arrives in a pre-selected order that might not be optimal for the purposes of the application.
In this case, transforming the data before storing it makes sense.

In the example, the fields are sorted into Flight Information and Aircraft Information.

The number of passengers on a flight and the capacity of the flight to hold passengers were moved to the end, and beginning of the groups so that passenger-related information would be adjacent.



In this example, the Row Key will be defined for the most common use case. The Query is to find all flights originating from the Atlanta airport and arriving between March 21st and 29th. The airport where the flight originates is in the Origin field. And the date when the aircraft landed is listed in the Arrival field.

If you use Origin as the Row Key, you will be able to pull out all flights from Atlanta -- but the Arrival field will not necessarily be in order. So that means searching through the column to produce the solution set.

If you use the Arrival field as the Row Key, it will be easy to pull out all flights between March 21st and 29th, but the airport of origin won't be organized. So you will be searching through the arrival column to produce the solution set.

In the third example, a Row Key has been constructed from information extracted from the Origin field and the Arrival field -- creating a constructed Row Key. Because the data is organized lexicographically by the Row Key, all the Atlanta flights will appear in a group, and sorted by date of arrival. Using this Row Key you can generate the solution set with only a scan.

In this example, the data was transformed when it arrived. So constructing a Row Key during the transformation process is straightforward.

Cloud Bigtable schema organization

Row Key	Column Families: Flight_Information					Aircraft_Information			
	Origin	Destination	Departure	Arrival	Passengers	Capacity	Make	Model	Age
ATL#arrival#20190321-1121	ATL	LON	20190321-0311	20190321-1121	158	162	B	737	18
ATL#arrival#20190321-1201	ATL	MEX	20190321-0821	20190321-1201	187	189	B	737	8
ATL#arrival#20190321-1716	ATL	YVR	20190321-1014	20190321-1716	201	259	B	757	23

Cloud Bigtable also provide Column Families. By accessing the Column Family, you can pull some of the data you need without pulling all of the data from the row or having to search for it and assemble it. This makes access more efficient.

Whenever there are rows containing multiple column values that are related, it is a good idea to group them into a column family. Some NoSQL databases suffer performance degradation if there are too many column families. Cloud Bigtable can handle up to 100 column families without losing performance. And it is much more efficient to retrieve data from one or more column families than retrieving all of the data in a row.

https://cloud.google.com/bigtable/docs/schema-design
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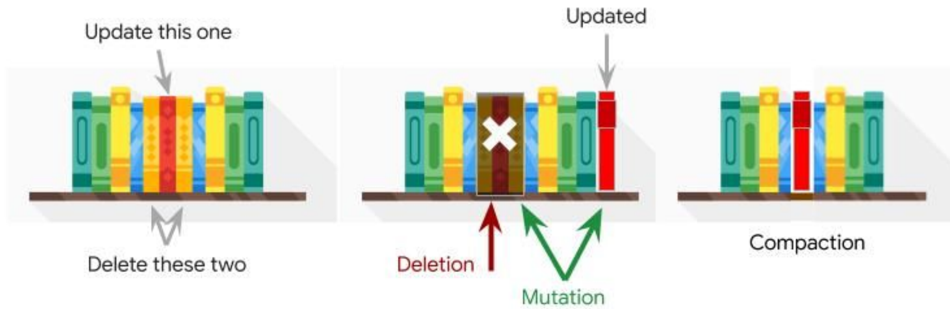
What happens when data in Cloud Bigtable is changed?



When you delete data, the row is marked for deletion and skipped during subsequent processing. It is not immediately removed.
If you make a change to data, the new row is appended sequentially to the end of the table, and the previous version is marked for deletion. So both rows exist for a period of time. Periodically, Cloud Bigtable compacts the table, removing rows marked for deletion and reorganizing the data for read and write efficiency.

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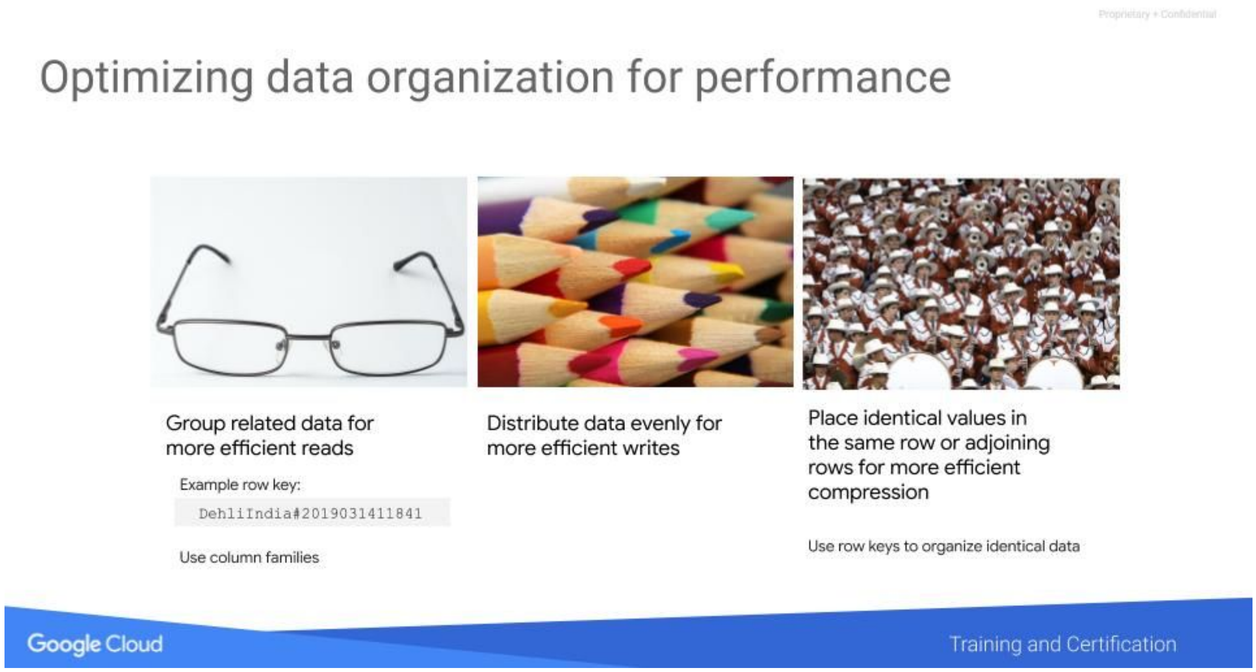

Distributing the writes across nodes provides the best write performance. One way to accomplish this is by choosing row keys that are randomly distributed.

However, choosing a row key that groups related rows so they are adjacent makes it much more efficient to read multiple rows at one time.

There are currently no configuration settings in Cloud Bigtable for compression. However, random data cannot be compressed as efficiently as organized data. Compression works best if identical values are near each other, either in the same row or in adjoining rows. If you arrange your row keys so that rows with identical data are adjacent, the data can be compressed more efficiently.

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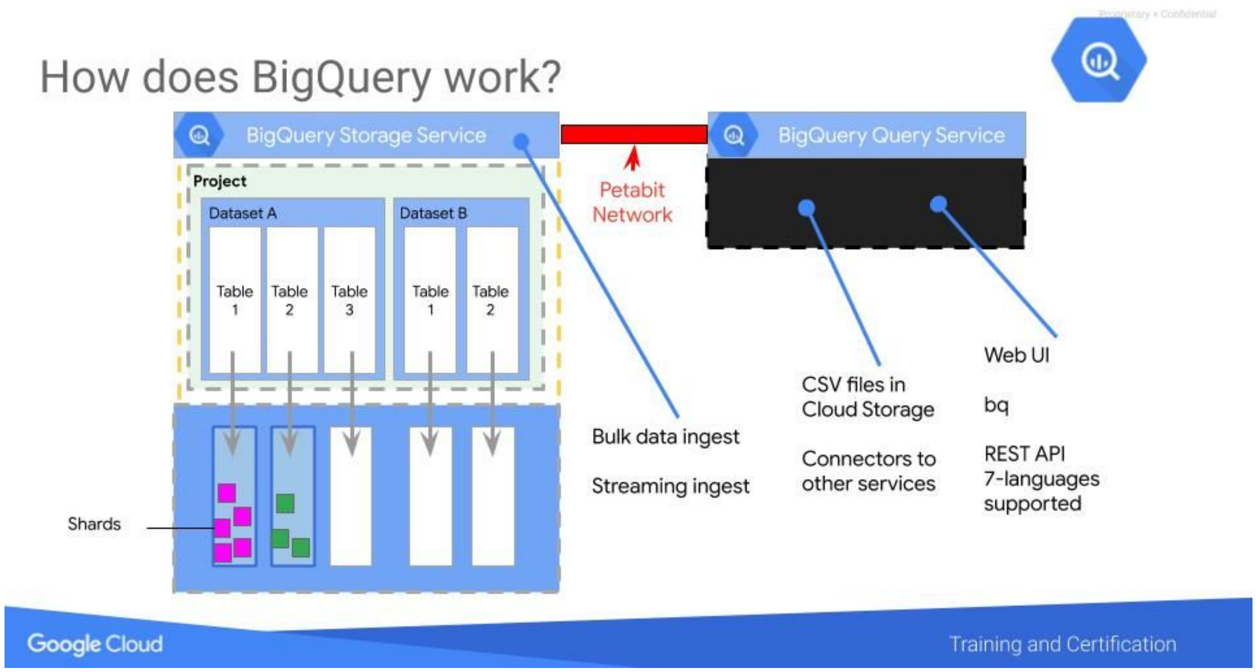

BigQuery is a Data Warehouse service. It is a "serverless" service, meaning that it is fully managed. So users do not have visibility or control over individual servers or clusters of servers.
BigQuery runs data processing jobs that can load, export, copy or query data.

BigQuery has two parts, a storage service and a query service, which work together. They are connected by Google's high speed internal network.

The storage service manages the data.
Data is contained within a project in datasets in tables. The tables are stored as highly compressed columns in Google's Colossus file system which provides durability and availability.

BigQuery Storage Service automatically shards and shuffles data in the underlying file system to provide a very high level of service at huge scales. The sharding occurs automatically and provides the advantages of data distribution while completely concealed from you at the Dataset and Table level.

The storage service supports bulk data ingest and streaming ingest. So it can work with huge amounts of data and also real-time data streams.

Thq query service runs interactive or batch queries that are submitted through console, the BigQuery web UI, the bq command line tool, or via REST API. The REST API is supported for seven programming languages.

There are connectors to other services such as Cloud Dataproc which simplify creating complex workflows between BigQuery and other GCP data processing services.
The query service can also run query jobs on data contained in other locations, such as tables in CSV files hosted in Cloud Storage.

BigQuery is most efficient when working with data contained in its own storage service.

The storage service and the query service work together to internally organize the data to make queries efficient over huge datasets of Terabytes and Petabytes in size.

The most important control over resource consumption and costs is writing a query that controls the amount of data processed. In general, this is done with SELECT by choosing subsets of data at the start of a job rather than by using LIMIT which only omits data from the final results at the end of a job.