Cloud Spanner - Defining Schemas and Understanding Query Plans

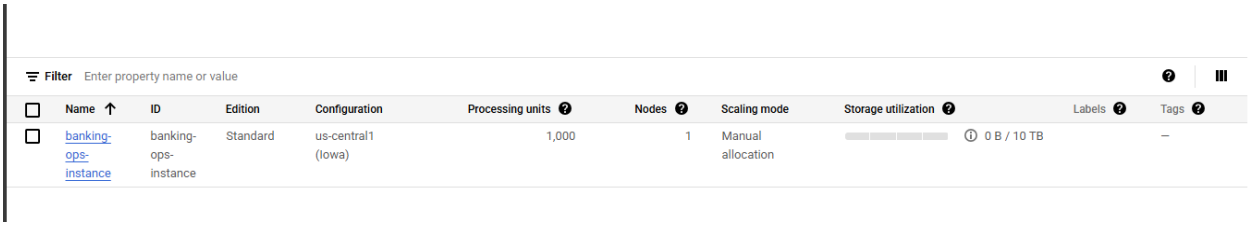
Objective: To gain hands-on experience in defining schemas in Google Cloud Spanner and analyzing query plans for query optimization in a managed relational database environment.

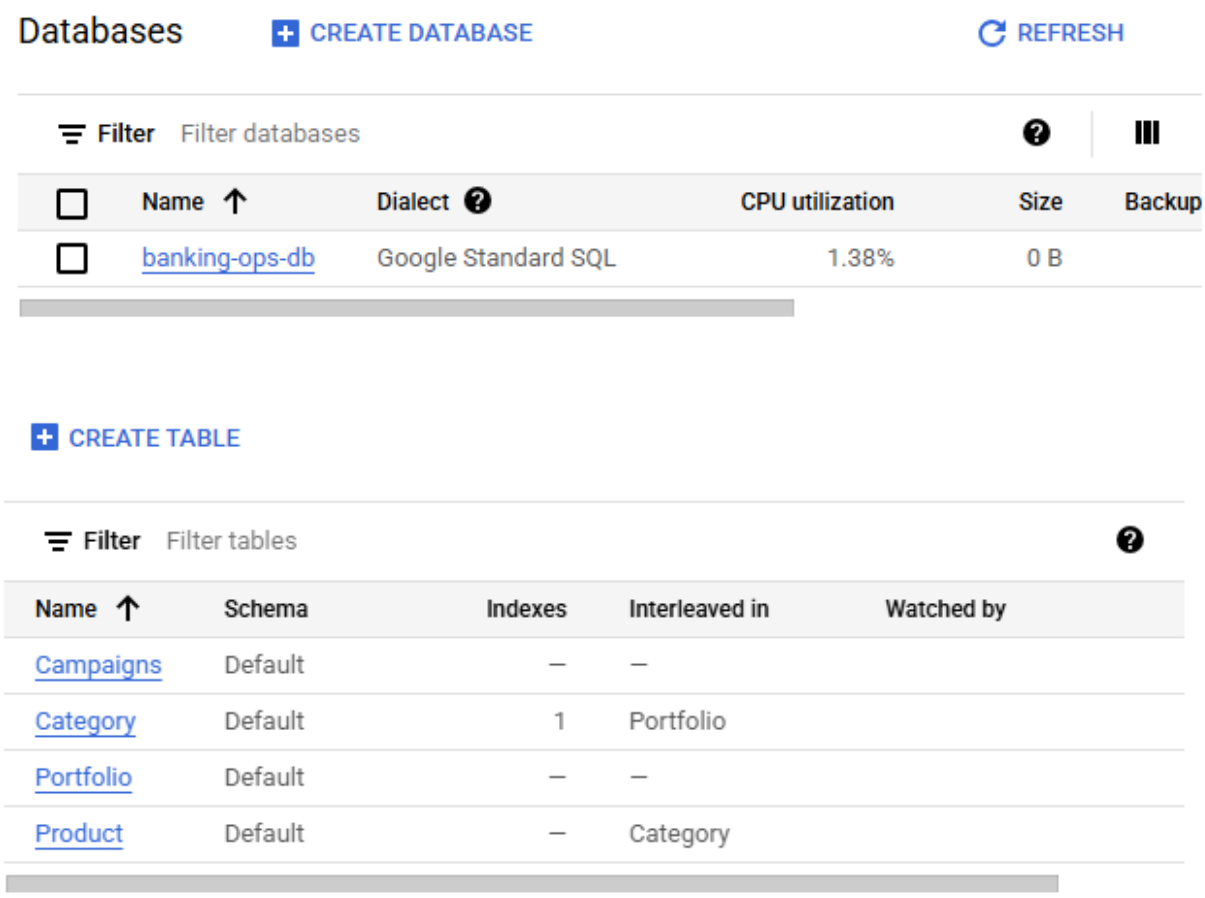
Introduction: Google Cloud Spanner is a fully managed, horizontally scalable, relational database service that offers global transactions and strong consistency. Defining efficient schemas and understanding query plans are essential for maintaining performance and scalability in your Cloud Spanner instances.

Task 1. Load data into tables

The **banking-ops-db** was created with empty tables. Follow the steps below to load data into three of the tables (**Portfolio**, **Category**, and **Product**).

1. From the Cloud Console, open the navigation menu (☰) > **View All Products**, under **Databases** click **Spanner**.
2. The instance name is **banking-ops-instance**, click on the name to explore the databases.
3. The associated database is named **banking-ops-db**. Click on the name, scroll down to **Tables**, and you will see there are four tables already in place.
4. On the left pane of the Console, click **Spanner Studio**. Then click the **+ New SQL Editor Tab** button in the right frame



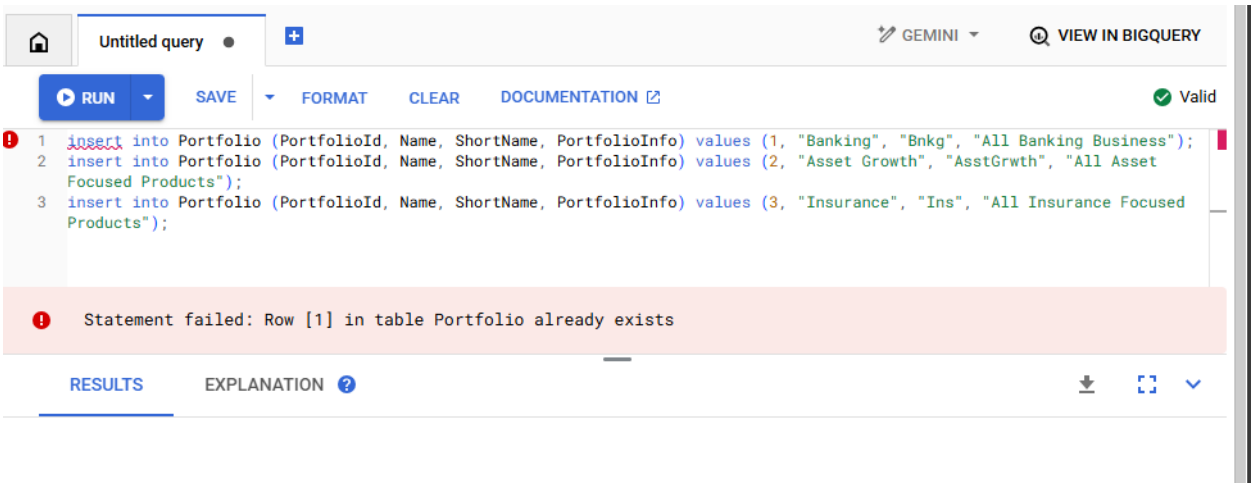


1. This takes you to the **Query** page. Paste the insert statements below as a single block to load the **Portfolio** table. Spanner will execute each in succession. Click **Run**:

   insert into Portfolio (PortfolioId, Name, ShortName, PortfolioInfo) values (1, "Banking", "Bnkg", "All Banking Business");

   insert into Portfolio (PortfolioId, Name, ShortName, PortfolioInfo) values (2, "Asset Growth", "AsstGrwth", "All Asset Focused Products");

   insert into Portfolio (PortfolioId, Name, ShortName, PortfolioInfo) values (3, "Insurance", "Ins", "All Insurance Focused Products");



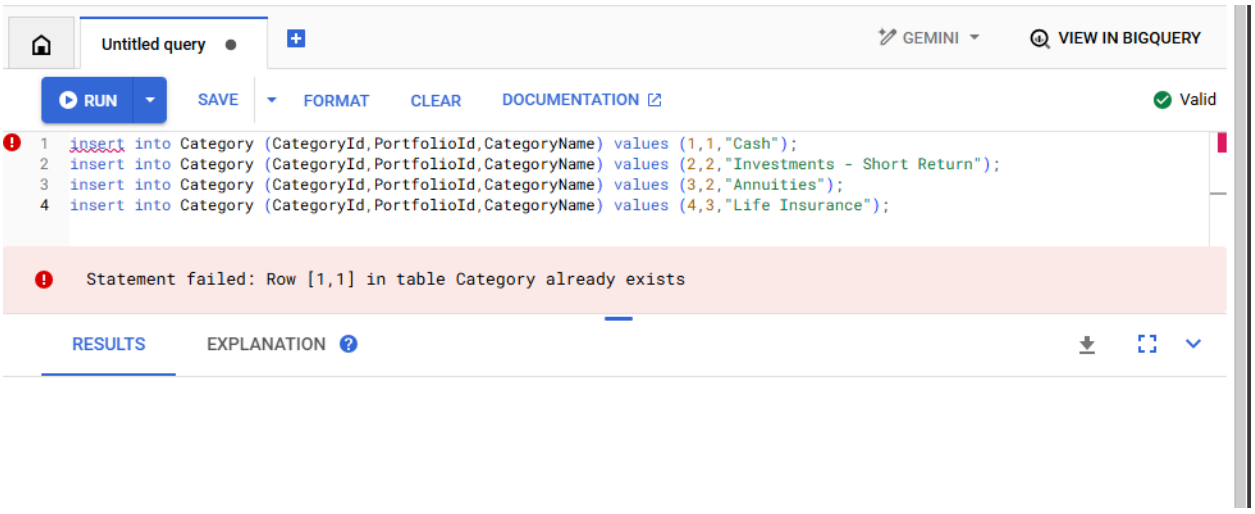
6. The lower page of the screen shows the results of inserting the data one row at a time. A green checkmark also appears on each row of inserted data. The **Portfolio** table now has three rows.
7. Click **Clear** in the top portion of the page.
8. Paste the insert statements below as a single block to load the **Category** table. Click **Run**:

   insert into Category (CategoryId,PortfolioId,CategoryName) values (1,1,"Cash");

   insert into Category (CategoryId,PortfolioId,CategoryName) values (2,2,"Investments - Short Return");

   insert into Category (CategoryId,PortfolioId,CategoryName) values (3,2,"Annuities");

   insert into Category (CategoryId,PortfolioId,CategoryName) values (4,3,"Life Insurance");



9. The lower page of the screen shows the results of inserting the data one row at a time. A green checkmark also appears on each row of inserted data. The **Category** table now has four rows.
10. Click **Clear** in the top portion of the page.
11. Paste the insert statements below as a single block to load the **Product** table. Click **Run**:

```
insert into Product
(ProductId,CategoryId,PortfolioId,ProductName,ProductAssetCode,ProductClass) values
(1,1,1,"Checking Account","ChkAcct","Banking LOB");

insert into Product
(ProductId,CategoryId,PortfolioId,ProductName,ProductAssetCode,ProductClass) values
(2,2,2,"Mutual Fund Consumer Goods","MFundCG","Investment LOB");

insert into Product
(ProductId,CategoryId,PortfolioId,ProductName,ProductAssetCode,ProductClass) values
(3,3,2,"Annuity Early Retirement","AnnuFixed","Investment LOB");

insert into Product
(ProductId,CategoryId,PortfolioId,ProductName,ProductAssetCode,ProductClass) values
(4,4,3,"Term Life Insurance","TermLife","Insurance LOB");

insert into Product
(ProductId,CategoryId,PortfolioId,ProductName,ProductAssetCode,ProductClass) values
(5,1,1,"Savings Account","SavAcct","Banking LOB");

insert into Product
(ProductId,CategoryId,PortfolioId,ProductName,ProductAssetCode,ProductClass) values
(6,1,1,"Personal Loan","PersLn","Banking LOB");

insert into Product
(ProductId,CategoryId,PortfolioId,ProductName,ProductAssetCode,ProductClass) values
(7,1,1,"Auto Loan","AutLn","Banking LOB");

insert into Product
(ProductId,CategoryId,PortfolioId,ProductName,ProductAssetCode,ProductClass) values
(8,4,3,"Permanent Life Insurance","PermLife","Insurance LOB");

insert into Product
(ProductId,CategoryId,PortfolioId,ProductName,ProductAssetCode,ProductClass) values
(9,2,2,"US Savings Bonds","USSavBond","Investment LOB");
```

Task 2. Use pre-built Python client library code to load data

You will be using the client libraries written in Python for the next several steps.

1. Open the **Cloud Shell** and paste the commands below to create and change into a new directory to hold the required files.

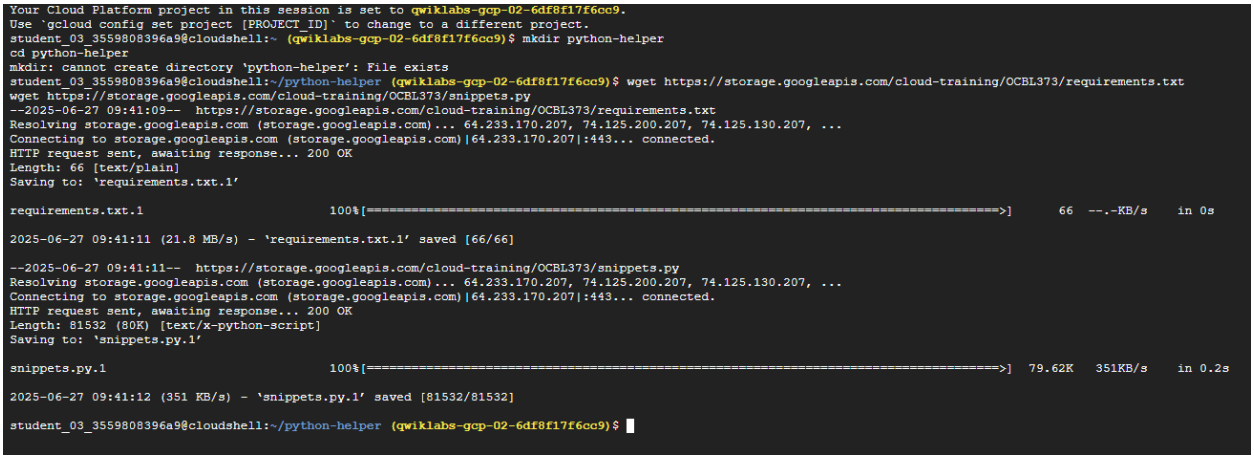
   mkdir python-helper

   cd python-helper

2. Next download two files. One is used to setup the environment. The other is the lab code.

   wget https://storage.googleapis.com/cloud-training/OCBL373/requirements.txt

   wget https://storage.googleapis.com/cloud-training/OCBL373/snippets.py



3. Create an isolated Python environment and install dependencies for the Cloud Spanner client.

   pip install -r requirements.txt

   pip install setuptools

   The **snippets.py** is a consolidated file with multiple Cloud Spanner DDL, DML, and DCL functions that you are going to use as a helper during this lab. Execute **snippets.py** using the **insert_data** argument to populate the **Campaigns** table

   python snippets.py banking-ops-instance --database-id banking-ops-db insert_data

```
student_03_3559808396a9@cloudshell:~/python-helper (qwiklabs-gcp-02-6df8f17f6cc9)$ python snippets.py banking-ops-instance --database-id  banking-ops-d
Traceback (most recent call last):
  File "/home/student_03_3559808396a9/python-helper/snippets.py", line 2204, in <module>
    insert_data(args.instance_id, args.database_id)
  File "/home/student_03_3559808396a9/python-helper/snippets.py", line 347, in insert_data
    with database.batch() as batch:
  File "/home/student_03_3559808396a9/.local/lib/python3.12/site-packages/google/cloud/spanner_v1/database.py", line 828, in __exit__
    self._batch.commit(
  File "/home/student_03_3559808396a9/.local/lib/python3.12/site-packages/google/cloud/spanner_v1/batch.py", line 182, in commit
    response = api.commit(
               ^^^^^^^^^^^
  File "/home/student_03_3559808396a9/.local/lib/python3.12/site-packages/google/cloud/spanner_v1/services/spanner/client.py", line 1704, in commit
    response = rpc(
               ^^^^
  File "/usr/local/lib/python3.12/dist-packages/google/api_core/gapic_v1/method.py", line 131, in __call__
    return wrapped_func(*args, **kwargs)
           ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
  File "/usr/local/lib/python3.12/dist-packages/google/api_core/retry/retry_unary.py", line 293, in retry_wrapped_func
    return retry_target(
           ^^^^^^^^^^^^^
  File "/usr/local/lib/python3.12/dist-packages/google/api_core/retry/retry_unary.py", line 153, in retry_target
    _retry_error_helper(
  File "/usr/local/lib/python3.12/dist-packages/google/api_core/retry/retry_base.py", line 212, in _retry_error_helper
    raise final_exc from source_exc
  File "/usr/local/lib/python3.12/dist-packages/google/api_core/retry/retry_unary.py", line 144, in retry_target
    result = target()
             ^^^^^^^^
  File "/usr/local/lib/python3.12/dist-packages/google/api_core/grpc_helpers.py", line 78, in error_remapped_callable
    raise exceptions.from_grpc_error(exc) from exc
```

```
student_03_3559808396a9@cloudshell:~/python-helper (qwiklabs-gcp-02-6df8f17f6cc9)$ python snippets.py banking-ops-instance --database-id  banking-ops-db query_data
CampaignId: 1, PortfolioId: 1, CampaignStartDate: 2025-06-27, CampaignEndDate: 2025-06-27, CampaignName: New Account Reward, CampaignBudget: 15000
CampaignId: 2, PortfolioId: 2, CampaignStartDate: 2025-06-27, CampaignEndDate: 2025-06-27, CampaignName: Intro to Investments, CampaignBudget: 5000
CampaignId: 3, PortfolioId: 2, CampaignStartDate: 2025-06-27, CampaignEndDate: 2025-06-27, CampaignName: Youth Checking Accounts, CampaignBudget: 25000
CampaignId: 4, PortfolioId: 3, CampaignStartDate: 2025-06-27, CampaignEndDate: 2025-06-27, CampaignName: Protect Your Family, CampaignBudget: 10000
```

Task 3. Query data with client libraries

The **query_data()** function in **snippets.py** can be used to query your database. In this case you use it to confirm the data loaded into the **Campaigns** table. You will not change any code, the section is shown here for your reference.

1. Execute **snippets.py** using the **query_data** argument to query the **Campaigns** table.

   python snippets.py banking-ops-instance --database-id banking-ops-db query_data

```
student_03_3559808396a9@cloudshell:~/python-helper (qwiklabs-gcp-02-6df8f17f6cc9)$ python snippets.py banking-ops-instance --database-id  banking-ops-db query_data
CampaignId: 1, PortfolioId: 1, CampaignStartDate: 2025-06-27, CampaignEndDate: 2025-06-27, CampaignName: New Account Reward, CampaignBudget: 15000
CampaignId: 2, PortfolioId: 2, CampaignStartDate: 2025-06-27, CampaignEndDate: 2025-06-27, CampaignName: Intro to Investments, CampaignBudget: 5000
CampaignId: 3, PortfolioId: 2, CampaignStartDate: 2025-06-27, CampaignEndDate: 2025-06-27, CampaignName: Youth Checking Accounts, CampaignBudget: 25000
CampaignId: 4, PortfolioId: 3, CampaignStartDate: 2025-06-27, CampaignEndDate: 2025-06-27, CampaignName: Protect Your Family, CampaignBudget: 10000
```

Task 4. Updating the database schema

As part of your DBA responsibilities you are required to add a new column called **MarketingBudget** to the **Category** table. Adding a new column to an existing table requires an update to your database schema. Cloud Spanner supports schema updates to a database while the database continues to serve traffic. Schema updates do not require taking the database offline and they do not lock entire tables or columns; you can continue reading and writing data to the database during the schema update.

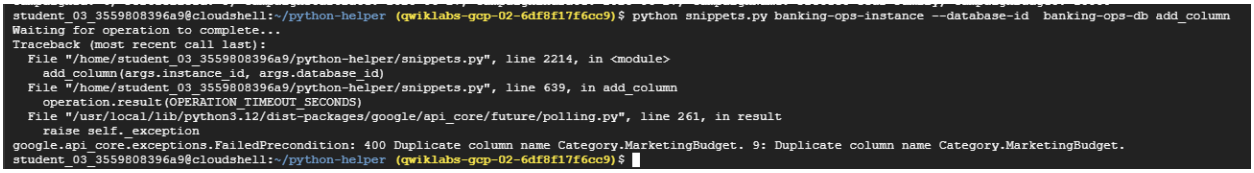
Adding a column using Python

The **update_ddl()** method of the **Database** class is used to modify the schema.

Use the **add_column()** function in **snippets.py** which implements that method. You will not change any code, the section is shown here for your reference.

1. Execute **snippets.py** using the **add_column** argument.

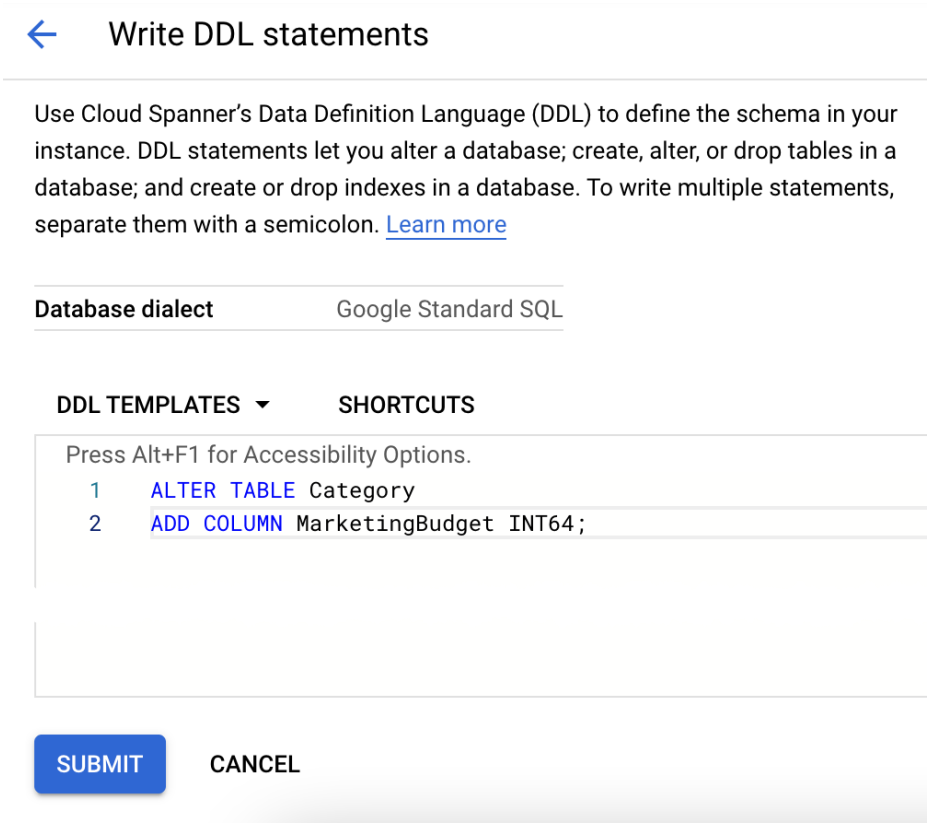
   python snippets.py banking-ops-instance --database-id banking-ops-db add_column



   Other options to add a column to an existing table include the following:

   Issuing a DDL command via the gcloud CLI.

1. Click the table name in the Database listing.
2. Click **Write DDL** in the top right corner of the page.
3. Paste the appropriate DDL in the **DDL Templates** box.
4. Click **Submit**.



1. Execute **snippets.py** using the **update_data** argument.

   python snippets.py banking-ops-instance --database-id banking-ops-db update_data

Query the table again to see the update. Execute **snippets.py** using the **query_data_with_new_column** argument

python snippets.py banking-ops-instance --database-id banking-ops-db query_data_with_new_column

Task 5. Add a Secondary Index

Suppose you wanted to fetch all rows of Categories that have CategoryNames values in a certain range. You could read all values from the CategoryName column using a SQL statement or a read call, and then discard the rows that don't meet the criteria, but doing this full table scan is expensive, especially for tables with a lot of rows. Instead you can speed up the retrieval of rows when searching by non-primary key columns by creating a secondary index on the table.

Adding a secondary index to an existing table requires a schema update. Like other schema updates, Cloud Spanner supports adding an index while the database continues to serve traffic. Cloud Spanner populates the index with data (also known as a "backfill") under the hood. Backfills might take several minutes to complete, but you don't have to take the database offline or avoid writing to certain tables or columns during this process.

Add a secondary index using the Python client library

Use the add_index() method to create a secondary index. You will not change any code, the section is shown here for your reference.

1. Execute **snippets.py** using the **add_index** argument.

   python snippets.py banking-ops-instance --database-id banking-ops-db add_index

Task 6. Examine Query plans

In this section, you will explore Cloud Spanner **Query Plans**.

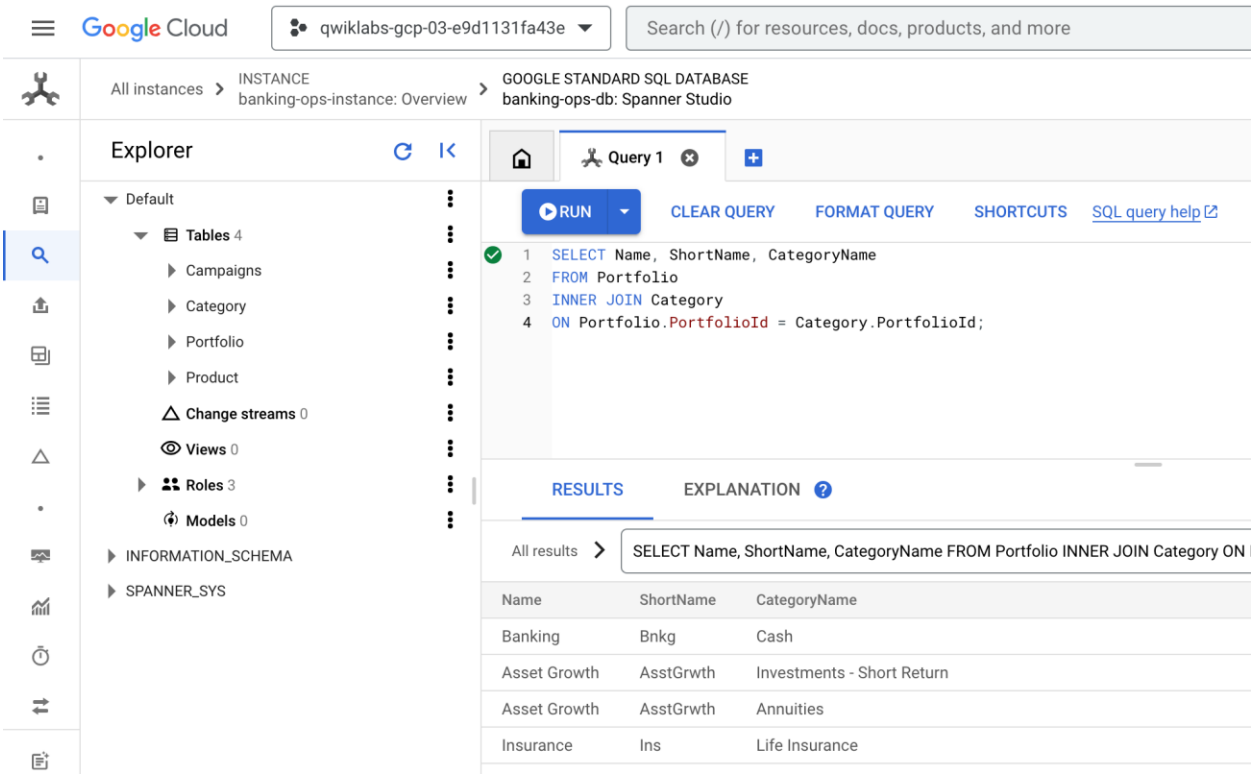
1. Return to the **Cloud Console**, it should still be on the **Query** tab of **Spanner Studio**. Clear any existing query, paste, and **Run** the following query:

   SELECT Name, ShortName, CategoryName

   FROM Portfolio

   INNER JOIN Category

   ON Portfolio.PortfolioId = Category.PortfolioId;

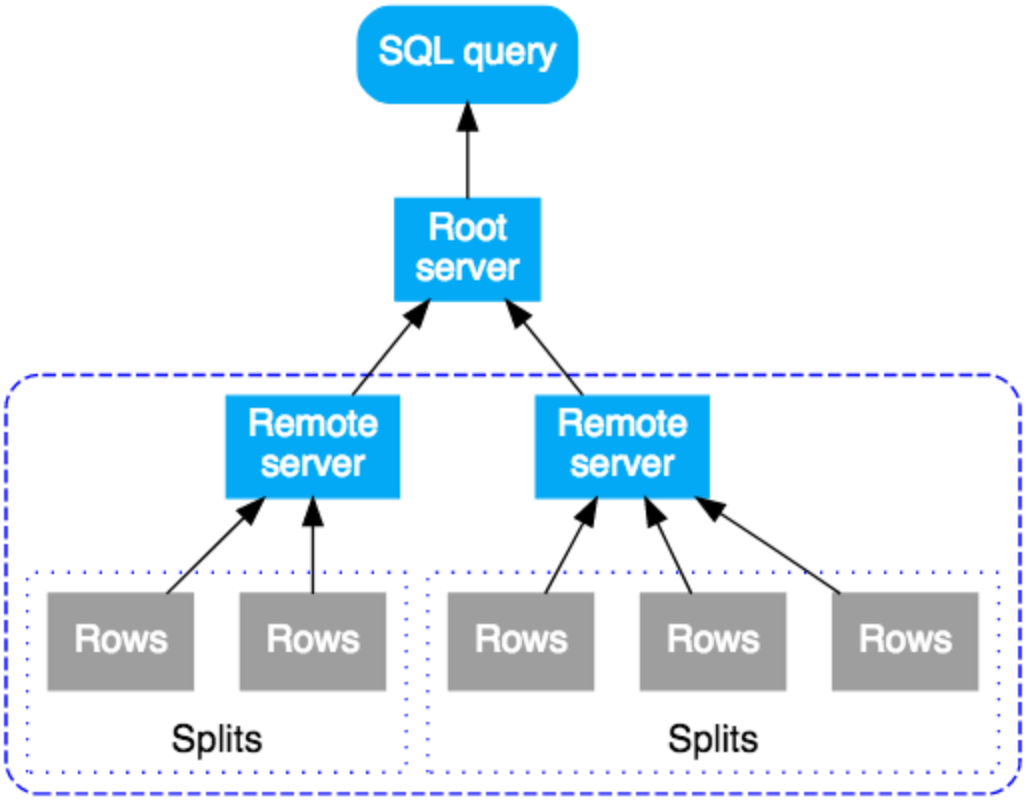


Life of a query

A SQL query in Cloud Spanner is first compiled into an execution plan, then it is sent to an initial root server for execution. The root server is chosen so as to minimize the number of hops to reach the data being queried. The root server then:

- Initiates remote execution of subplans (if necessary)
- Waits for results from the remote executions
- Handles any remaining local execution steps such as aggregating results
- Returns results for the query

Remote servers that receive a subplan act as the "root" server for their subplan, following the same model as the top-most root server. The result is a tree of remote executions. Conceptually, query execution flows from top to bottom, and query results are returned from bottom to top. The following diagram shows this pattern


SQL query
Root server
Remote server
Remote server
Rows
Rows
Rows
Rows
Rows
Splits
Splits