

This tutorial walks you through the following steps using the Cloud Spanner client library for C#:

- Create a Cloud Spanner instance and database.
- Write, read, and execute SQL queries on data in the database.
- Update the database schema.
- Update data using a read-write transaction.
- Add a secondary index to the database.
- Use the index to read and execute SQL queries on data.
- Retrieve data using a read-only transaction.

This tutorial uses Cloud Spanner, which is a billable component of the Google Cloud. For information on the cost of using Cloud Spanner, see [Pricing \(/spanner/pricing\)](/spanner/pricing).

1. Complete the steps described in [Set up \(/spanner/docs/getting-started/set-up\)](/spanner/docs/getting-started/set-up), which covers creating and setting a default Google Cloud project, enabling billing, enabling the Cloud Spanner API, and setting up OAuth 2.0 to get authentication credentials to use the Cloud Spanner API.

In particular, ensure that you run `gcloud auth application-default login` (</sdk/gcloud/reference/auth/application-default/login>) to set up your local development environment with authentication credentials.

2. Set the `GOOGLE_PROJECT_ID` environment variable to your Google Cloud project ID.

a. First, to set `GOOGLE_PROJECT_ID` for the current PowerShell session:

b. Then, to set `GOOGLE_PROJECT_ID` for all processes created after this command:

3. Download credentials.

a. Go to the **Credentials** page in the Google Cloud Console.

[Go to the Credentials page \(https://console.cloud.google.com/apis/credentials\)](https://console.cloud.google.com/apis/credentials)

b. Click **Create credentials** and choose **Service account key**.

c. Under "Service account", choose **Compute Engine default service account**, and leave **JSON** selected under "Key type". Click **Create**. Your computer downloads a JSON file.

4. Set up credentials. For a file named `FILENAME.json` in `CURRENT_USER`'s Downloads directory, located on the `C` drive, run the following commands to set `GOOGLE_APPLICATION_CREDENTIALS` to point to the JSON key:

a. First, to set `GOOGLE_APPLICATION_CREDENTIALS` for this PowerShell session:

b. Then, to set `GOOGLE_APPLICATION_CREDENTIALS` for all processes created after this command:

5. Clone the sample app repository to your local machine:

Alternatively, you can [download the sample](https://github.com/GoogleCloudPlatform/dotnet-docs-samples/archive/master.zip)

(<https://github.com/GoogleCloudPlatform/dotnet-docs-samples/archive/master.zip>) as a zip file and extract it.

6. Open `Spanner.sln`, located in the `dotnet-docs-samples\spanner\api` directory of the downloaded repository, with Visual Studio 2017 or later, then build it.
7. Change to the directory within the downloaded repository that contains the compiled application. For example:

When you first use Cloud Spanner, you must create an instance, which is an allocation of resources that are used by Cloud Spanner databases. When you create an instance, you choose an *instance configuration*, which determines where your data is stored, and also the number of nodes to use, which determines the amount of serving and storage resources in your instance.

Execute the following command to create a Cloud Spanner instance in the region `us-central1` with 1 node:

Note that this creates an instance with the following characteristics:

- Instance ID `test-instance`
- Display name `Test Instance`
- Instance configuration `regional-us-central1` (Regional configurations store data in one region, while multi-region configurations distribute data across multiple regions. Learn

more in [Instances](/spanner/docs/instances/) (/spanner/docs/instances/.)

- Node count of 1 (`node_count` corresponds to the amount of serving and storage resources available to databases in the instance. Learn more in [Node count](/spanner/docs/instances#node_count) (/spanner/docs/instances#node_count).)

You should see:

The samples repo contains a sample that shows how to use Cloud Spanner with C#.

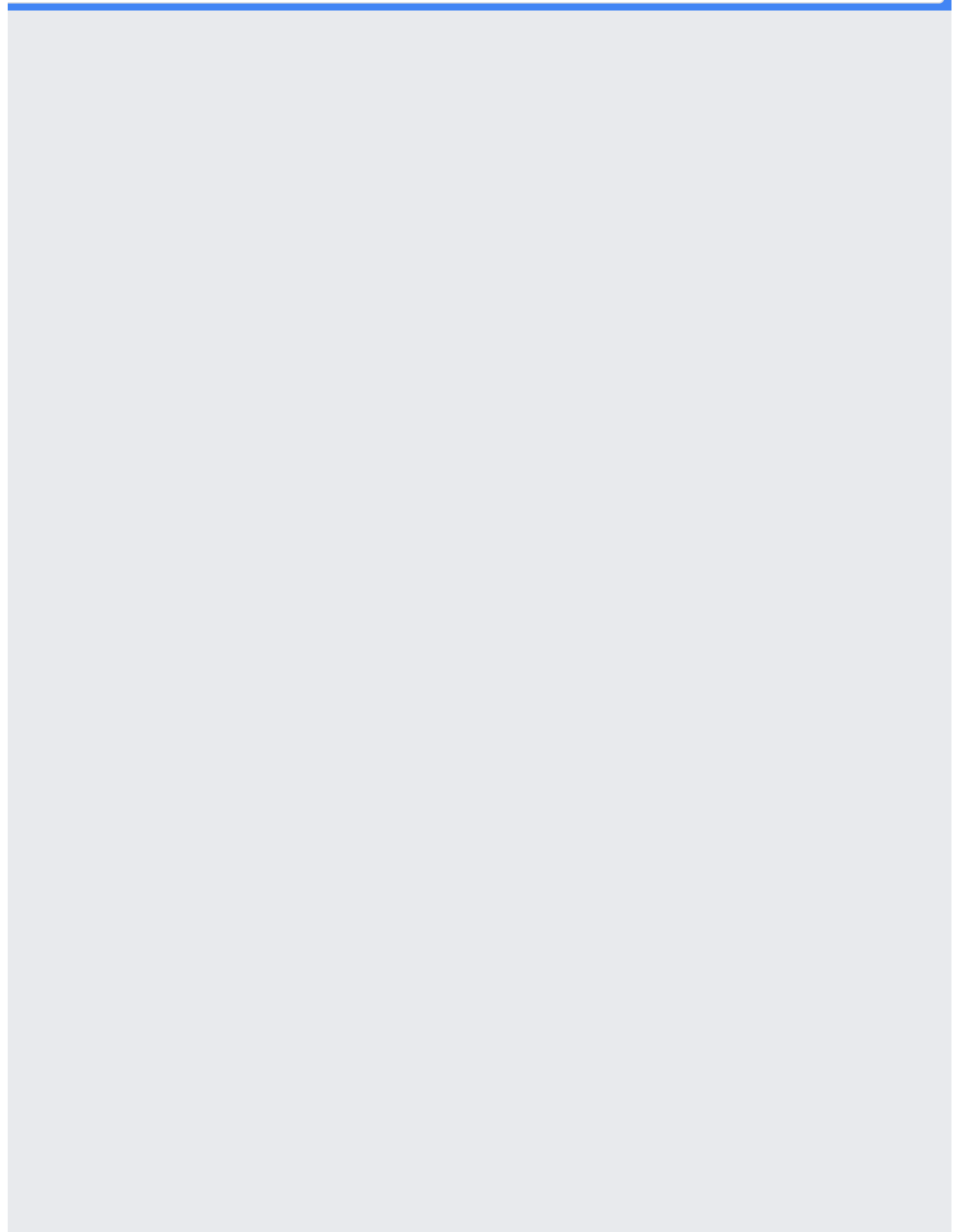
Take a look through the `spanner/api/Spanner/Program.cs` file, which shows how to create a database and modify a database schema. The data uses the example schema shown in the [Schema and data model](/spanner/docs/schema-and-data-model#creating-interleaved-tables) (/spanner/docs/schema-and-data-model#creating-interleaved-tables) page.

Create a database called `example-db` in the instance called `test-instance` by running the following at the command line.

You should see:

You have just created a Cloud Spanner database. The following is the code that created the database.

`//github.com/GoogleCloudPlatform/dotnet-docs-samples/blob/master/spanner/api/Spanner/Program.cs)`



The code also defines two tables, `Singers` and `Albums`, for a basic music application. These tables are used throughout this page. Take a look at the [example schema](/spanner/docs/schema-and-data-model#creating-interleaved-tables) (/spanner/docs/schema-and-data-model#creating-interleaved-tables) if you haven't already.

The next step is to write data to your database.

Before you can do reads or writes, you must create a `SpannerConnection` (<https://googleapis.github.io/google-cloud-dotnet/docs/Google.Cloud.Spanner.Data/api/Google.Cloud.Spanner.Data.SpannerConnection.html>) :

```
github.com/GoogleCloudPlatform/dotnet-docs-samples/blob/master/spanner/api/QuickStart/Program.cs)
```

You can think of a `SpannerConnection` as a database connection: all of your interactions with Cloud Spanner must go through a `SpannerConnection`.

Read more in the [SpannerConnection](https://googleapis.github.io/google-cloud-dotnet/docs/Google.Cloud.Spanner.Data/api/Google.Cloud.Spanner.Data.SpannerConnection.html)

(<https://googleapis.github.io/google-cloud-dotnet/docs/Google.Cloud.Spanner.Data/api/Google.Cloud.Spanner.Data.SpannerConnection.html>) reference.

You can insert data using Data Manipulation Language (DML) in a read-write transaction.

You use the `ExecuteNonQueryAsync()` method to execute a DML statement.

```
//github.com/GoogleCloudPlatform/dotnet-docs-samples/blob/master/spanner/api/Spanner/Program.cs)
```

Run the sample using the `writeUsingDml` argument.

You should see:

You can also insert data using [mutations](/spanner/docs/modify-mutation-api) (/spanner/docs/modify-mutation-api).

You can insert data using the [`connection.CreateInsertCommand\(\)`](#).

(https://googleapis.github.io/google-cloud-dotnet/docs/Google.Cloud.Spanner.Data/api/Google.Cloud.Spanner.Data.SpannerConnection.html#Google_Cloud_Spanner_Data_SpannerConnection_CreateInsertCommand_System_String_Google_Cloud_Spanner_Data_SpannerParameterCollection_)

method, which creates a new `SpannerCommand` to insert rows into a table. The

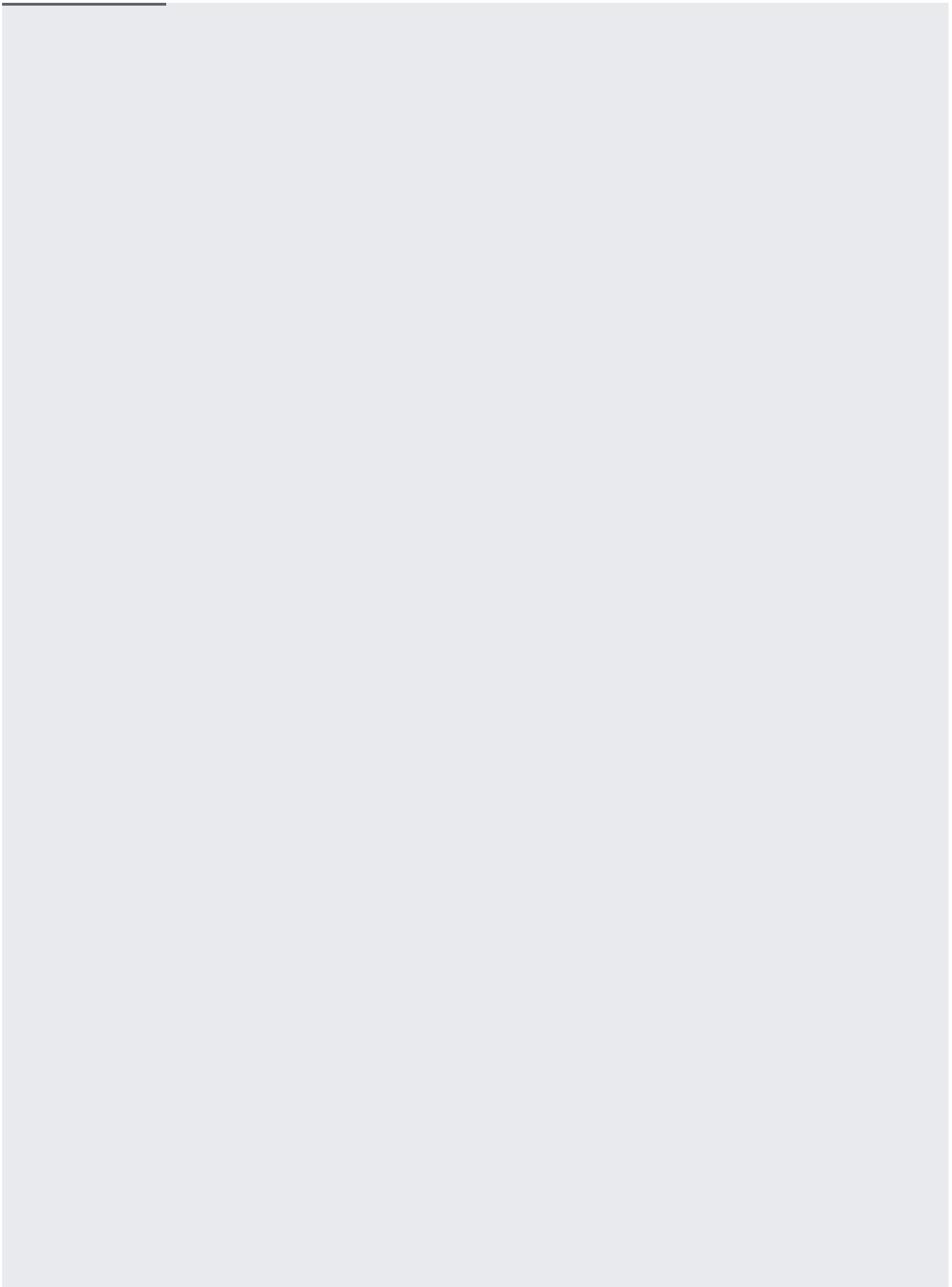
[`SpannerCommand.ExecuteNonQuery\(\)`](#).

(https://googleapis.github.io/google-cloud-dotnet/docs/Google.Cloud.Spanner.Data/api/Google.Cloud.Spanner.Data.SpannerCommand.html#Google_Cloud_Spanner_Data_SpannerCommand_ExecuteNonQueryAsync_System_Threading_CancellationToken_)

method adds new rows to the table.

This code shows how to insert data using mutations:

```
//github.com/GoogleCloudPlatform/dotnet-docs-samples/blob/master/spanner/api/Spanner/Program.cs)
```



Run the sample using the `insertSampleData` argument.

You should see:

Cloud Spanner supports a native SQL interface for reading data, which you can access on the command line using the `gcloud` command-line tool or programmatically using the Cloud Spanner client library for C#.

Execute the following SQL statement to read the values of all columns from the `Albums` table:

Note: See [SQL syntax \(/spanner/docs/query-syntax\)](/spanner/docs/query-syntax) for the Cloud Spanner SQL reference.

The result should be:

In addition to executing a SQL statement on the command line, you can issue the same SQL statement programmatically using the Cloud Spanner client library for C#.

Use `ExecuteReaderAsync()`.

(<https://googleapis.github.io/google-cloud-dotnet/docs/Google.Cloud.Spanner.Data/api/Google.Cloud.Spanner.Data.SpannerCommand.html#Google.Cloud.Spanner.Data.SpannerCommand.ExecuteReaderAsync>)

to run the SQL query.

```
//github.com/GoogleCloudPlatform/dotnet-docs-samples/blob/master/spanner/api/Spanner/Program.cs)
```

Here's how to issue the query and access the data:

You should see the following result:

You can include custom values in SQL statements using parameters. Here is an example of using `@lastName` as a parameter in the `WHERE` clause to query records containing a specific value for `LastName`.

```
//github.com/GoogleCloudPlatform/dotnet-docs-samples/blob/master/spanner/api/Spanner/Program.cs)
```

Here's how to issue the query with a parameter and access the data:

You should see the following result:

Assume you need to add a new column called **MarketingBudget** to the **Albums** 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 writing data to the database during the schema update. Read more

about supported schema updates and schema change performance in [Schema updates](#) (/spanner/docs/schema-updates).

You can add a column on the command line using the `gcloud` command-line tool or programmatically using the Cloud Spanner client library for C#.

Use the following `ALTER TABLE` (/spanner/docs/data-definition-language#alter_table) command to add the new column to the table:

You should see:

Use `CreateDdlCommand()`.

(https://googleapis.github.io/google-cloud-dotnet/docs/Google.Cloud.Spanner.Data/api/Google.Cloud.Spanner.Data.SpannerConnection.html#Google_Cloud_Spanner_Data_SpannerConnection_CreateUpdateCommand_System_String_Google_Cloud_Spanner_Data_SpannerParameterCollection_)

to modify the schema:

```
//github.com/GoogleCloudPlatform/dotnet-docs-samples/blob/master/spanner/api/Spanner/Program.cs)
```

Run the sample using the `addColumn` command.

You should see:

The following code writes data to the new column. It sets `MarketingBudget` to `100000` for the row keyed by `Albums(1, 1)` and to `500000` for the row keyed by `Albums(2, 2)`.

```
//github.com/GoogleCloudPlatform/dotnet-docs-samples/blob/master/spanner/api/Spanner/Program.cs)
```


Run the sample using the `writeDataToNewColumn` command.

You should see:

You can also execute a SQL query to fetch the values that you just wrote.

Here's the code to execute the query:

```
//github.com/GoogleCloudPlatform/dotnet-docs-samples/blob/master/spanner/api/Spanner/Program.cs)
```

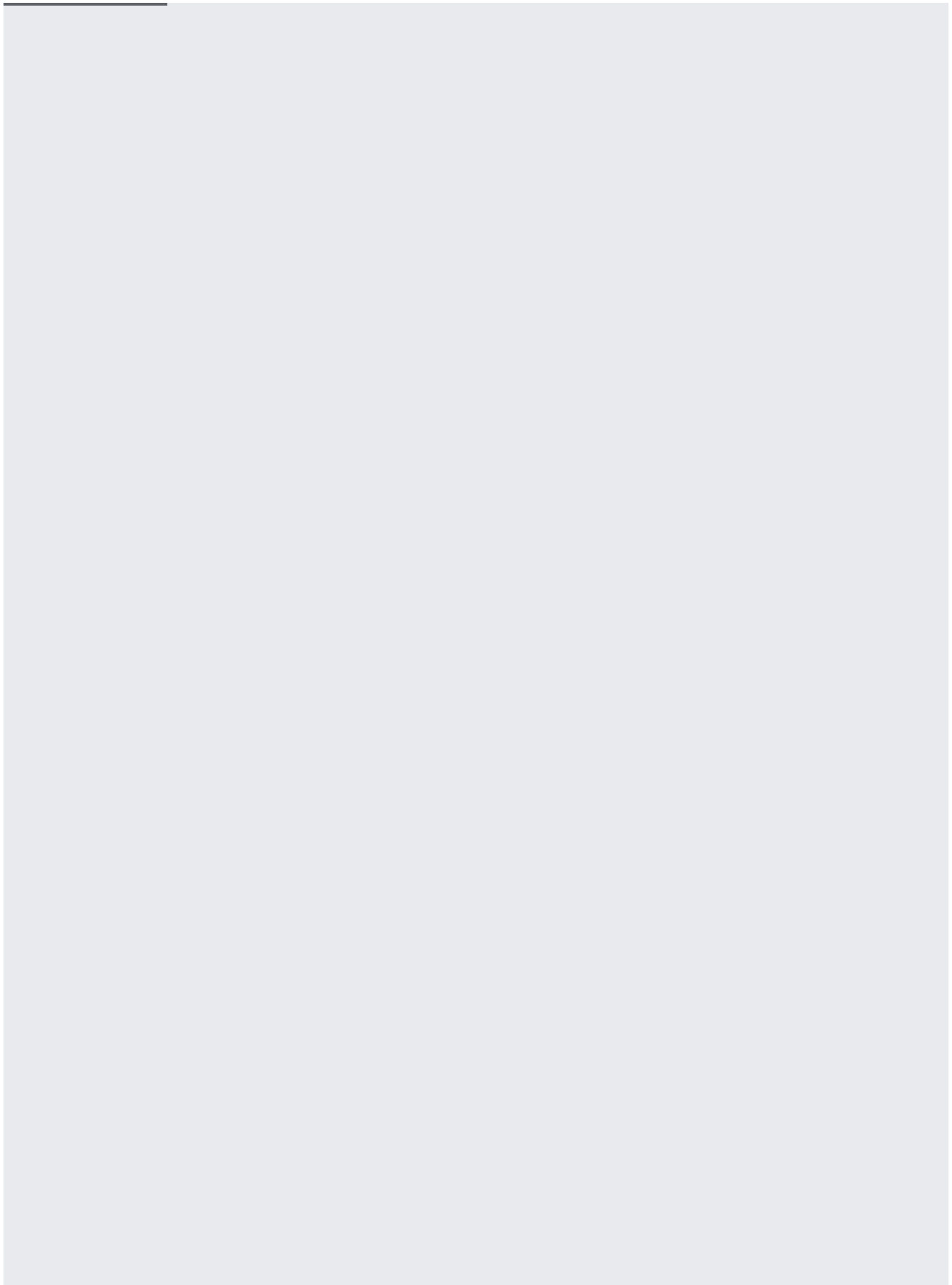
To execute this query, run the sample using the `queryNewColumn` argument.

You should see:

You can update data using DML in a read-write transaction.

You use the `ExecuteNonQueryAsync()` method to execute a DML statement.

```
//github.com/GoogleCloudPlatform/dotnet-docs-samples/blob/master/spanner/api/Spanner/Program.cs)
```



Run the sample using the `writeWithTransactionUsingDml` argument.

You should see:

Cloud Spanner performs retries for each network call and is resilient to network failures. However, a deadlock can occur under heavy stress, which causes a Cloud Spanner transaction to throw an "Aborted" `SpannerException`. To handle this exception, you must use a "retry" approach, as shown below, to retry the entire transaction.

First, define a method that will be called when the transaction needs to be retried. The following example defines a method named `RetryRobot`.

```
//github.com/GoogleCloudPlatform/dotnet-docs-samples/blob/master/spanner/api/Spanner/Program.cs)
```

Next, create an instance, named `retryRobot`, of the `RetryRobot` method, specifying `IsTransientSpannerFault()` as the error condition that should be retried. Then execute the entire transaction using `retryRobot.Eventually`.

Here is the code to perform a retry:

```
//github.com/GoogleCloudPlatform/dotnet-docs-samples/blob/master/spanner/api/Spanner/Program.cs)
```

Note: You can also [update data using mutations](#)

([/spanner/docs/modify-mutation-api#updating_rows_in_a_table](#)).

Suppose you wanted to fetch all rows of `Albums` that have `AlbumTitle` values in a certain range. You could read all values from the `AlbumTitle` 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](#) ([/spanner/docs/secondary-indexes](#)) 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 automatically backfills the index with your existing data. Backfills might take a few minutes to complete, but you don't need to take the database offline or avoid writing to the indexed table during this process. For more details, see [index backfilling](#) ([/spanner/docs/secondary-indexes#adding_an_index](#)).

After you add a secondary index, Cloud Spanner automatically uses it for SQL queries that are likely to run faster with the index. If you use the read interface, you must specify the index that you want to use.

You can add an index on the command line using the `gcloud` command line tool or programmatically using the Cloud Spanner client library for C#.

Use the following `CREATE INDEX` (`/spanner/docs/data-definition-language#create_index`) command to add an index to the database:

You should see:

Use `CreateDdlCommand()`.

([https://googleapis.github.io/google-cloud-dotnet/docs/Google.Cloud.Spanner.Data/api/Google.Cloud.Spanner.Data.SpannerConnection.html#Google.Cloud.Spanner.Data.SpannerConnection.CreateDdlCommand\(System.String,System.String\)](https://googleapis.github.io/google-cloud-dotnet/docs/Google.Cloud.Spanner.Data/api/Google.Cloud.Spanner.Data.SpannerConnection.html#Google.Cloud.Spanner.Data.SpannerConnection.CreateDdlCommand(System.String,System.String)))
to add an index:

```
//github.com/GoogleCloudPlatform/dotnet-docs-samples/blob/master/spanner/api/Spanner/Program.cs)
```


Run the sample using the `addIndex` command.

Adding an index can take a few minutes. After the index is added, you should see:

You might have noticed that the read example above did not include reading the `MarketingBudget` column. This is because Cloud Spanner's read interface does not support the ability to join an index with a data table to look up values that are not stored in the index.

Create an alternate definition of `AlbumsByAlbumTitle` that stores a copy of `MarketingBudget` in the index.

Adding an index can take a few minutes. After the index is added, you should see:

Use `CreateDdlCommand()`.

([https://googleapis.github.io/google-cloud-dotnet/docs/Google.Cloud.Spanner.Data/api/Google.Cloud.Spanner.Data.SpannerConnection.html#Google.Cloud.Spanner.Data.SpannerConnection.CreateUpdateCommand\(System.String,Google.Cloud.Spanner.Data.SpannerParameterCollection\)](https://googleapis.github.io/google-cloud-dotnet/docs/Google.Cloud.Spanner.Data/api/Google.Cloud.Spanner.Data.SpannerConnection.html#Google.Cloud.Spanner.Data.SpannerConnection.CreateUpdateCommand(System.String,Google.Cloud.Spanner.Data.SpannerParameterCollection)))

to add an index with a **STORING** clause:

```
//github.com/GoogleCloudPlatform/dotnet-docs-samples/blob/master/spanner/api/Spanner/Program.cs)
```

Run the sample using the `addStoringIndex` command.

You should see:

Now you can execute a read that fetches all `AlbumId`, `AlbumTitle`, and `MarketingBudget` columns from the `AlbumsByAlbumTitle2` index:

Read data using the storing index you created by executing a query that explicitly specifies the index:

```
//github.com/GoogleCloudPlatform/dotnet-docs-samples/blob/master/spanner/api/Spanner/Program.cs)
```

Run the sample using the `queryDataWithStoringIndex` command.

You should see output similar to:

Suppose you want to execute more than one read at the same timestamp. Read-only transactions (/spanner/docs/transactions#read-only_transactions) observe a consistent prefix of the transaction commit history, so your application always gets consistent data. Use the .NET framework's TransactionScope()

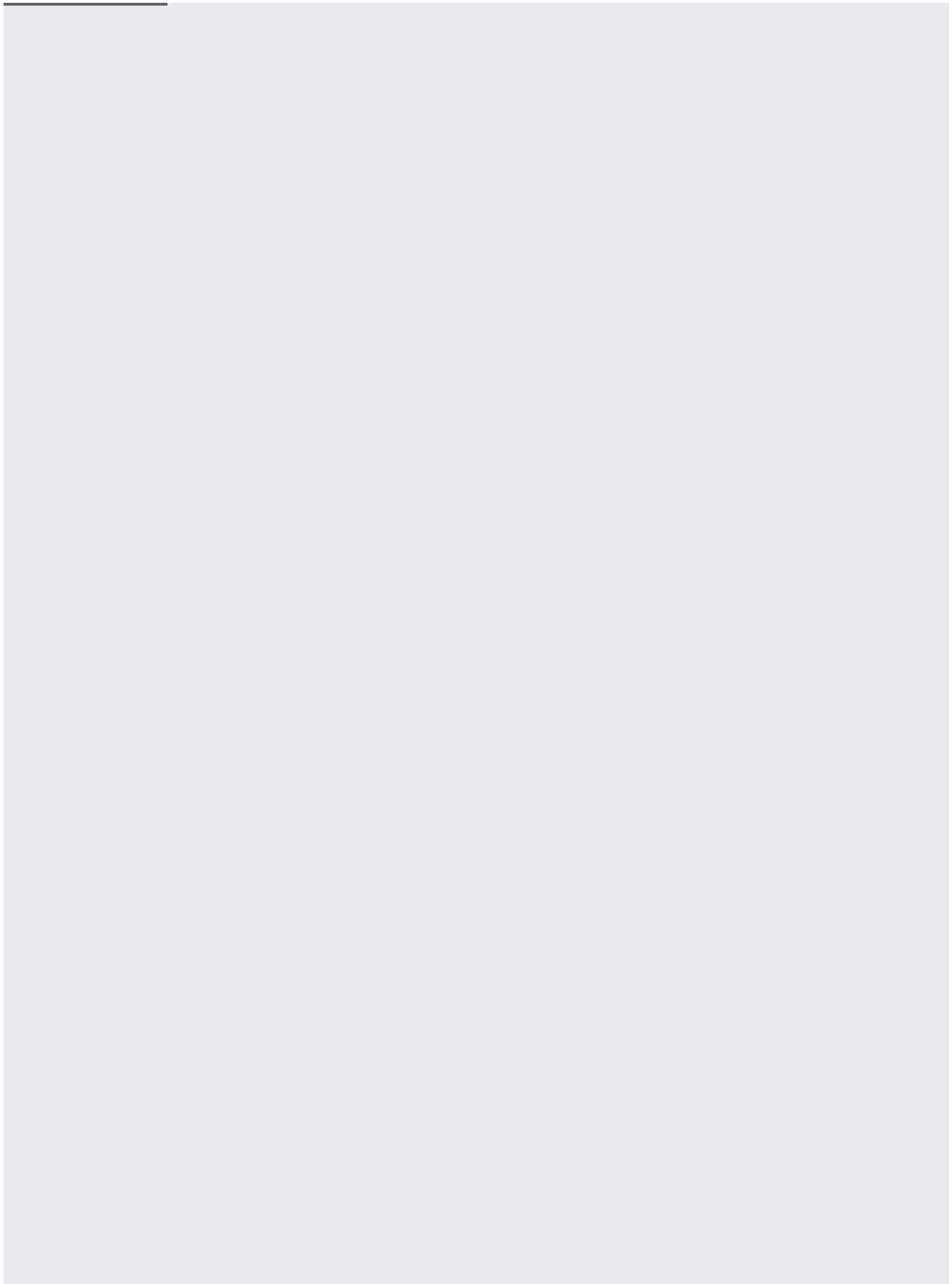
(<https://msdn.microsoft.com/en-us/library/system.transactions.transactionscope>) along with

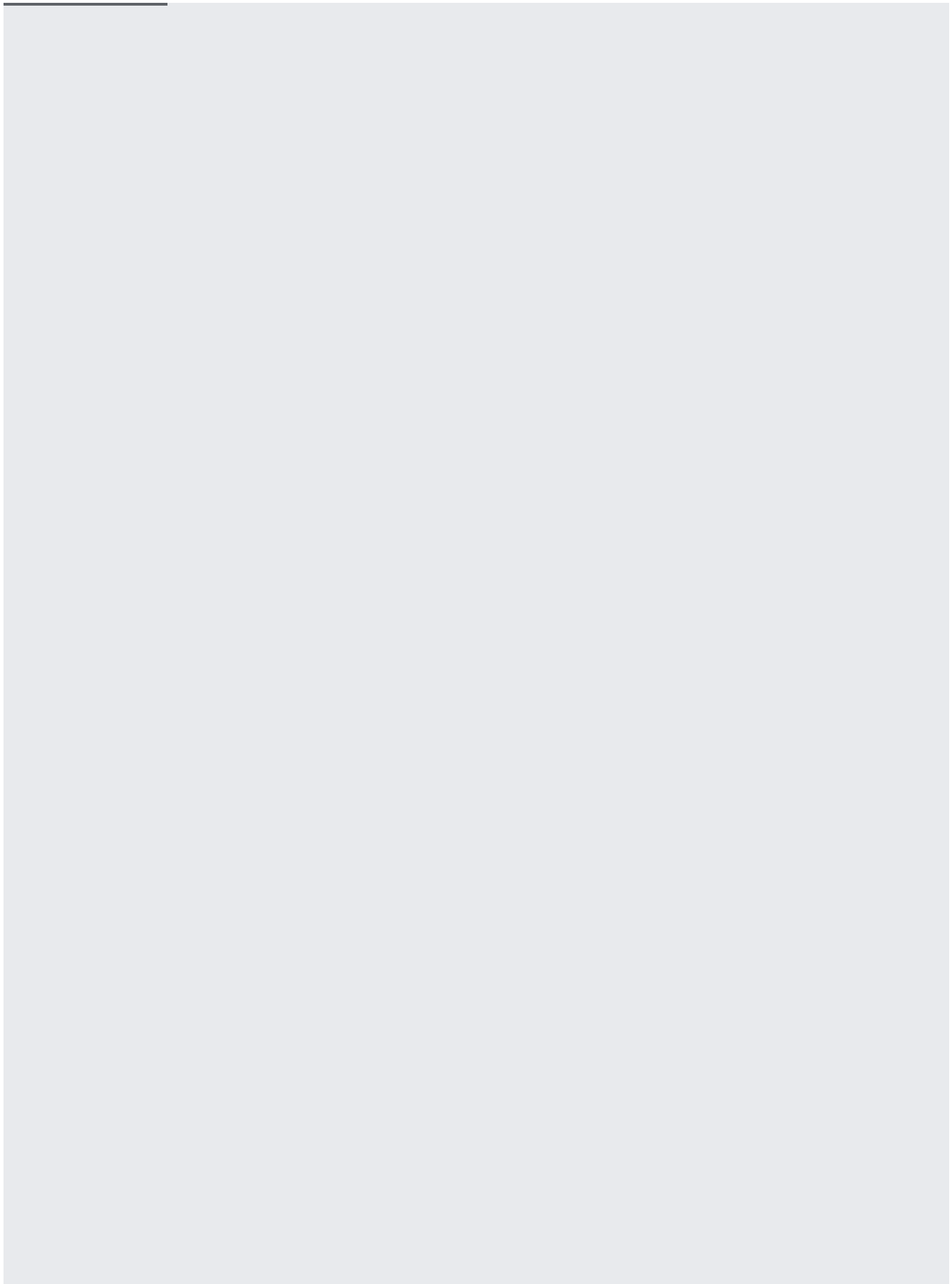
OpenAsReadOnlyAsync()

(https://googleapis.github.io/google-cloud-dotnet/docs/Google.Cloud.Spanner.Data/api/Google.Cloud.Spanner.Data.SpannerConnection.html#Google_Cloud_Spanner_Data_SpannerConnection_OpenAsReadOnlyAsync_Google_Cloud_Spanner_Data_TimestampBound_System_Threading_CancellationToken_)

for executing read-only transactions.

The following shows how to run a query and perform a read in the same read-only transaction:





Run the sample using the `queryDataWithTransaction` command.

You should see output similar to:

To avoid incurring additional charges to your Google Cloud account for the resources used in this tutorial, drop the database and delete the instance that you created.

If you delete an instance, all databases within it are automatically deleted. This step shows how to delete a database without deleting an instance (you would still incur charges for the instance).

1. Go to the **Cloud Spanner Instances** page in the Google Cloud Console.

[Go to the Instances page \(https://console.cloud.google.com/spanner/instances\)](https://console.cloud.google.com/spanner/instances)

2. Click the instance.
3. Click the database that you want to delete.
4. In the **Database details** page, click **Delete**.
5. Confirm that you want to delete the database and click **Delete**.

Deleting an instance automatically drops all databases created in that instance.

1. Go to the **Cloud Spanner Instances** page in the Google Cloud Console.

[Go to the Instances page \(https://console.cloud.google.com/spanner/instances\)](https://console.cloud.google.com/spanner/instances)

2. Click your instance.
3. Click **Delete**.
4. Confirm that you want to delete the instance and click **Delete**.

- [Access Cloud Spanner in a virtual machine instance \(/spanner/docs/configure-virtual-machine-instance\)](#): create a virtual machine instance with access to your Cloud Spanner database.
- Learn about authorization and authentication credentials in [Getting started with authentication \(/docs/authentication/getting-started\)](#).
- Learn more [Cloud Spanner concepts \(/spanner/docs/concepts\)](#).