HarbourBridge UI User Guide

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Introduction

HarbourBridge is an open source schema and data migration tool for migrations to Cloud Spanner. It provides a unified interface for the migration wherein it gives users the flexibility to modify the generated spanner schema and run end to end migration from a single interface. It provides the capabilities of editing table details like columns, primary key, foreign key, indexes, etc and provides insights on the schema conversion performance along with highlighting important issues and suggestions.

Terms/Terminology

- **Connection Profile** - A representation of a source or destination in terms of the connectivity information required to connect to it (e.g. hostname, user, etc).
- **Migration job** - A migration job represents the process of migrating schema and/or data from source to destination, including managing the dump of historical data, replicating data continuously, monitoring and error handling
- **Session file** - A session file is a snapshot of an ongoing HarbourBridge conversion session. It contains metadata for migration and is structured in JSON format.
- **Interleave -** Spanner's table interleaving is a good choice for many parent-child relationships. With interleaving, Spanner physically co-locates child rows with parent rows in storage. Co-location can significantly improve performance. For more information on interleaving check here.
- **Migration Request Id -** A unique identifier generated for each migration request.
- **Synthetic Primary Key -** It is mandatory for a table in spanner to have a primary key. In cases where the primary key is missing in the source database, HarbourBridge generates a new column **synth_id** and populates it with UUID.
- **Metadata database -** A spanner database with the name **harbourbridge_metadata** which is responsible for storing saved sessions from HarbourBridge.

Currently Unsupported

- **Source database** - We provide support for migrations from following source databases from HarbourBridge UI - MySQL, PostgreSQL, Oracle and SQL Server. All other databases are currently unsupported.
- **Transformations -** Complex transformation like row operations, table splitting, table merging, etc are currently not supported.

User Journeys

HarbourBridge provides support for both schema and data migration. For schema migration, HarbourBridge automatically builds a default Spanner schema from the schema of the source database. This schema can be customized using the HarbourBridge schema assistant. After schema customizations the user can then go ahead with the migration wherein they select the mode of migration - schema, data or schema and data and type of migration - bulk migration or minimal downtime migration and then execute the migration. After all the details have been specified, a database gets created in Spanner with the customized schema and data is copied from the existing database to Spanner.

Running an end to end migration comprises of five basic steps, each of these will be talked about in detail in the following sections:

1. Setting up HarbourBridge
2. Connecting to a Spanner Instance
3. Connecting to source database
4. Setting up spanner schema
5. Creating spanner database and migrating data to Spanner

Setting up HarbourBridge

Before starting an end to end migration the user first needs to perform a few steps to set up the environment. Follow these steps to ensure you have a working Cloud Spanner setup, and the necessary permissions in place. Once the user is authenticated and they have created a spanner instance, they can start using HarbourBridge using either of the two mechanisms:

Build from source

This mechanism provides access to the latest version of HarbourBridge. In order to connect to build HarbourBridge from source, the user can make a copy of the HarbourBridge codebase from the github repository by running the following commands:

```
git clone https://github.com/cloudspannerecosystem/harbourbridge
cd harbourbridge
make build
```

To start the HarbourBridge UI, run the following command:

```
./harbourbridge web
```

Using Gcloud

Note: Please note that this mechanism will work only on linux machines.

This mechanism provides access to the last released version of HarbourBridge. In order to connect to HarbourBridge via Gcloud, the user can install the harbourbridge component of gcloud by executing the below command:

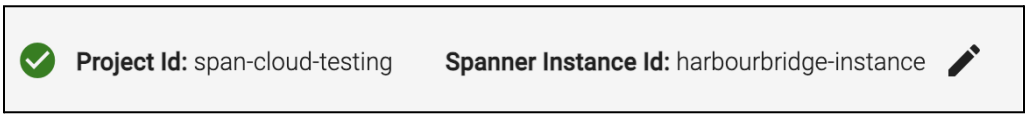
```
gcloud components install harbourbridge
```

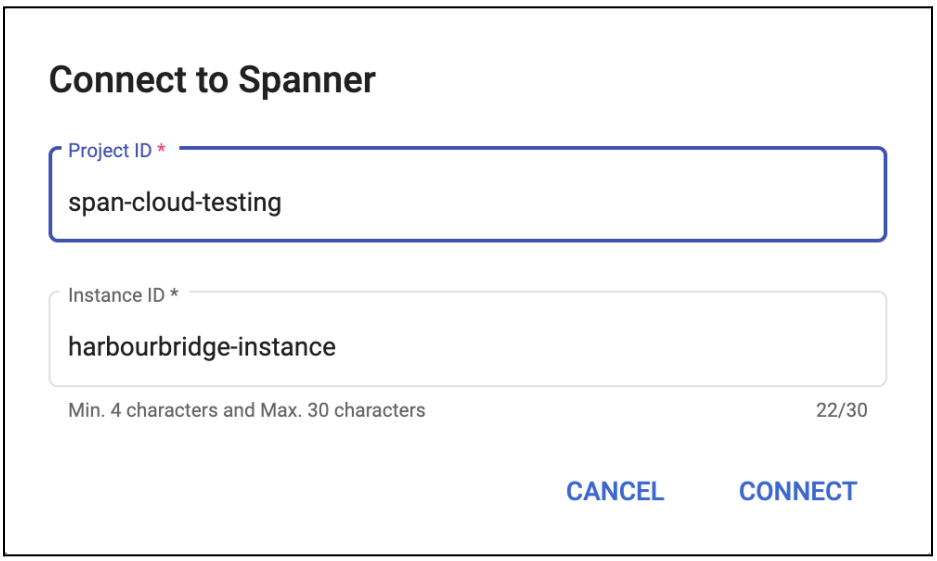
To start the HarbourBridge UI, run the following command:

```
gcloud alpha spanner migration web
```

Connecting to a Spanner Instance

To perform a migration the user needs to connect to a spanner instance where they specify a valid GCP(Google Cloud Platform) project ID and a valid spanner instance. After the successful connection to the spanner instance HarbourBridge validates if the metadata database exists. If not, then a new metadata database is created.

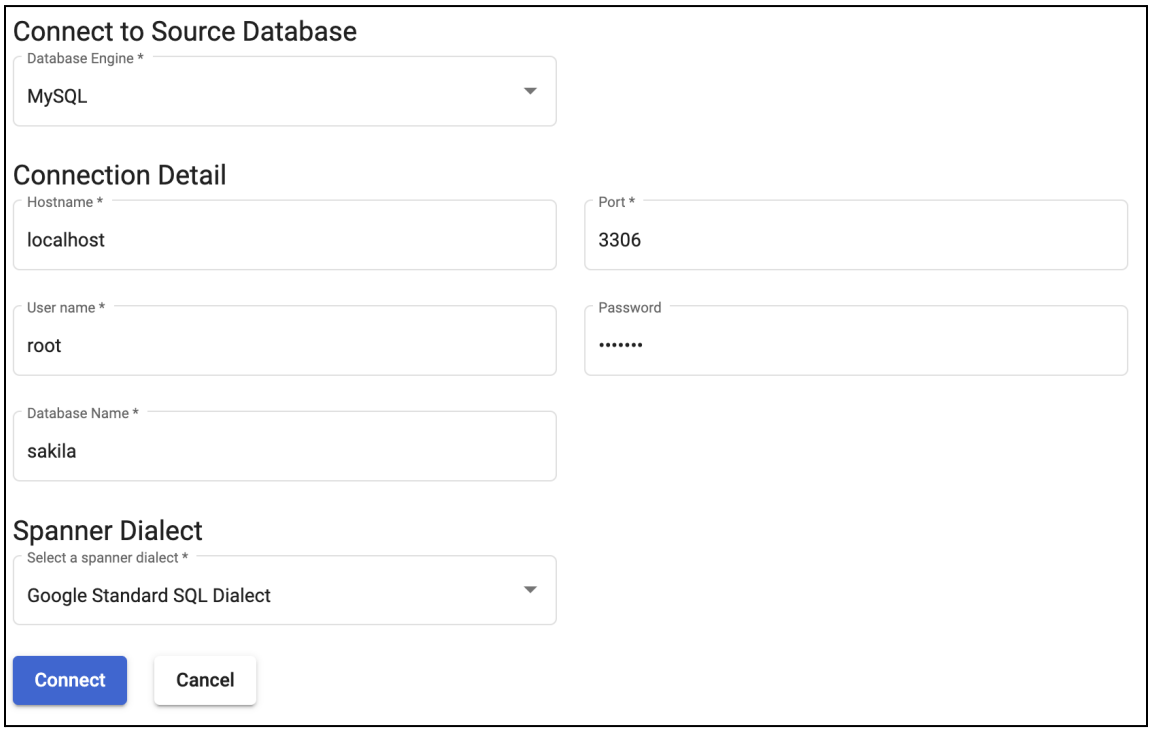




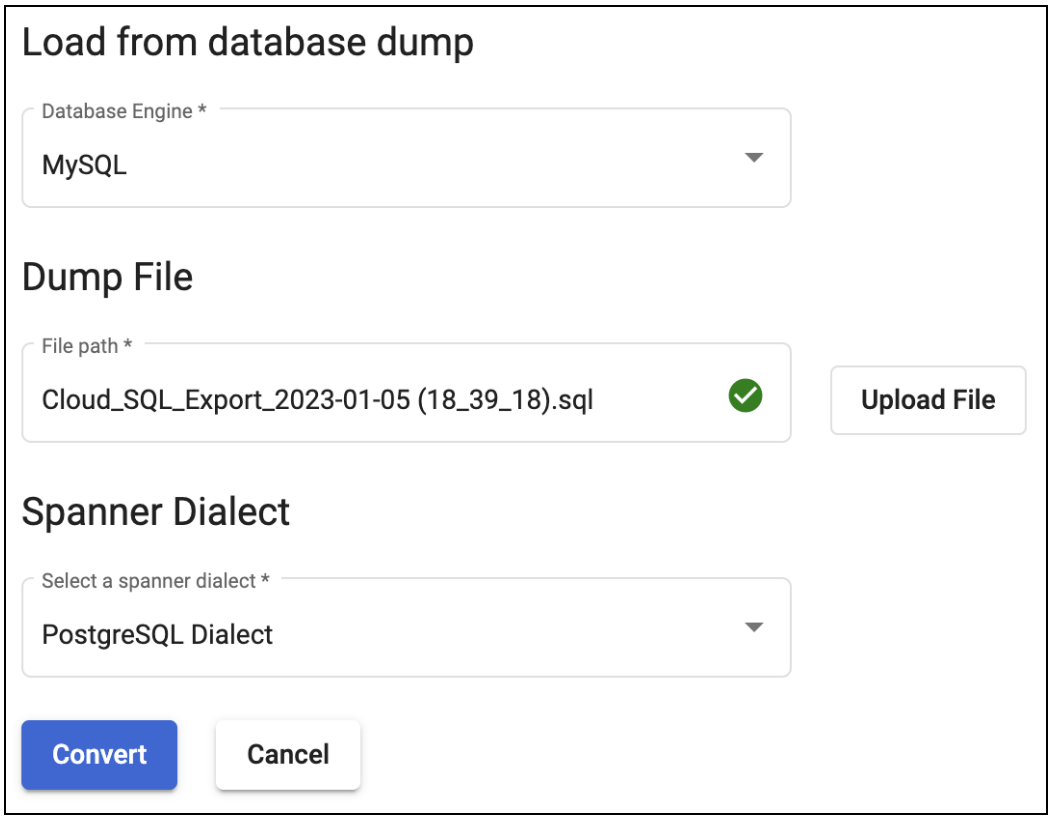
Source database connection mechanism

HarbourBridge allows users to connect to the source database via three connection mechanisms:

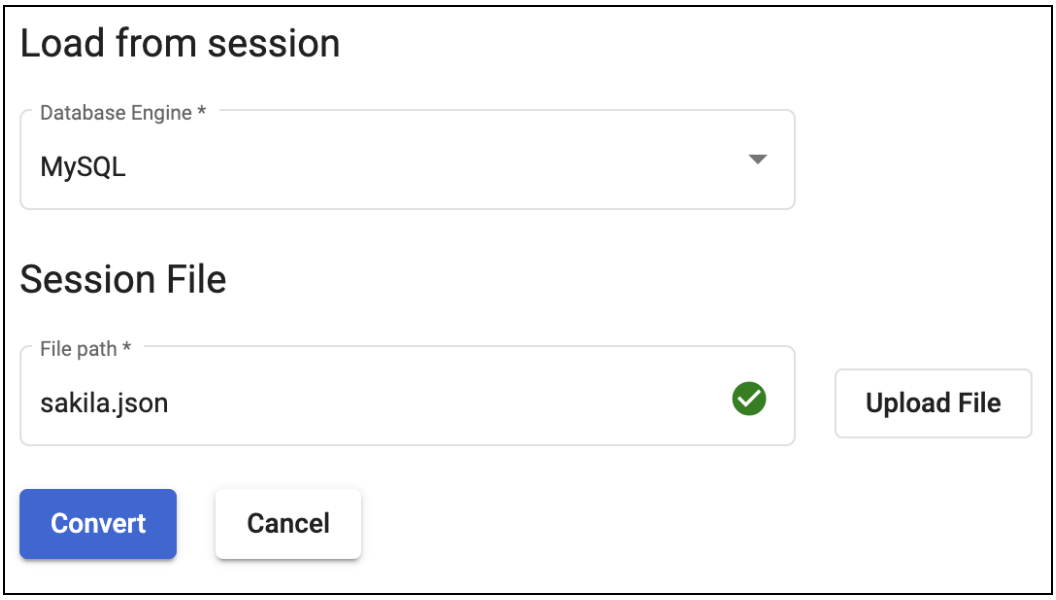
- **Connect to Database** - In this connection mechanism the user needs to first select the type of source database engine and then specify the source database connection details like host, port, username , password and database name. Currently, HarbourBridge UI supports the following source databases - MySQL, PostgreSQL, Oracle and SQLServer. User also needs to specify the **spanner dialect,** it specifies the query language used. Spanner provides support for two dialects - Google Standard SQL and PostgreSQL. Note: Users can connect to both local and cloud instances.



- **Load database dump** - The user needs to generate a dump of their source database and then provide a path to the generated dump file in the input along with the type of database engine. HarbourBridge supports dump file migration for MySQL and PostgreSQL. User also needs to specify the **spanner dialect,** it specifies the query language used. Spanner provides support for two dialects - Google Standard SQL and PostgreSQL. Dump files for MySQL and PostgreSQL can be generated by using mysqldump and pg_dump commands respectively. Please note that the dump file should be present in the same machine on which HarbourBridge is running.



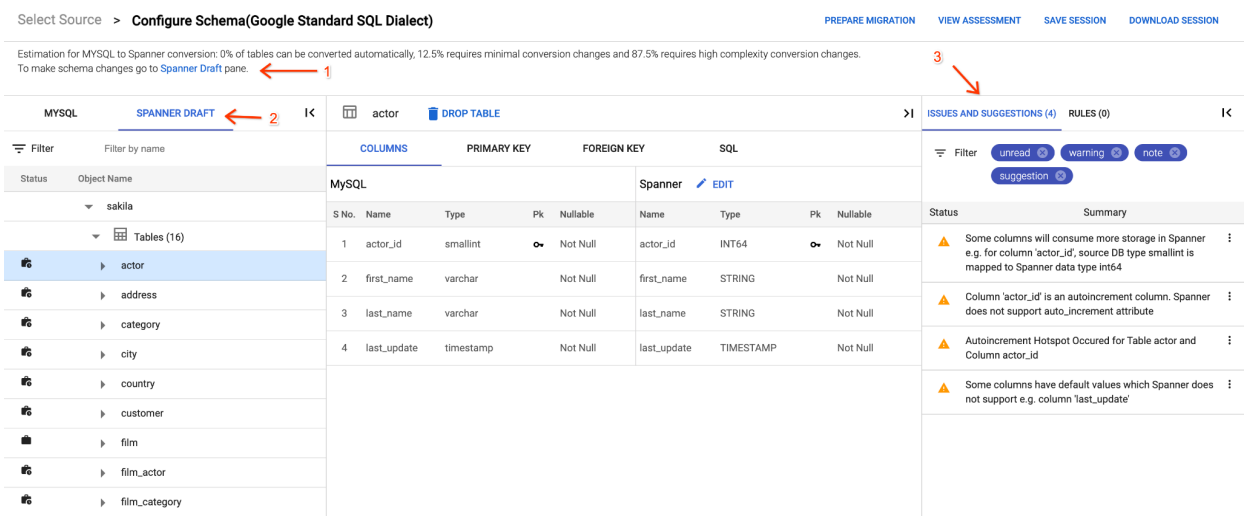
- **Load session file** - In cases where the user would want to save the schema modifications and come back to them later , for instance in case of complex databases or if multiple users are working on the same database they can do so with the help of session files. Users just need to select the database engine and specify the file path for the saved session file to resume the migration process. Please note that the session file should be present in the same machine on which HarbourBridge is running.



Configure Schema

In the configure schema page, the user can view details of the source database and how the spanner database would look like after migration. This includes following information:

1. Conversion Assessment
2. Spanner Draft
    a. Table details
        i. Column
        ii. Primary Key
        iii. Foreign Key
        iv. Interleave
        v. SQL
    b. Index details
3. Issues & Suggestions



Conversion Assessment

Conversion assessment helps the user to understand the complexity of the schema conversion. It is broken down into 3 categories - automatic conversion, minimal complexity conversion and high complexity conversion. The conversion complexity is calculated based on the warnings and issues per table.

Spanner Draft

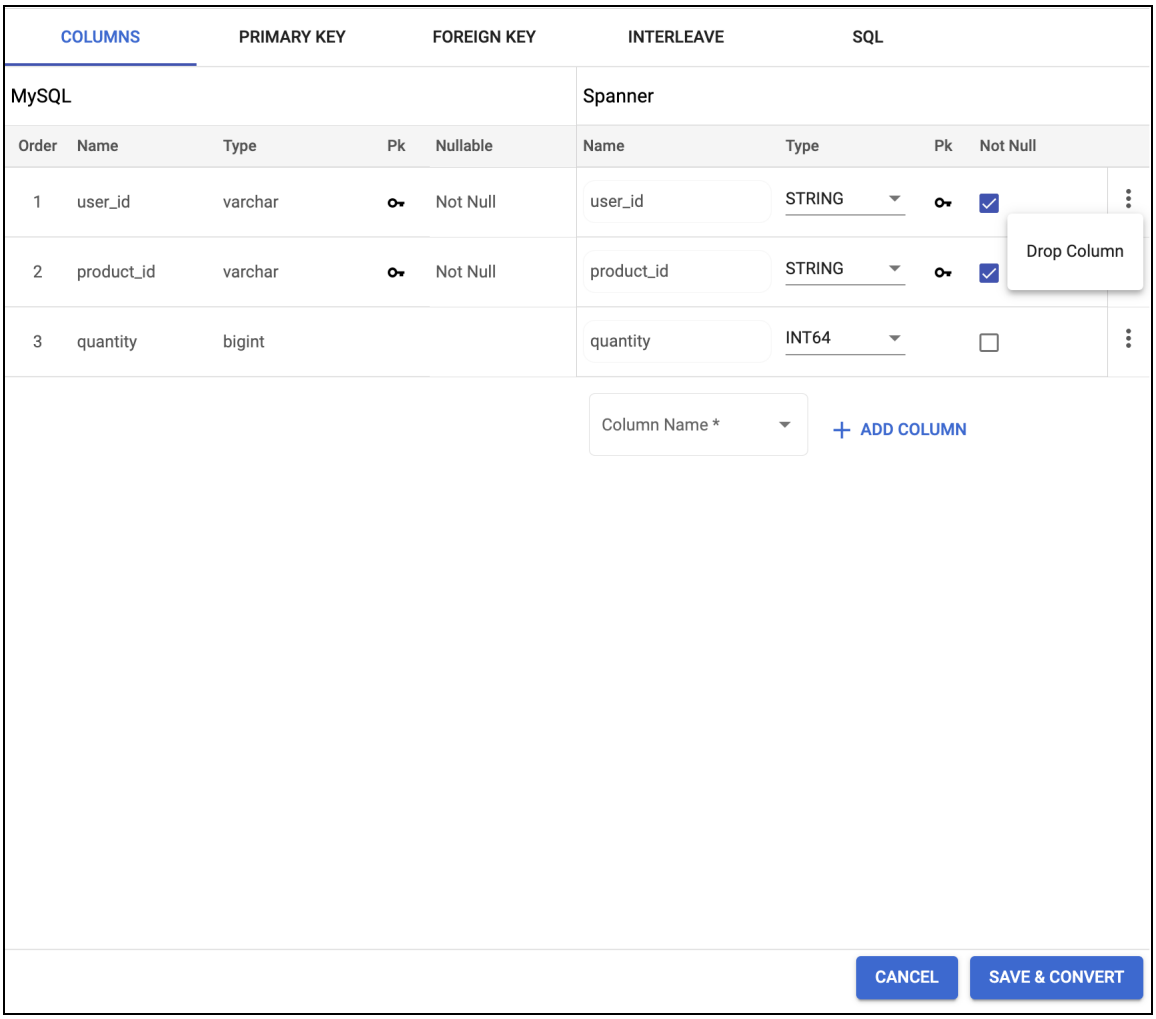
When migrating a schema to Spanner, using the default conversion may be sub-optimal owing to functional differences in the features supported and different performance characteristics of Spanner. Following the best practices, it may be better to change keys, drop or add some indexes, or add/remove columns to existing tables in the Spanner schema.

Tables

Users can view detailed information for a table by selecting it from the **Spanner Draft** section. This includes details on columns, primary keys, foreign keys, interleave property, spanner DDL and the option to edit these along with deleting or restoring the table.

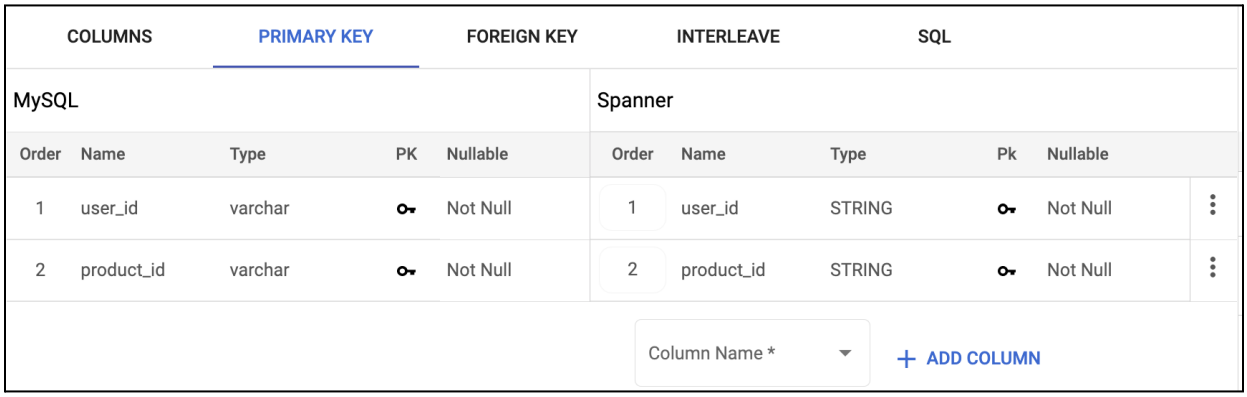
Column

Column tab provides information on the columns that are a part of the selected table. It also provides the option to edit the column wherein a user can modify a column name, delete a column, change the data type of the column or modify the null property of the column. Once the user is done with required modifications, they can click on **SAVE & CONVERT** and the update would reflect in the session file and across all the components in the database.



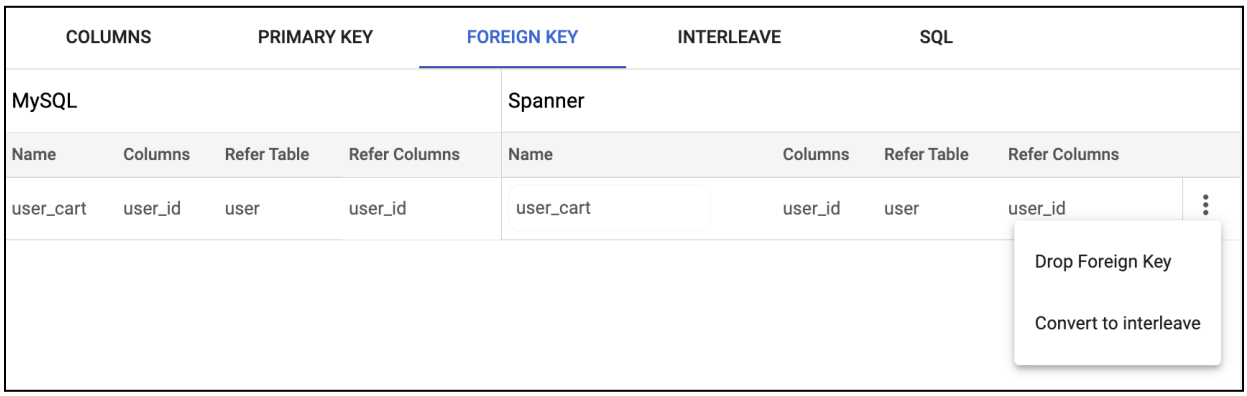
Primary Key

Users can view and edit the primary key of a table from the primary key tab. They can remove/add a column from the primary key or change the order of columns in the primary key. Once these changes are made, the session file is updated and they can also be verified from the SQL tab.



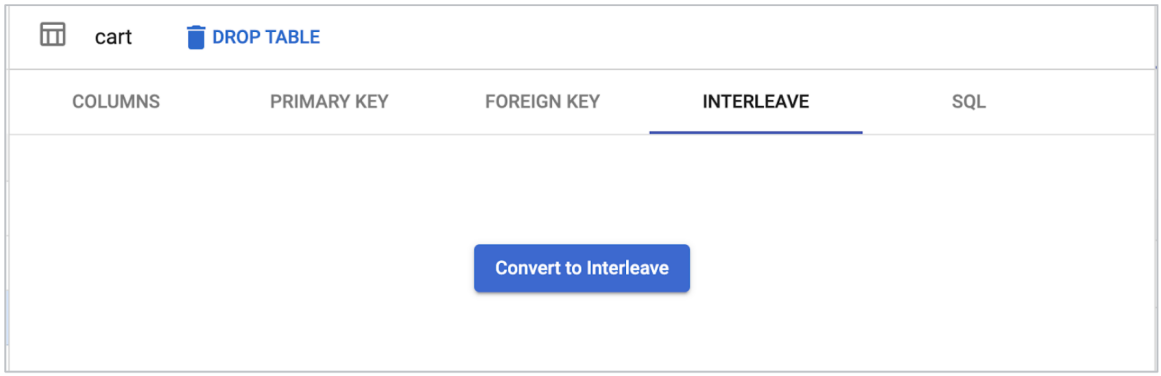
Foreign Key

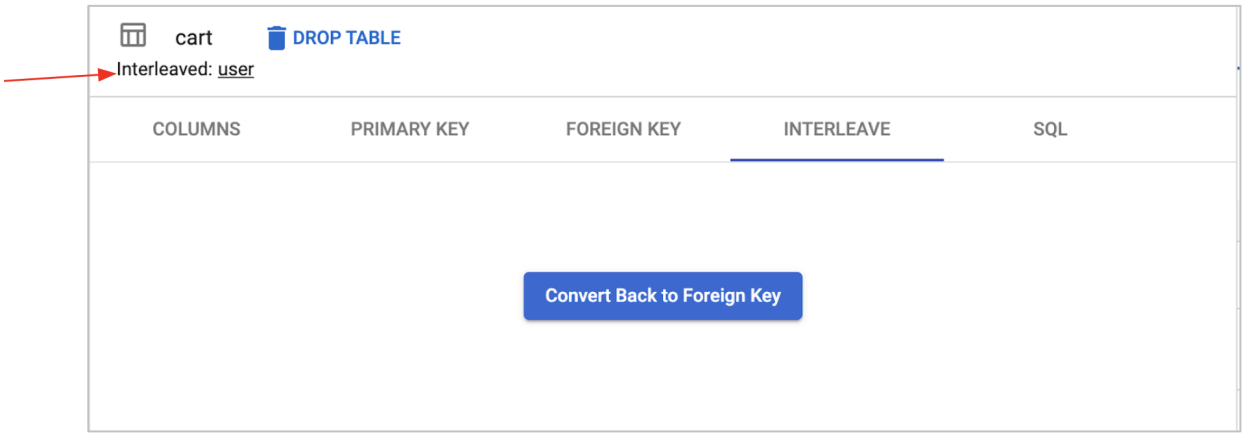
Users can view and edit the foreign key of a table from the foreign key tab. They can modify the foreign key constraint name, drop the foreign key or convert the foreign key into interleave, if the table is interleavable. Once these changes are made the session file is updated.



Interleave

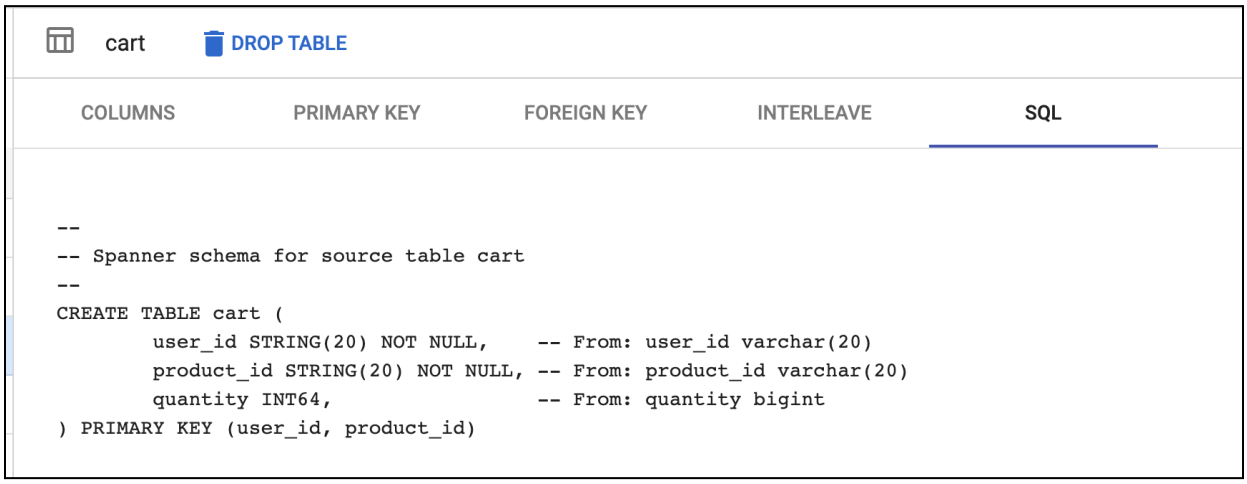
Interleaving physically co-locates child rows with parent rows in storage. Co-location can significantly improve performance.For example, if there is a *Customers* table and an *Invoices* table, and the application frequently fetches all the invoices for a customer, users can define Invoices as an interleaved child table of Customers. In doing so, a data locality relationship between two independent tables is declared resulting in significant performance improvement. HarbourBridge provides the option to convert a table into an interleaved table if it fulfills all the criteria.The Interleave tab shows up only for tables which are possible candidates for interleaving, based on the existing foreign keys. Once a table is converted into an interleaved table, the UI shows the information of the parent table. Users can also choose to remove this interleaving property and restore the foreign key by clicking on '**Convert back to foreign key**'.
Note: Interleaving property needs to be set during the migration and a table cannot be interleaved after migration.





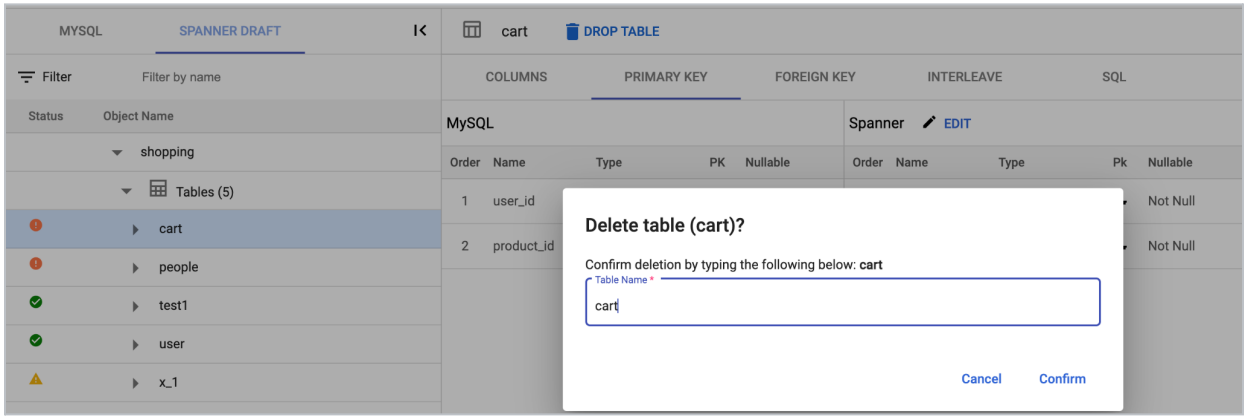
SQL

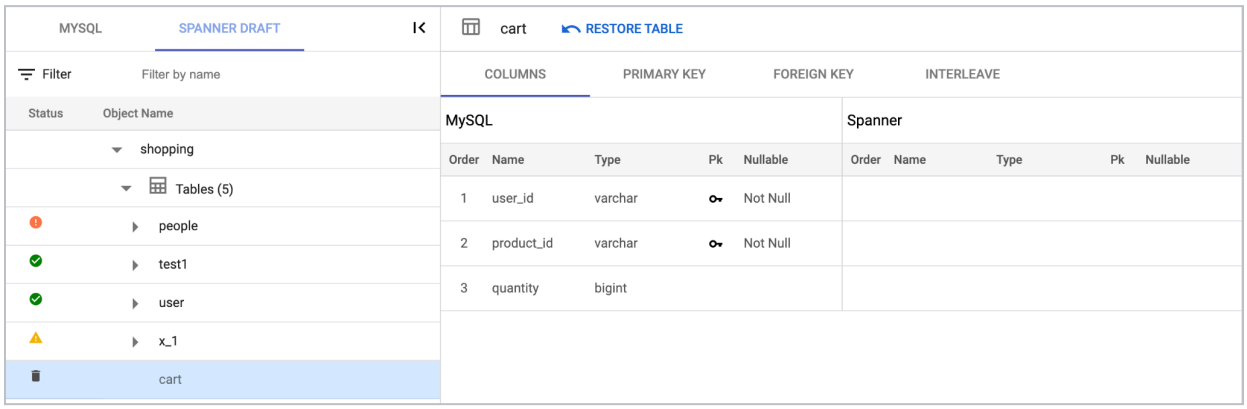
Once the user is done with all the schema modifications they can then visit the SQL tab which shows the Spanner DDL for the modified schema.



Drop & Restore Table

HarbourBridge also provides the users with the capability to drop and restore tables from the spanner database. Once the table is dropped, it appears as **deleted** under the Spanner Draft section and can be **restored** from there.





Indexes

HarbourBridge provides information on indexes for source and spanner databases. It gives details of columns that are a part of the index along with their sort order. Users can edit the index and modify the order of columns in the index,sort order of the columns, add new columns to the index and remove columns from the index.

index1 (TABLE: CART) DROP INDEX

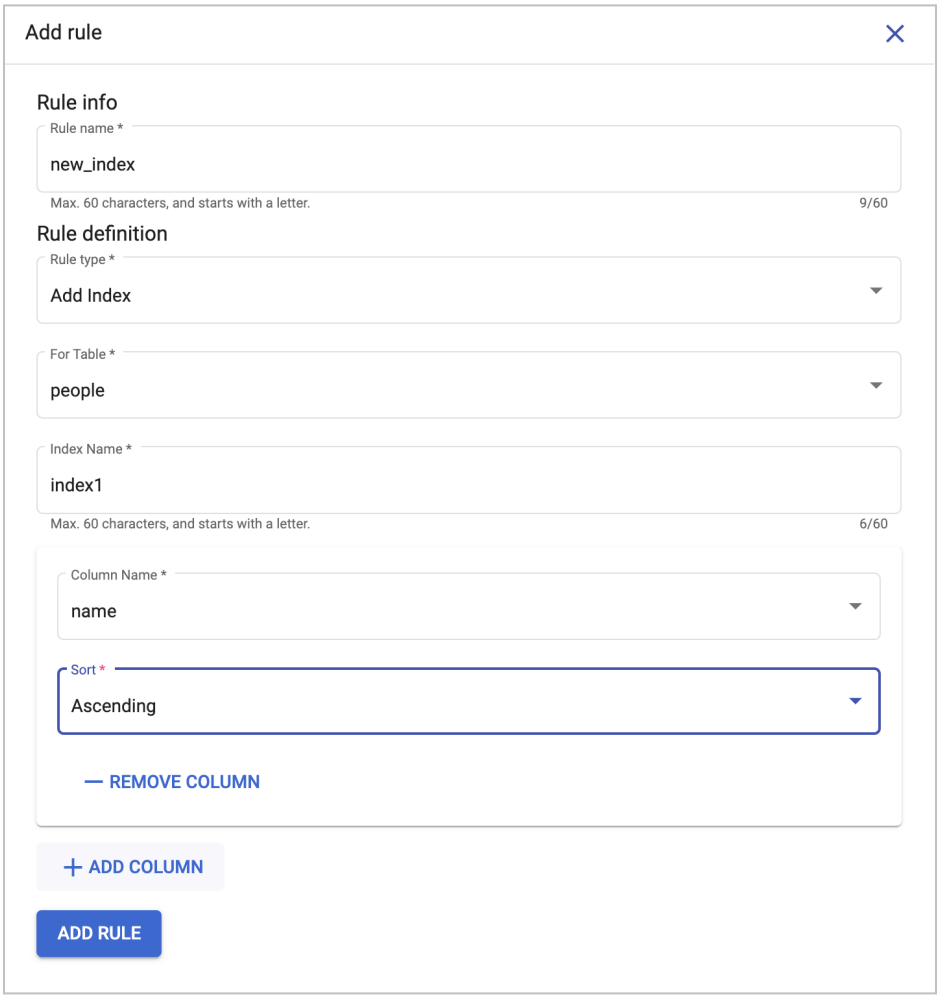
MySQL			Spanner EDIT		
Column	Sort By	Column Order	Column	Sort By	Column Order
quantity	Asc	1	quantity	Asc	1
user_id	Asc	2	user_id	Asc	2
product_id	Asc	3	product_id	Asc	3

Drop & Restore Index

HarbourBridge also provides the users with the capability to drop and restore existing indexes from the spanner database. Once the index is deleted, it appears as **deleted** under the Spanner Draft section and can be **restored** from there.

Add Secondary Index

Apart from the existing indexes for the source database, users can also add secondary indexes for any table, if required. In order to add an index for a table, the user needs to select the **Add Index** option and provide some details mandatory to create an index like **index name**, **columns** that are a part of the index and their **sort order**.



Issues & Suggestions

HarbourBridge scans through the generated spanner schema and notifies the user of any warnings encountered. It also makes intelligent suggestions to the user which would help them utilize the spanner capabilities to the fullest.

Following are some of the warnings and suggestions handled by HarbourBridge:

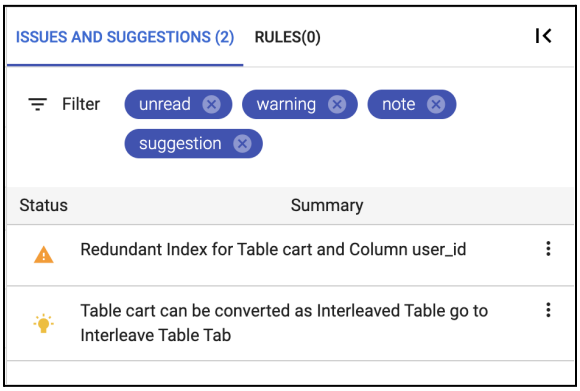
Warnings

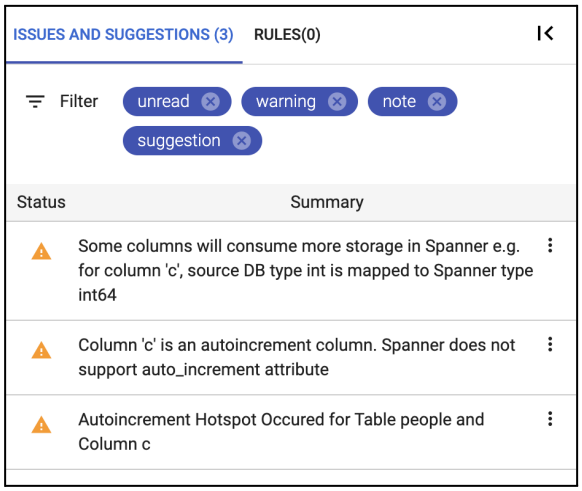
- Detection of an auto-increment key in source database because auto-increments are currently not supported in spanner

- Spanner data type consuming more storage than source data type
- Redundant indexes
- Addition of synthetic primary key - synth_id
- Hotspotting due to timestamp or auto-increment keys

Suggestions

- Modifications related to converting a table into an interleaved one
- Converting an index to interleaved index





Change Global Data type

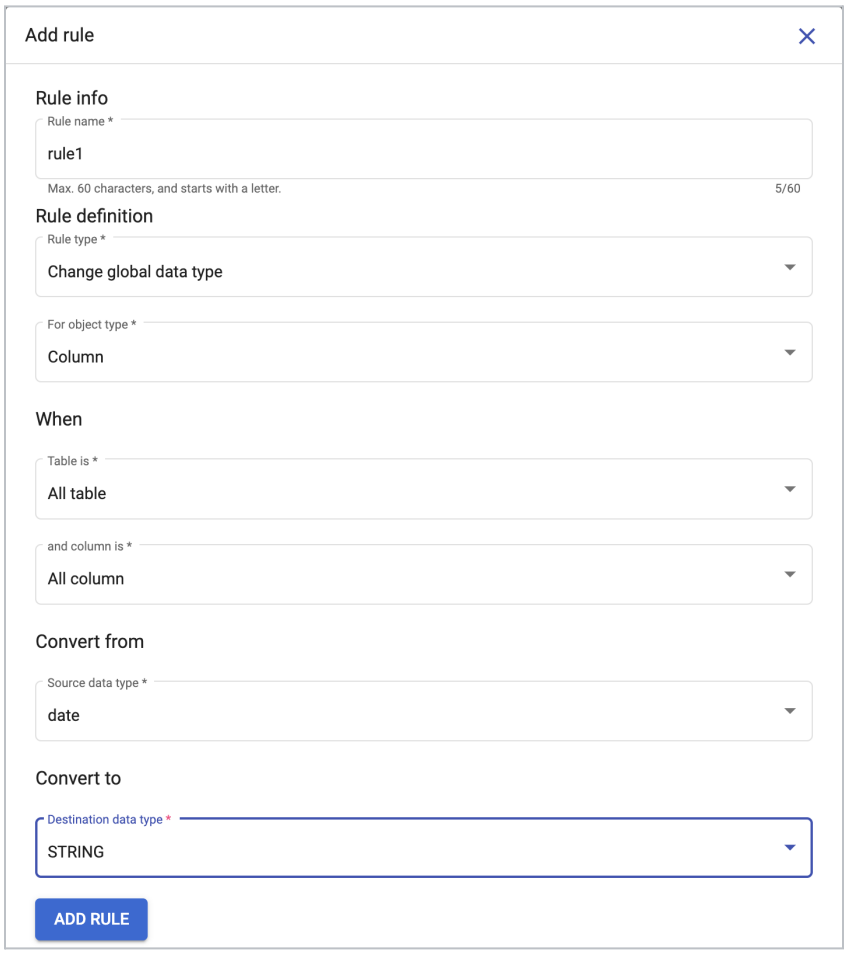
HarbourBridge has a default mapping for all the data types of the supported databases. But it also provides the users with the flexibility to modify the data type mapping, if required. For changing the global data type the user needs to go to the **Rules tab** and click on **Add Rule**, an add rule form opens up wherein the user needs to select the rule type as **Change global data type** and specify the source data type for which they need to modify the mapping and the resulting spanner datatype they want it to be mapped to. After specifying all these details once a user clicks on **Add Rule**, the rule takes effect immediately and the spanner data type is modified based on the new data type mapping.

MySQL

Order	Name	Type	Pk	Nullable
1	name	varchar		
2	birth_date	date		
3	c	int	🔑	Not Null

Spanner EDIT

Order	Name	Type	Pk	Nullable
1	name	STRING		
2	birth_date	DATE		
3	c	❗ INT64	🔑	Not Null



MySQL

Order	Name	Type	Pk	Nullable
1	name	varchar		
2	birth_date	date		
3	c	int	🔑	Not Null

Spanner EDIT

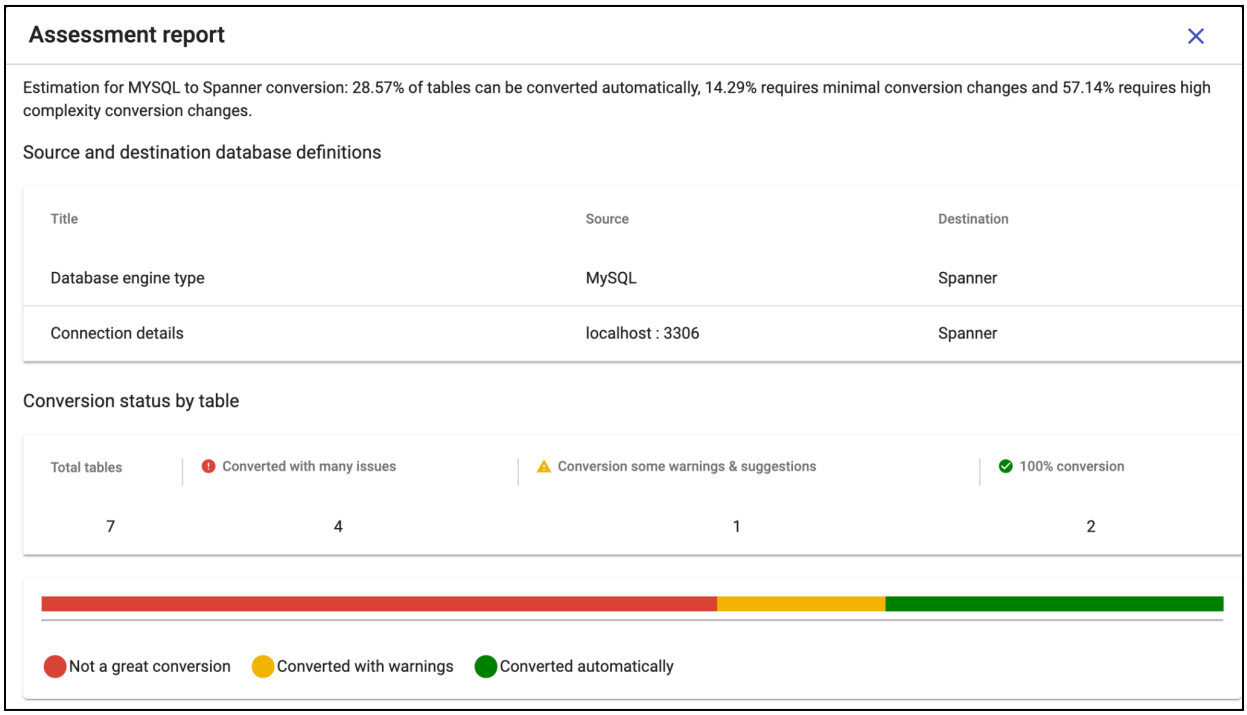
Order	Name	Type	Pk	Nullable
1	name	STRING		
2	birth_date	❗ STRING		
3	c	❗ INT64	🔑	Not Null

Review Changes

In cases where the user is modifying any column associated with an interleaved table, HarbourBridge provides a review pane which shows how their changes would impact tables across the database. And once the user has verified these changes they can click on '**Confirm Conversion**' and the changes would be applied to the database.

View Assessment

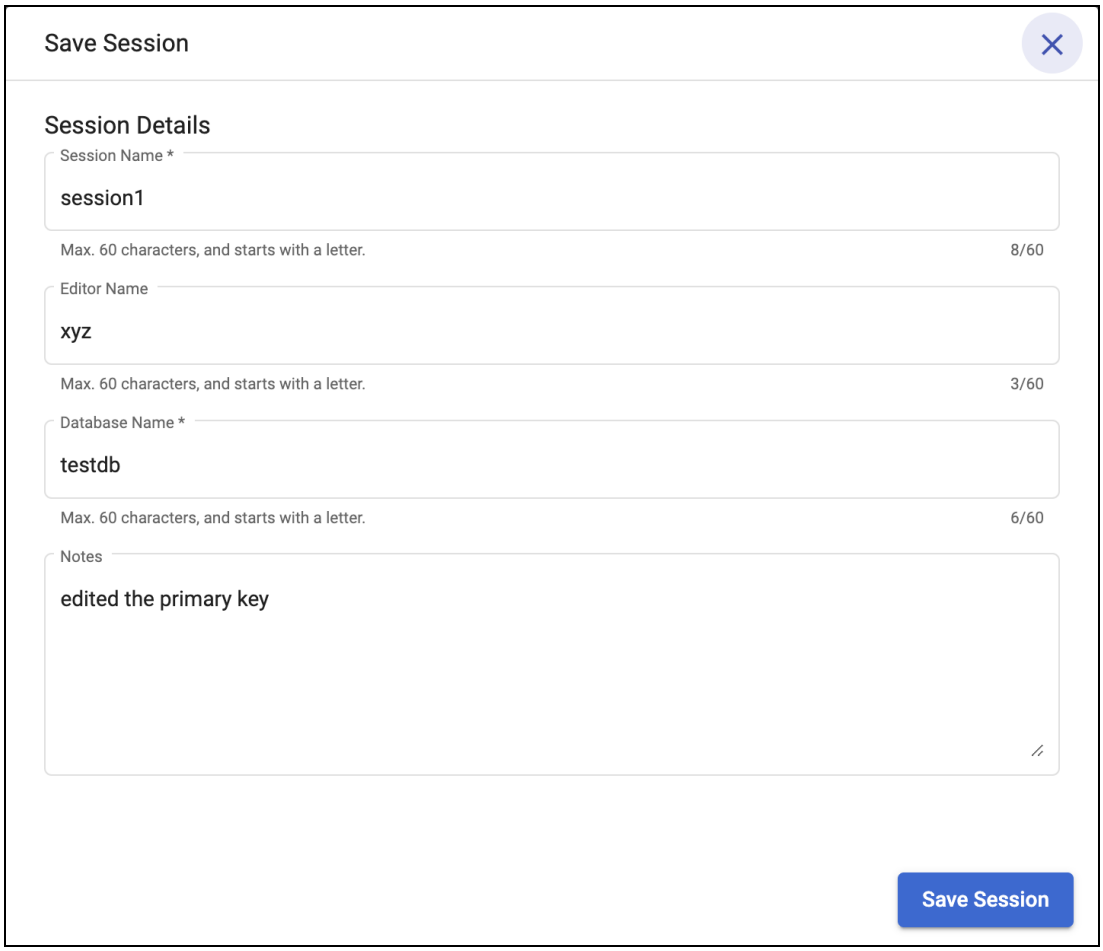
It provides the summary of schema conversion in terms of assessment report. Assessment report helps the user to understand the complexity of the schema conversion. It's broken down into 3 categories - automatic conversion, minimal complexity conversion and high complexity conversion. The conversion complexity is calculated based on the warnings and issues.



Session Management

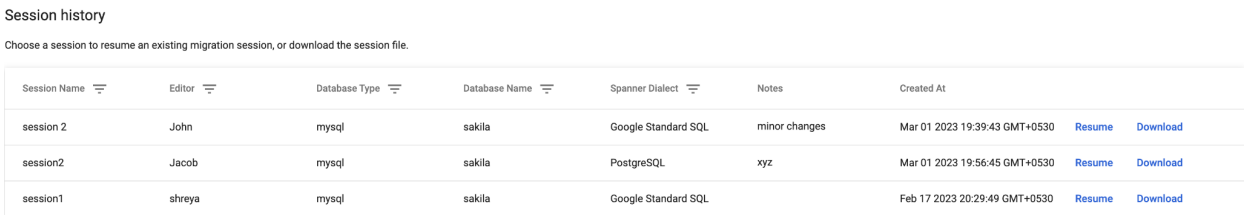
Save Session

HarbourBridge provides support for collaborative schema modifications so that users can check-point their schema edits and resume later from the point they left off. It also allows multiple users to work simultaneously on the schema assessment for the same database. For this, users can save a session after any schema modifications by completing a small form wherein they specify the session name, editor name, database name and some notes related to the current session. Once a user clicks on save, an entry is created in the metadata database with corresponding session details and they can resume the session anytime by going to the Session History section in the home page.



Session History

All the saved sessions show up here with the details about database name, editor name, spanner dialect, etc. Users can resume or download a session from this section. In case a user resumes a session it would be equivalent to the load session file connection mechanism, the only difference is that metadata is fetched from the metadata database in the configured spanner instance. In case a user wishes to download a session file, they can do so by clicking on the **Download** button for the required session.



Prepare Migration

Once the user is done with schema modifications, they can go ahead with the next step in migration wherein the database gets created in Spanner with the modified schema and data gets migrated to the new spanner database from the existing source database.

Migration Modes

There are three supported modes of migration:

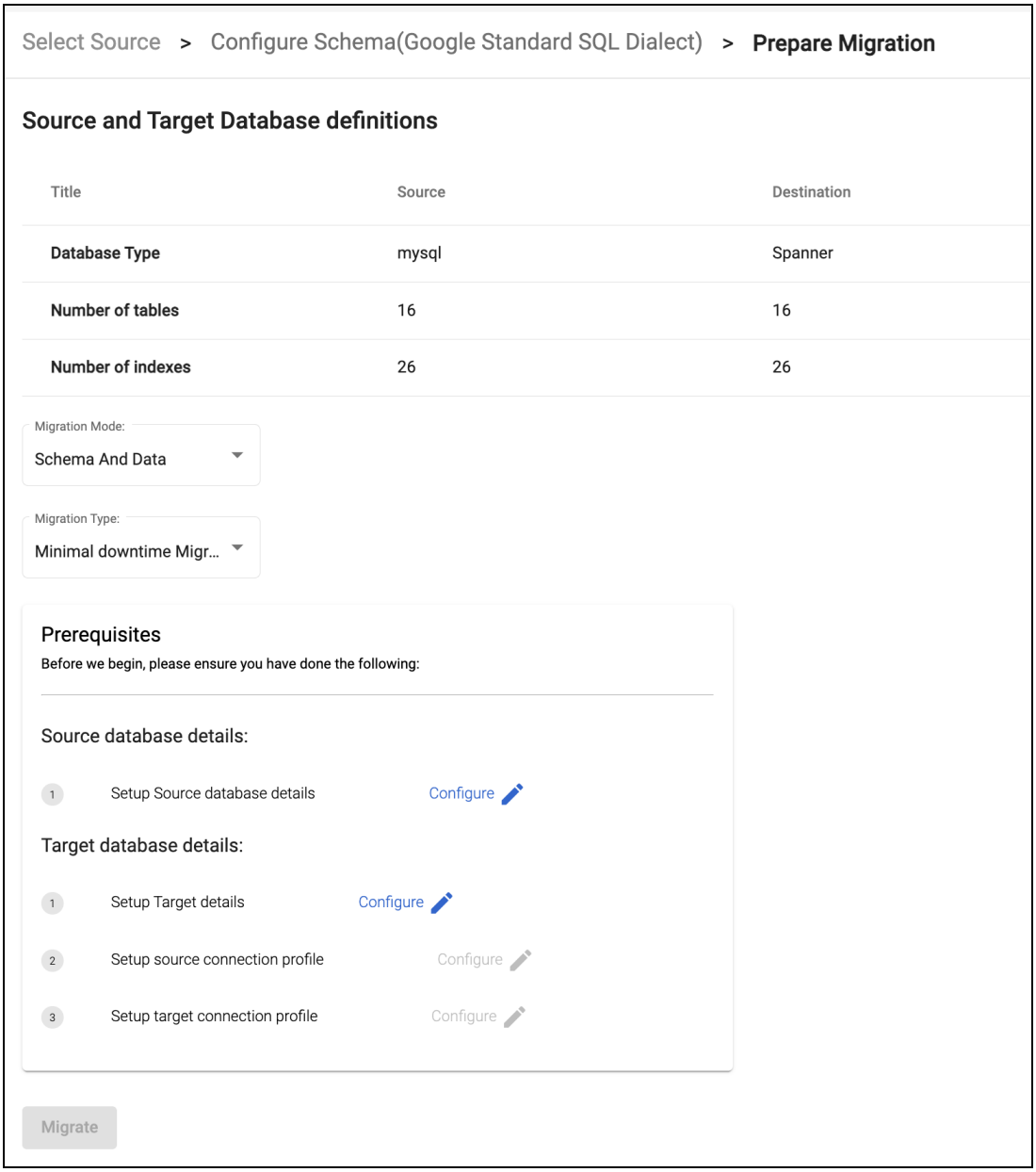
- **Schema** - This mode of migration creates a spanner database with modified schema without writing any data to the new spanner database.
- **Data** - This mode of migration writes data to an existing Spanner database. Please note that for data migration to work the schema of the existing spanner database must match with HarbourBridge's generated spanner schema.
- **Schema and Data** - This mode will create a new spanner database with the modified schema and perform the data migration to the new schema.

Migration Types

HarbourBridge supports two types migration:

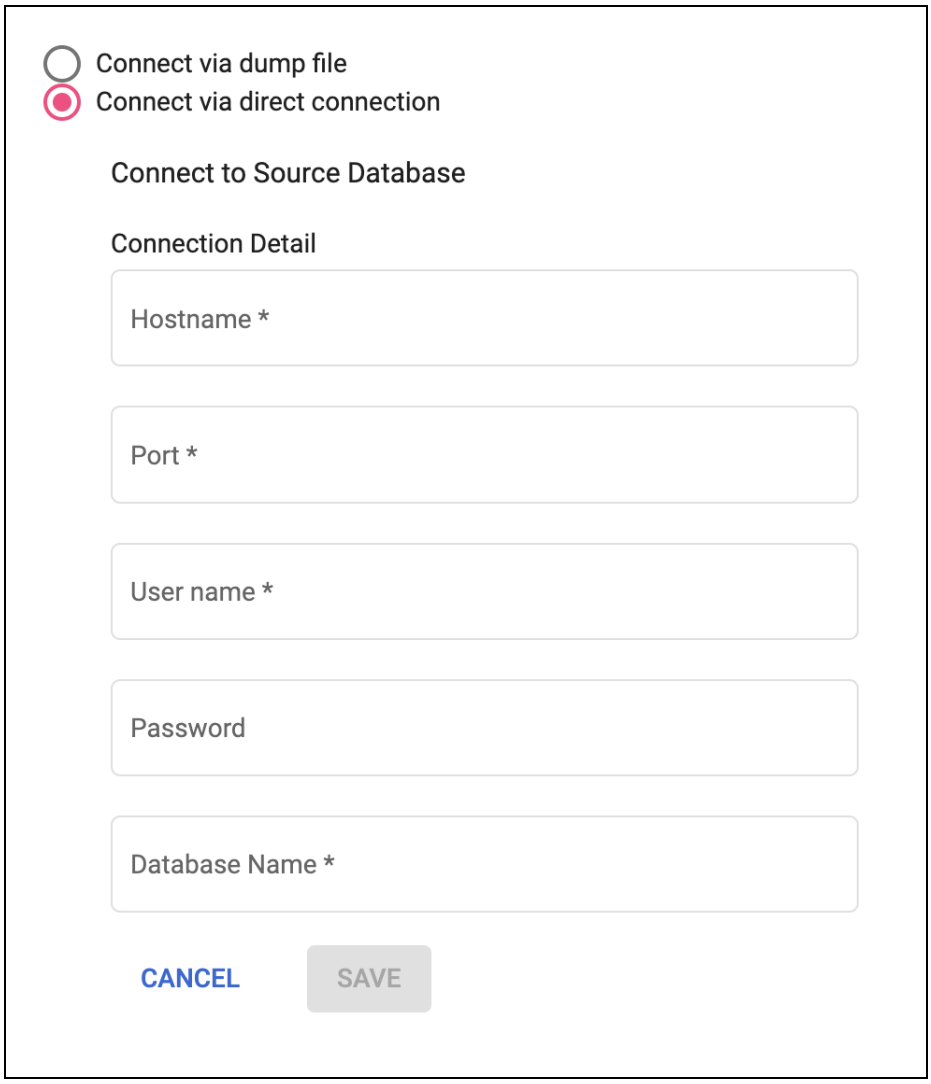
- **Bulk migration** - HarbourBridge reads data from the source database and writes it to the database created in Cloud Spanner. Changes which happen to the source database during the bulk migration may or may not be written to Spanner. To achieve a consistent version of data, stop writing on the source while migration is in progress. While there is no technical limit on the size of the database, it is recommended for migrating moderate-size datasets to Spanner(up to about 100GB).
- **Minimal downtime migration** - A minimal downtime migration consists of two components, migration of existing data from the database and the stream of changes (writes and updates) that are made to the source database during migration, referred to as change database capture (CDC). Using HarbourBridge, the entire process where Datastream reads data from the source database and writes to a GCS bucket and data flow reads data from GCS bucket and writes to a spanner database can be orchestrated using a unified interface. It is suggested for databases that require minimal downtime and for larger databases(> 100GB). Currently, HarbourBridge provides minimal downtime migration support for **MySQL, Oracle and PostgreSQL** databases.

The **Prepare Migration** page provides a summary of the source and target databases. It also provides users with the options for selecting migration mode and migration type. Once the users select these values they need to set up source and target database details. Each of these is described in detail below.



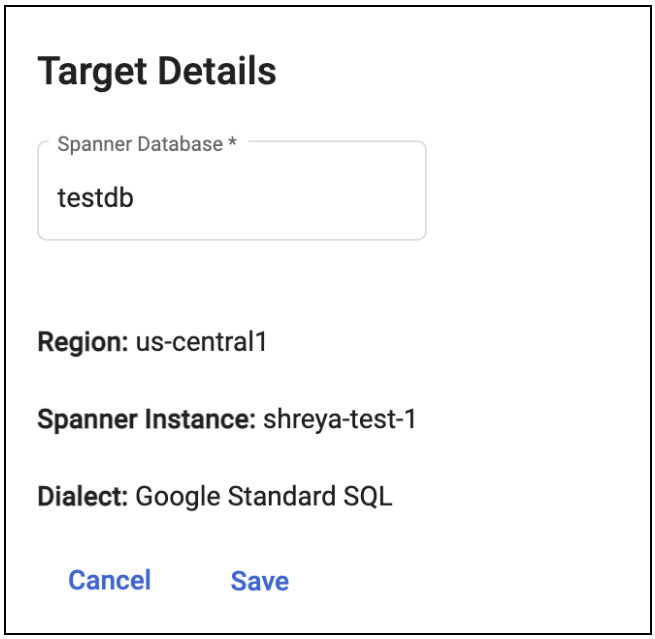
Setting up source database details

This is required only in case of session file connection mechanism. In this case HarbourBridge needs the source database details to perform data migration. While specifying the source database details, the user can either use **direct connection** or **dump file** connection mechanism and specify the required parameters to connect to the source database. Once the user clicks on save, HarbourBridge shows error or success depending on the status of their connection.



Setting up target database details

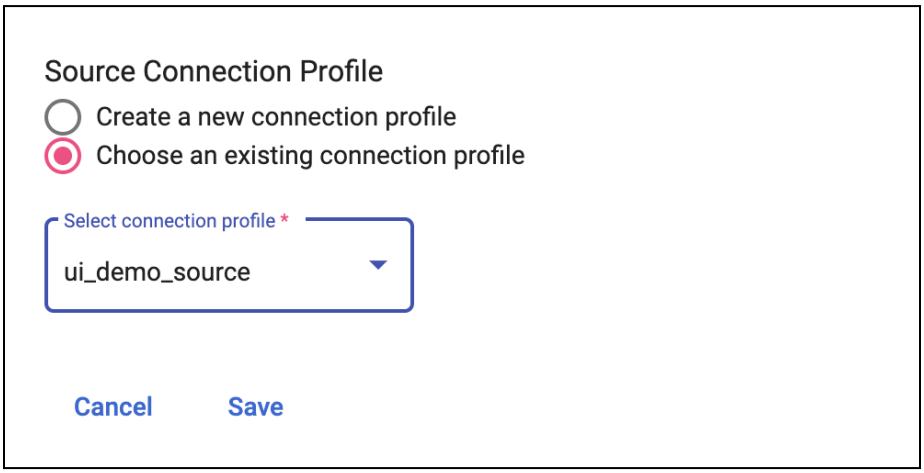
In order to create a spanner database and/or migrate data to it, the user needs to specify the target **database name,** it serves as the name of the spanner database that gets created.

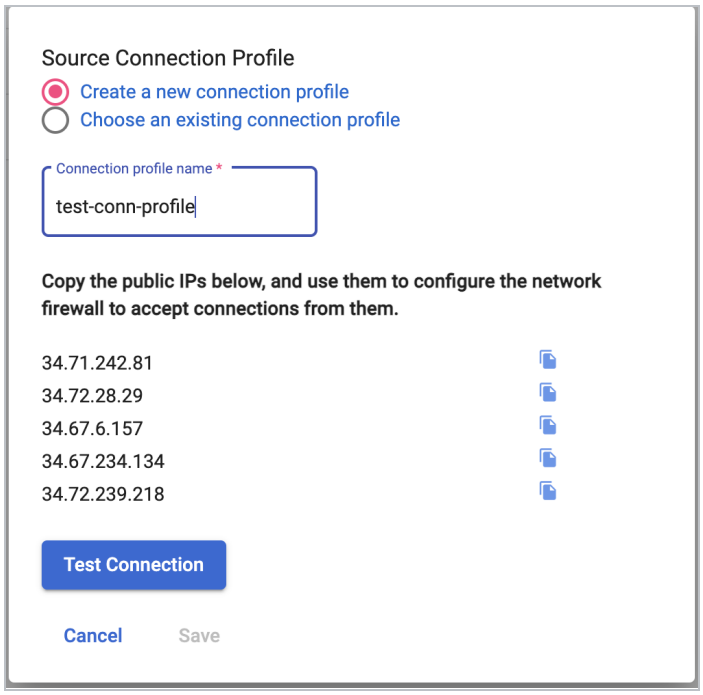


Setting up connection profiles

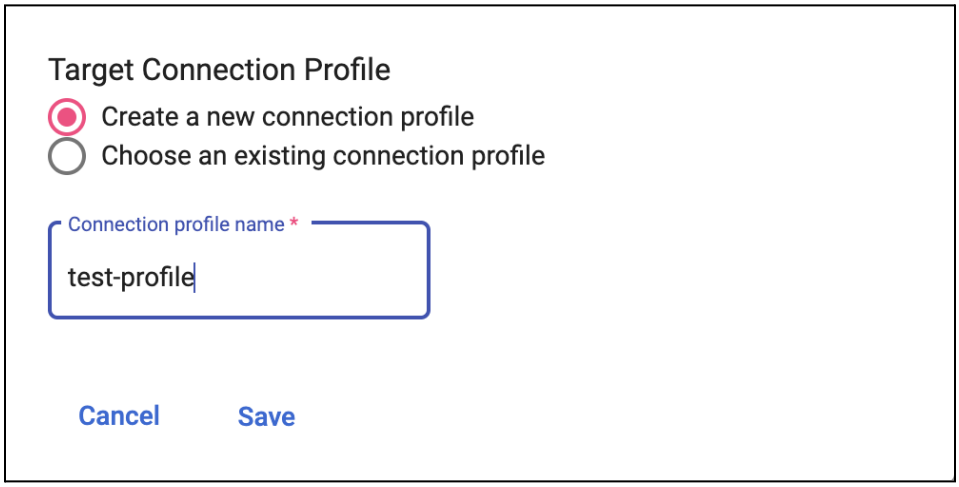
In case of minimal downtime migration, HarbourBridge needs information about connection profiles which are required by the datastream. There are two connection profiles that need to be set up - **source connection profile** and **target connection profile**.

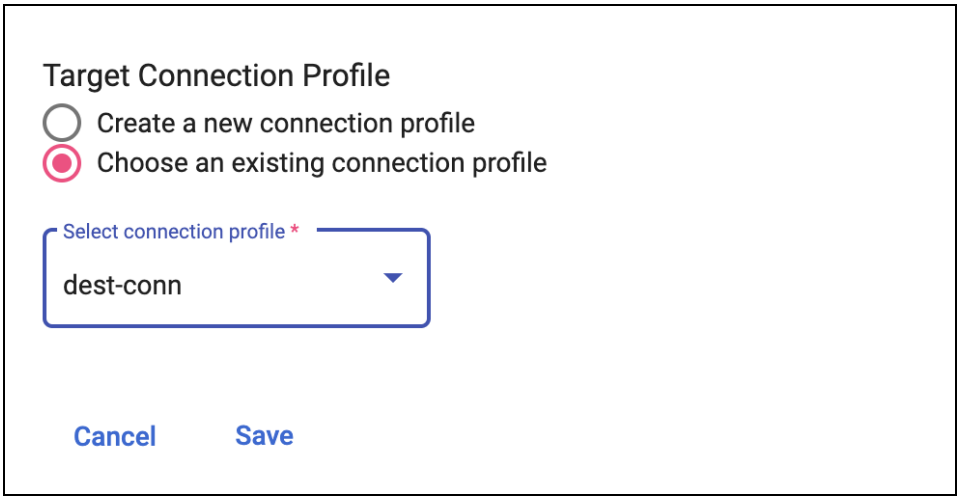
- **Source connection profile** is used by datastream to connect to the source database and read the data from the source database. Users can either use an existing source connection profile or create a new connection profile from HarbourBridge by specifying a new name for the connection profile and allowlisting the IPs.





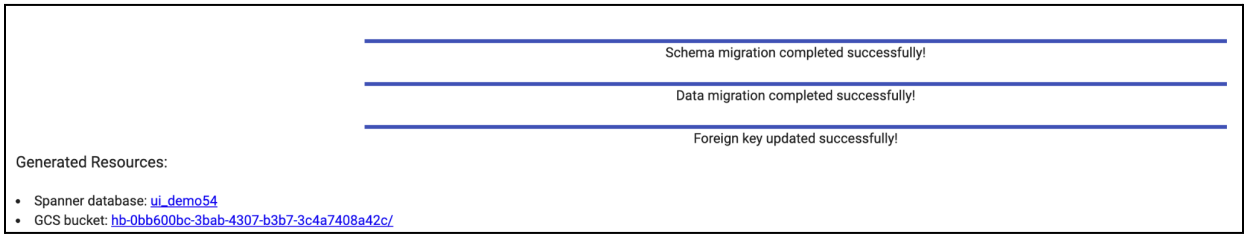
- **Target connection profile** is used to connect to the GCS bucket where the datastream writes data written to. Users can either use an existing target connection profile or create a new one from HarbourBridge by specifying a new name for the connection profile. Please ensure that the GCS bucket is empty in case you choose an existing connection profile to ensure consistency between source and spanner database. In case the user opts for a new target connection profile, HarbourBridge creates a new GCS bucket with bucket name as the Migration Request ID.





Monitoring

HarbourBridge tracks the updates for schema migration, data migration and foreign key update. This information is polled from the backend at **5 sec** intervals and presented in the UI with separate progress bars. In case of an error during migration, the state of these progress bars is marked as canceled. After the successful completion of migration the generated resources are presented to the users for utilization.



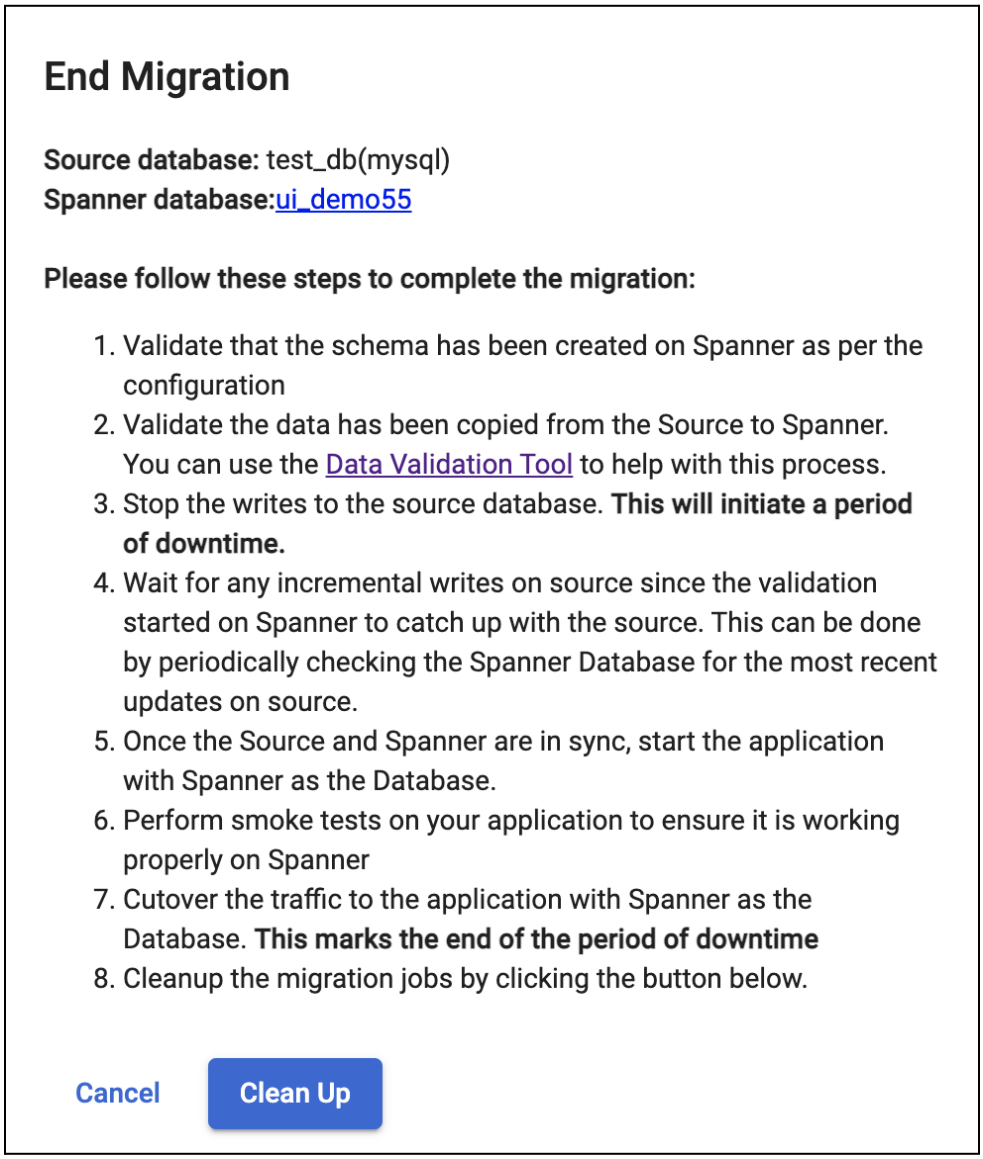
Generated Resources

For the different types of migration following are the list of resources generated:

- **Bulk migration** - Link to spanner database created and the GCS bucket which has the session file written to it.
- **Minimal downtime migration** - Link to spanner database created, GCS bucket with session file, datastream and dataflow job launched.

End migration

This is applicable only in case of minimal downtime migration. After a successful schema migration and initialization of dataflow and datastream jobs HarbourBridge presents the user with the steps to be followed to complete the migration. After completion of the migration process users can choose to clean up the migration jobs by clicking on the **Clean Up** button present on the UI.



FAQ

1. How to start the HarbourBridge UI ?
- To bring up the HarbourBridge UI, please follow the steps mentioned here.
2. Can HarbourBridge be used without connecting to the spanner instance?
- Yes, HarbourBridge can be used for schema assessment and modifications without connecting to the spanner instance
3. When is a table interleavable?
- A table is interleavable into a parent table if it has a foreign key referencing the parent table and the primary key is a superset of the primary key of the parent table.
4. What to do in case you are unable to connect to a spanner instance?

- If you are connecting from a GCE VM please verify the access scope of your GCE VM. It should be set to **Allow full access to all Cloud APIs** to allow connections to Cloud API. In case it is set to **default** access, please modify the access level by following the steps below and try again -
    - Stop the VM
    - Edit the VM configuration and change the access scope to **Allow full access to all Cloud APIs.**
    - Restart the VM
- Otherwise, execute the following command: **gcloud auth application-default login**

5. What happens behind the scenes in minimal downtime migration?

- HarbourBridge orchestrates the entire process using a unified interface, which comprises the following steps:.

    1. Setting up a GCS bucket to store incoming change events on the source database while the snapshot migration progresses.
    2. Setting up the bulk load of the snapshot data and stream of incoming change events using Datastream. **Within the HarbourBridge UI, source and target connection profile will need to be setup**
    3. Setting up the Dataflow job to migrate the change events into Spanner, which drains the GCS bucket over time.

    Once the GCS bucket is almost empty, users need to stop writing to the source database so that the remaining change events can be applied. This results in a short downtime while Spanner catches up to the source database. Afterwards,the application can be cut over to Spanner. Currently, HarbourBridge provides minimal downtime migration support for **MySQL, Oracle and PostgreSQL** databases.