CS 329E Project 6, due Thursday, 04/17.

Objectives

Implement an end-to-end data pipeline in dbt from your previously developed SQL and python notebooks. This will entail crafting dbt models, executing them, and testing the generated tables for data integrity.

Methodology

Go through your staging, intermediate, and mart notebooks and identify the SQL and Python blocks which contain one or more mutations. Apply the appropriate conversion strategy detailed below based to the type of mutation you are evaluating:

- For create-table-as-select, insert-table-as-select, and pandas Dataframe writes, convert each one to a dbt model such that SQL statements are translated into dbt SQL models and Python blocks are translated into dbt Python models:
    - SQL models should have one or more common table expressions, followed by a select statement for dbt to evaluate and persist as a table.
    - Python models should contain data manipulations that can't easily be expressed in SQL, namely complex LLM interactions and conditional logic. They must return a dataset formatted as a PySpark Dataframe. Note: Python models get executed on a Dataproc cluster on GCP which uses a PySpark runtime, hence the need to convert from Pandas to PySpark Dataframe.
    - All models that source from the raw layer should call the source() function to read the raw tables.
    - All models that source from the staging layer or above should call the ref() function to read the staging or intermediate tables, whether they are the final table or just a temp table.

- For DML statements, copy them into post-hooks or rewrite them as select statements.

- For uniqueness, not null tests, and referential integrity tests, convert them to yaml and add them to `schema.yml` using dbt's unique and not null and relationship constructs. Note that in order to test for the uniqueness of a combination of fields, an additional macro is required, which you can copy from this example. For more details on macros see the Hints section.

- Drop table statements can be translated into post-hooks and attached to the final model so that they get executed only after the final table has been created. For example, if `tmp_airports` is a temp table that persists some intermediate results and is used to create the final table called `Airport`, add the drop table statement into a post-hook in the Airport.sql file.

Implementation Plan

- After running the `dbt init` command, go to the models folder and delete the `examples` subfolder. Create the following directory structure in its place:
  - `models/stg`
  - `models/int`
  - `models/mrt`

- Edit your `dbt_project.yml` file based on this example. This file should specify your `stg`, `int`, and `mrt` folder names, dataset names, as well as materialization type. Use table materialization instead of view. Follow this naming convention: `dbt_[your-domain]_stg`, `dbt_[your-domain]_int`, and `dbt_[your-domain]_mrt` for your BQ datasets.

- Create a macro in the dbt macros folder called `generate_schema_name.sql` and copy the contents from this file into it. This macro is needed to avoid datasets being named like this: `dbt_air_travel_stg_dbt_air_travel_stg`.

- To specify the data source for the staging tables, create a `schema.yml` file in your `models/stg` directory by following this example. This will allow us to refer to the raw tables using dbt's `source()` function. Note: we are not creating a new raw dataset for dbt, we will source the dbt generated staging tables from the existing raw dataset (`[your-domain]_raw`).

- Create your model files under each model subfolder, one layer at a time, starting with the `stg` models. Look at the snippets repo to see how this was done for the air travel example.

- Run the dbt run command to compile your models. This should be run iteratively so that you can more easily debug errors. My suggestion is to port one model at a time. Make sure that the model compiles and it generates the expected output in BQ before continuing. Once you have the staging tables built, proceed with the int layer, etc. Note: the intermediate layer will take you longer to port because sections of the Python code will need to be rewritten for dbt.

- Once all of your intermediate models compile, prepare a `schema.yml` file with your primary key and foreign key constraints by following this example. Primary key constraints are specified as uniqueness and not null checks, while foreign key constraints are specified as relationship checks.

  All of your final int models should be represented in one or more `schema.yml` files. If all of your int models are located in the same folder, you'll end up with a single `schema.yml`. If your int models are spread out across multiple subfolders, you'll end up with multiple `schema.yml` files. Remember that we're only verifying the referential integrity of the final tables in the int layer, so there is no need to create tests for the staging and mart layers.

- Execute the dbt test command to run your data integrity tests on your final tables in the int layer. Resolve any errors from those tests and ensure that your uniqueness, not null, and relationship checks all pass. To resolve the errors, you will need to modify your models, re-run them, and then re-run the failing tests until they pass. Don't worry if the primary key and foreign key constraints are not visible from BQ Studio. There is a bug in the dbt bigquery connector that prevents those constraints from getting created correctly. The key outcome is for all of your dbt tests to pass.

- Generate one or more lineage graphs that capture the dependencies between the models. To do that, you'll first need to compile the documentation for your warehouse and then bring up the UI, just like we did during the setup. Take a screenshot of your full lineage graph. If your graph has > 30 nodes and is difficult to visualize in its entirety, take additional screenshots of each layer (staging, intermediate, and mart).

- To submit your work, clone your repo onto the VM and make a new project6 folder. Copy your top-level dbt project folder into this project6 one. For the lineage graphs, make a lineage subfolder in your project6 folder. Place your screenshots there.

- Once you have committed your code changes, create the usual submission.json file and upload it to Canvas by the deadline. Only one person per group needs to do this step.

Hints

- To get started, run the `dbt init [your-domain]` command to generate a new dbt project for your warehouse. You'll need to modify `.dbt/profiles.yml` just like we did during the setup. From there, you should create the proper directory structure under the models folder and then modify the default `dbt_project.yml`. You should also create the two macros and the `models/stg/schema.yml` file.

- I suggest keeping around your temp tables in BigQuery until you have verified the correctness of the final models. Otherwise, you will be recompiling them several times, which slows down development.

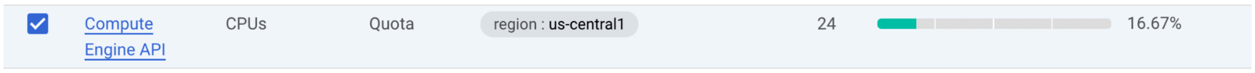
- To speed up the `dbt run` command, you can increase the number of threads from 1 to 3 in your `.dbt/profiles.yml`. This will allow dbt to execute up to 3 models concurrently without violating dependencies.

- To save time, you can compile a specific model, or models that match a specific path, using the `--select` option. More details here.

- If you are renaming a model or changing the schema of an existing model, use the `dbt run --full-refresh` option. More details here.

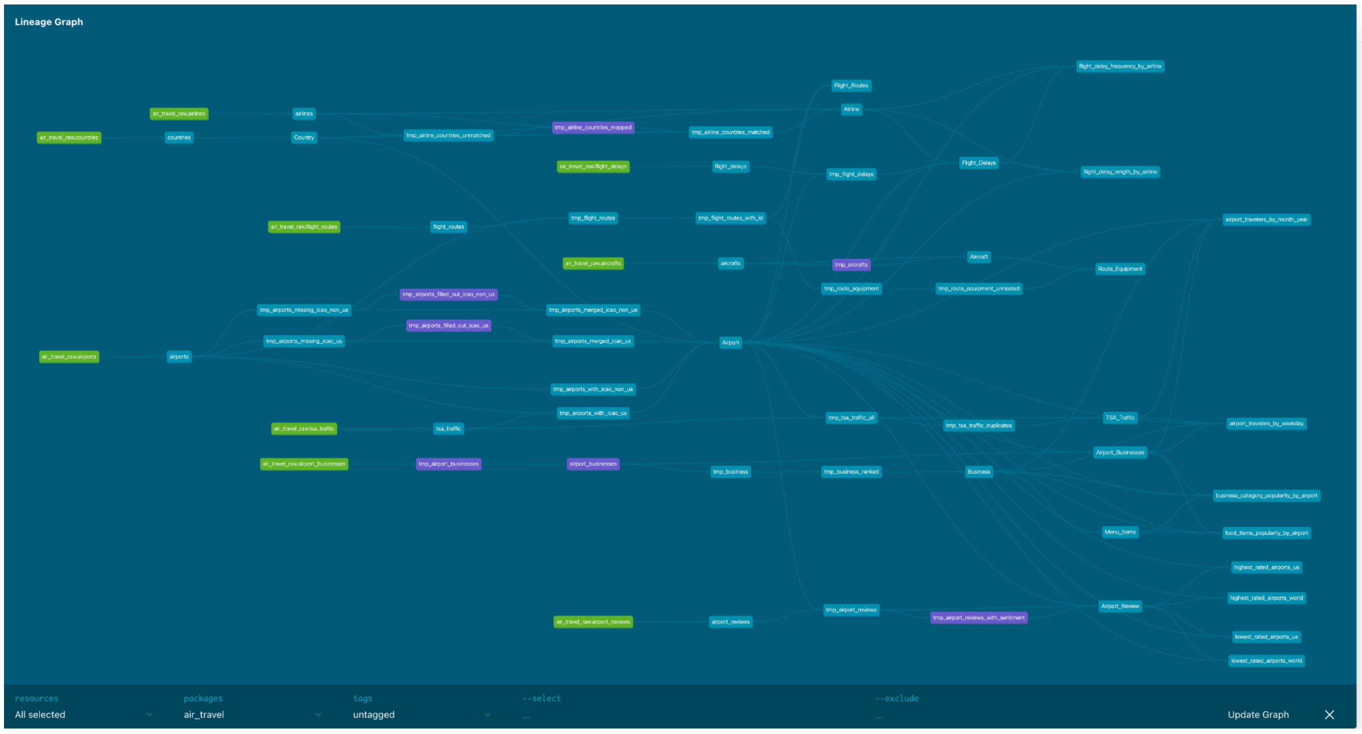
- For the primary key, foreign key, uniqueness, not null and relationship tests, I would suggest copying one of the `schema.yml` files from the snippets repo (such as this one) and using it as your starting point.

- If you get an “Insufficient quota” error, whether it be CPU or Persistent Disk, go to the Quotas page and request an increase for the resource in question. For CPU, I would recommend requesting 48 CPUs in the us-central1 region, which would be double from the current allocation. For storage, I would recommend also doubling the volume of available disk to 8 TB. These requests should get auto-approved within minutes. If they don’t, please contact me as soon as possible.



✓	Compute Engine API	CPUs	Quota	region : us-central1	24	16.67%

- To create the lineage graphs, run `dbt docs generate` followed by `dbt docs serve --port 8181` on the machine where you are running dbt. If you are running dbt on a VM, you’ll also need to bring up a local terminal, run `gcloud init`, and then set up the ssh tunnel to connect to the VM. You can use this command to create the tunnel:
```
gcloud compute ssh dbt --project [GCP-PROJECT_ID] --zone us-central1-c --
-NL 8181:localhost:8181
```
  Be sure to replace `[GCP-PROJECT_ID]` with your own project. Then, open a browser on your local machine and navigate to `http://localhost:8181`. To view the lineage graph, click on this icon: on the bottom-right corner of the home page. The graph should look similar to the image below:


Lineage Graph
air_travel_raw.airlines
air_travel_raw.countries
countries
airlines
Country
tmp_airline_countries_unmatched
tmp_airline_countries_mapped
tmp_airline_countries_matched
Flight_Routes
Airline
flight_delay_frequency_by_airline
air_travel_raw.flight_delays
flight_delays
tmp_flight_delays
Flight_Delays
flight_delay_length_by_airline
air_travel_raw.flight_routes
flight_routes
tmp_flight_routes
tmp_flight_routes_with_id
airport_travelers_by_month_year
air_travel_raw.aircrafts
aircrafts
tmp_aircrafts
Aircraft
Route_Equipment
tmp_airports_filled_out_icao_non_us
tmp_route_equipment
tmp_route_equipment_unnested
tmp_airports_missing_icao_non_us
tmp_airports_merged_icao_non_us
tmp_airports_filled_out_icao_us
tmp_airports_missing_icao_us
tmp_airports_merged_icao_us
Airport
air_travel_raw.airports
airports
tmp_airports_with_icao_non_us
tmp_airports_with_icao_us
tmp_tsa_traffic_all
TSA_Traffic
air_travel_raw.tsa_traffic
tsa_traffic
tmp_tsa_traffic_duplicates
airport_travelers_by_weekday
Airport_Businesses
air_travel_raw.airport_businesses
tmp_airport_businesses
airport_businesses
tmp_business
tmp_business_ranked
Business
business_category_popularity_by_airport
Menu_Items
food_items_popularity_by_airport
highest_rated_airports_us
highest_rated_airports_world
tmp_airport_reviews
Airport_Review
air_travel_raw.airport_reviews
airport_reviews
tmp_airport_reviews_with_sentiment
lowest_rated_airports_us
lowest_rated_airports_world
Update Graph

resources: All selected
packages: air_travel
tags: untagged
--select: ...
--exclude: ...

CS 329E Project 6 Rubric

Due Date: 04/17/25

dbt project folder is thorough and meets all requirements **-5** for each missing table or model file in staging, intermediate or mart datasets **-4** for each empty table in staging, intermediate or mart datasets **-2** for each failing uniqueness, not null or relationship test **-2** for each missing primary key or foreign key constraint not captured in one or more `schema.yml` files **-2** for each model file not using `source()` or `ref()` **-3** for not following dataset naming convention **-90** missing dbt project folder under `project6`	90
Lineage subfolder contains one or more screenshots of the model dependency graph **-1** for each missing model or dependency that doesn't correspond to the model files in the repo **-2** model names are not legible in the provided screenshot(s) **-10** missing lineage folder under `project6`	10

`submission.json` submitted into Canvas. Your project **will not** be graded without this submission. The file should have the following schema:
 	
`{`
`    "commit-id": "your most recent commit ID from Github",`
`    "project-id": "your project ID from GCP"`
`}`
 	
Example:
 	
`{`
`    "commit-id": "dab96492ac7d906368ac9c7a17cb0dbd670923d9",`
`    "project-id": "some-project-id"`
`}`
	Required

Total Credit:	**100**