

Apache Airflow Final Project Report — ETL Toll Data Pipeline

1. Introduction

In today's data-driven world, efficient data extraction, transformation, and loading (ETL) processes are crucial for analytics and decision-making. This project demonstrates the use of **Apache Airflow** — a powerful workflow orchestration tool — to automate and schedule ETL tasks.

The objective is to process toll data from various file formats (CSV, TSV, and fixed-width text) and consolidate it into a single transformed dataset that can be used for traffic pattern analysis.

By completing this project, I gained **hands-on experience in workflow automation, task dependencies, data transformation, and Airflow DAG creation.**

2. Skills Learned

Through this project, I developed the following skills:

- **Apache Airflow DAG Design:** Creating and managing Directed Acyclic Graphs for task automation
- **Bash Scripting in Airflow:** Using BashOperator to execute Linux commands for ETL steps
- **ETL Workflow Automation:** Automating extraction, transformation, and loading processes
- **Data Manipulation in Linux:** Handling CSV, TSV, and fixed-width text files using shell commands
- **Dependency Management:** Establishing relationships between sequential Airflow tasks
- **Error Handling and Retries:** Configuring retries and alerts for robust pipeline execution
- **Airflow UI Monitoring:** Monitoring DAG runs, logs, and task progress visually

3. Objectives

This project aims to develop Apache Airflow DAG that will:

- Extract data from a csv file
- Extract data from a tsv file
- Extract data from a fixed-width file
- Transform the data
- Load the transformed data into the staging area

Task 1: Set up the lab environment

- Start Apache Airflow.
- Open a terminal and create a directory structure for the staging area as follows:

`/home/project/airflow/dags/finalassignment/staging`

- Execute the following commands to give appropriate permission to the directories.

```
sudo chmod -R 777 /home/project/airflow/dags/finalassignment
```

- Download the data set from the source to the following destination using the `curl` command.

```
sudo curl https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DB0250EN-SkillsNetwork/labs/Final%20Assignment/tolldata.tgz -o /home/project/airflow/dags/finalassignment/tolldata.tgz
```

Task 2: Create imports, DAG argument, and definition

- Create a new file named ETL_toll_data.py in /home/project directory and open it in the file editor.
- Import all the necessary packages to build the DAG.
- Define the DAG arguments as per the following details in the ETL_toll_data.py file:

Parameter	Value
owner	<You may use any dummy name>
start_date	today
email	<You may use any dummy email>
email_on_failure	True
email_on_retry	True
retries	1
retry_delay	5 minutes

The screenshot displays the Databricks workspace interface. On the left, a sidebar contains navigation icons. The main area is split into two panes. The left pane shows a table of DAG arguments for the file ETL_toll_data.py:

Parameter	Value
owner	<You may use any dummy name>
start_date	today
email	<You may use any dummy email>
email_on_failure	True
email_on_retry	True
retries	1
retry_delay	5 minutes

Below the table, instructions are provided: 'Take a screenshot of the task code. Name the screenshot dag_args.jpg.' and '4. Define the DAG in the ETL_toll_data.py file using the following details.' A second table shows the DAG configuration:

Parameter	Value
DAG id	ETL_toll_data
Schedule	Daily once
default_args	As you have defined in the previous step

The right pane shows the Python code in ETL_toll_data.py:

```
1 from datetime import datetime, timedelta
2 from airflow import DAG
3 from airflow.operators.bash import BashOperator
4
5 default_args = {
6     'owner': 'sangeta C.',
7     'start_date': datetime.now(),
8     'email': ['srt3@gmail.com'],
9     'email_on_failure': True,
10    'email_on_retry': True,
11    'retries': 1,
12    'retry_delay': timedelta(minutes=5),
13}
```

At the bottom, a terminal window shows the command to run the DAG:

```
thia@thiadocker-sangeta:~/home/project$ sudo touch ETL_toll_data.py
thia@thiadocker-sangeta:~/home/project$ ls -l /home/project/ETL_toll_data.py
-rw-r--r-- 1 thia users 788 Oct 31 23:19 /home/project/ETL_toll_data.py
thia@thiadocker-sangeta:~/home/project$
```

- Define the DAG in the ETL_toll_data.py file using the following details.

Parameter	Value
DAG id	ETL_toll_data
Schedule	Daily once
default_args	As you have defined in the previous step
description	Apache Airflow Final Assignment

The screenshot displays the Apache Airflow web interface on the left and a code editor on the right. The web interface shows the 'DAG Definition' tab for a DAG named 'ETL_toll_data'. The 'Parameters' section is expanded, showing the following details:

Parameter	Value
DAG id	ETL_toll_data
Schedule	Daily once
default_args	As you have defined in the previous step
description	Apache Airflow Final Assignment

Below the parameters, there is a section for 'Take a screenshot of the command and output you used. Name the screenshot: dag_definition.jpg'. At the end of the exercise, it states: 'At the end of this exercise, you should have the following screenshots with .jpg or .png extensions: 1. dag_arg.jpg 2. dag_definition.jpg'.

The code editor on the right shows the Python code for the DAG definition in 'ETL_toll_data.py':

```

1 from datetime import datetime, timedelta
2 from airflow import DAG
3 from airflow.operators.bash import BashOperator
4
5 default_args = {
6     'owner': 'sangeeta K',
7     'start_date': datetime.now(),
8     'email': ['srk12@gmail.com'],
9     'email_on_failure': True,
10    'email_on_retry': True,
11    'retries': 3,
12    'retry_delay': timedelta(minutes=5),
13 }
14
15 with DAG(
16     dag_id='ETL_toll_data',
17     default_args=default_args,
18     description='Apache Airflow Final Assignment',
19     schedule_interval='@daily',
20 ) as dag:
21     task
  
```

The terminal at the bottom shows the command to run the DAG definition file:

```

thai@theladocker-sangsteramd:/home/projects $ sudo touch ETL_toll_data.py
thai@theladocker-sangsteramd:/home/projects $ ls -l /home/projects/ETL_toll_data.py
-rw-r--r-- 1 thai user 700 Oct 13 23:10 /home/projects/ETL_toll_data.py
thai@theladocker-sangsteramd:/home/projects $
  
```

Task 3: Create the tasks using BashOperator

- Create a task named `unzip_data` to unzip data. Use the data downloaded in the first part of this assignment in Set up the lab environment and uncompress it into the destination directory using `tar`.

The screenshot displays the Apache Airflow web interface. On the left, a sidebar contains navigation icons. The main panel shows 'Exercise 3: Create the tasks using BashOperator' with three numbered steps. Step 1 describes creating a task named `unzip_data` to unzip data. Step 2 describes creating a task named `extract_data_from_csv` to extract fields from a CSV file. Step 3 describes creating a task named `extract_data_from_json` to extract fields from a JSON file. The right panel shows the task definition for `unzip_data` in the `ETL_toll_data.py` file. The code defines a `default_args` dictionary with values for `owner`, `start_date`, `email`, `email_on_failure`, `email_on_retry`, `retries`, and `retry_delay`. It then defines a `DAG` object with `dag_id`, `default_args`, `description`, and `scheduler_interval`. The `unzip_data` task is defined as a `BashOperator` with `task_id` and `bash_command`.

```
1. Create a task named unzip_data to unzip data.
Use the data downloaded in the first part of this
assignment in 'Set up the lab environment' and
uncompress it into the destination directory using
'tar'.

Take a screenshot of the task code. Name the
screenshot unzip_data.jpg.

You can locally enter and read through the file
fileformat.txt to understand the column details.

2. Create a task named extract_data_from_csv to
extract the fields source, timestamp,
normalized_vehicle_number, and vehicle
type from the vehicle_data.csv file and save
them into a file named csv_data.csv.

Take a screenshot of the task code. Name the
screenshot extract_data_from_csv.jpg.

3. Create a task named extract_data_from_json to
extract the fields number of sales, total sales
id, and total sales date from the
total_sales_data.json file and save it into a file
```

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ETL_toll_data.py
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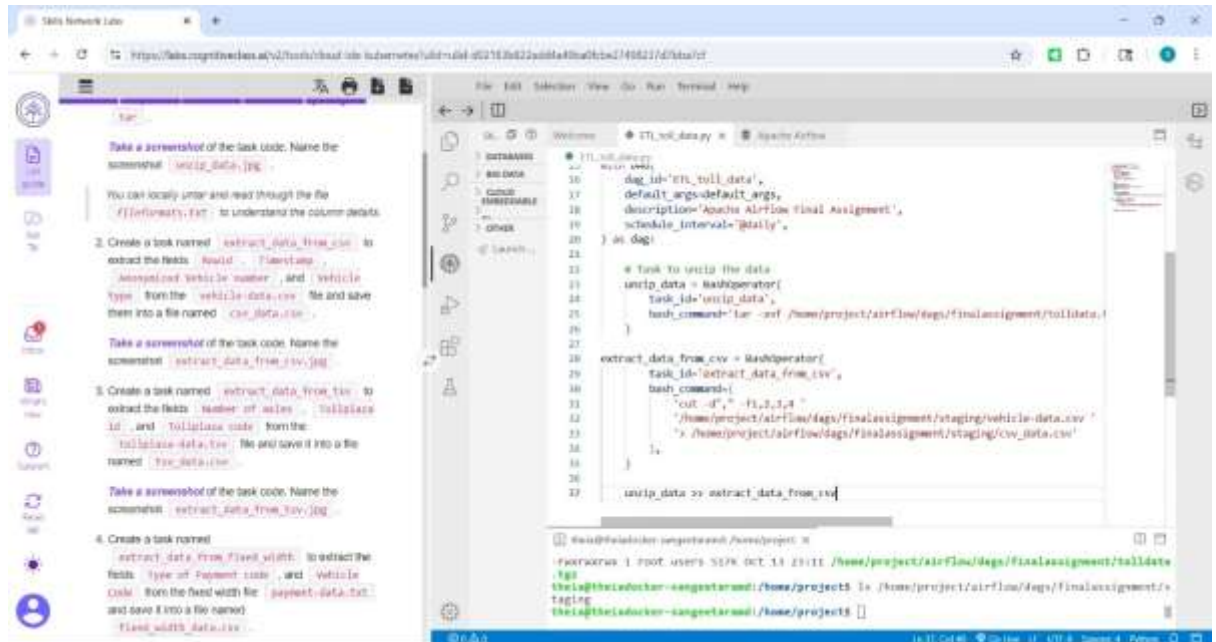
default_args = {
    'owner': 'sangeeta K',
    'start_date': datetime.now(),
    'email': ['srki@gmail.com'],
    'email_on_failure': True,
    'email_on_retry': True,
    'retries': 1,
    'retry_delay': timedelta(minutes=5),
}

with DAG(
    dag_id='ETL_toll_data',
    default_args=default_args,
    description='Apache Airflow Final Assignment',
    scheduler_interval='@daily',
) as dag:

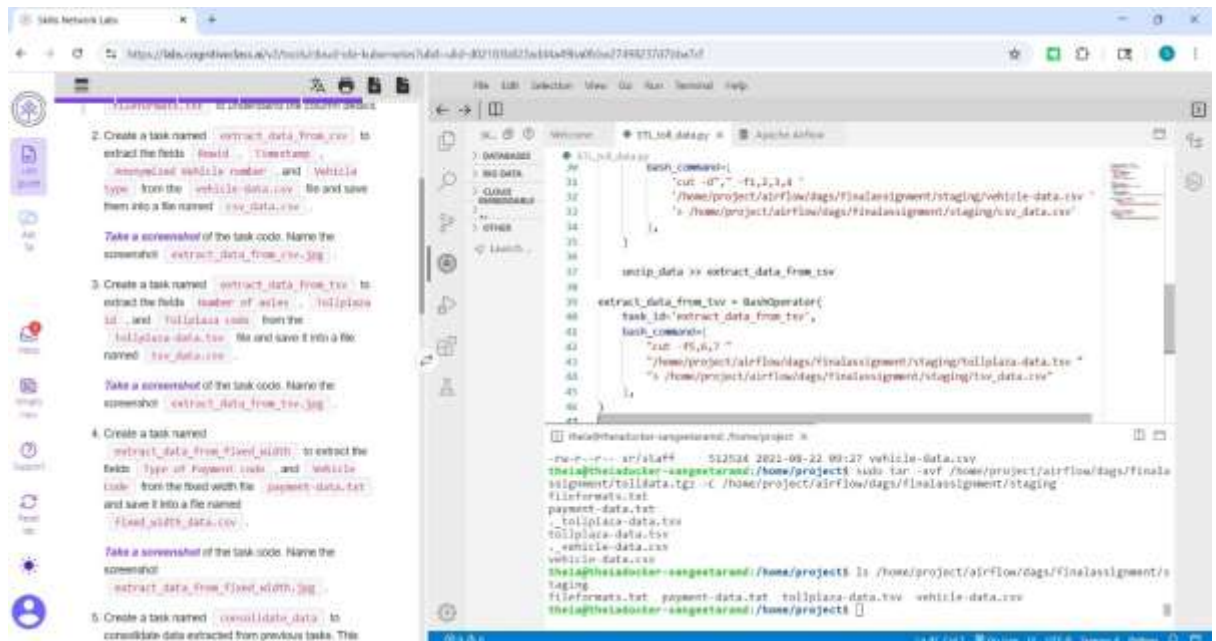
    # Task to unzip the data
    unzip_data = BashOperator(
        task_id='unzip_data',
        bash_command='tar -xvf /home/project/airflow/dags/finalassignment/tolldata.1
    )
```

```
thalia@thaliadocker-sangeetaram:/home/projects$ sudo touch ETL_toll_data.py
thalia@thaliadocker-sangeetaram:/home/projects$ ls -l /home/projects/ETL_toll_data.py
-rw-r--r-- 1 thalia users 200 Oct 15 23:10 /home/projects/ETL_toll_data.py
thalia@thaliadocker-sangeetaram:/home/projects$
```

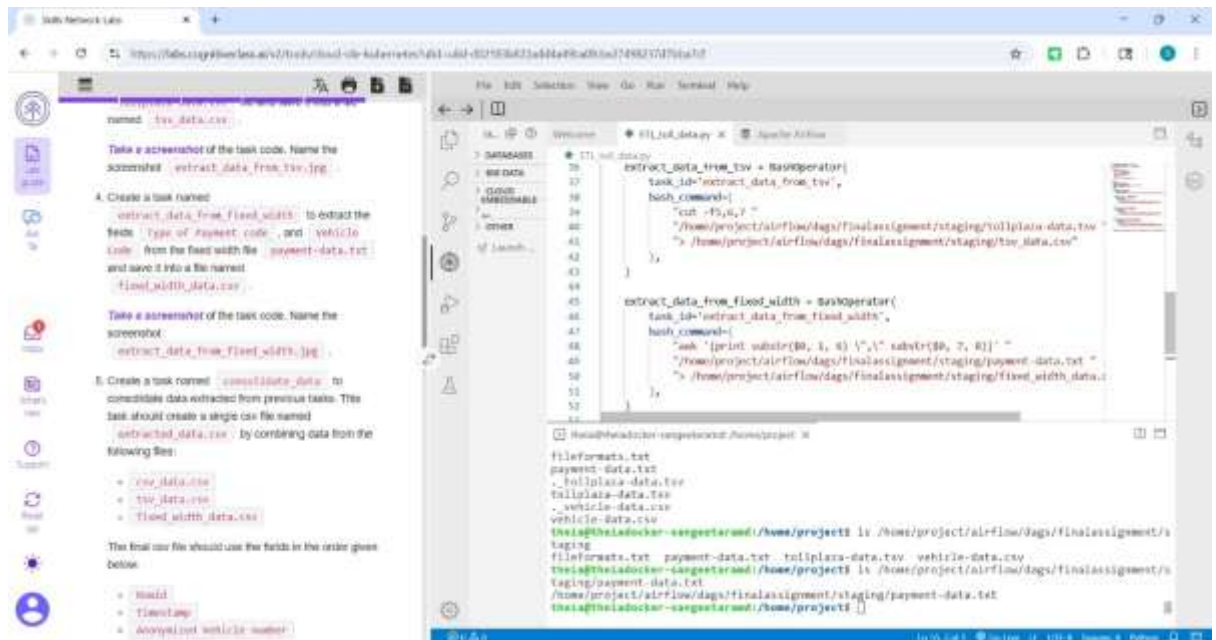
- Create a task named `extract_data_from_csv` to extract the fields Rowid, Timestamp, Anonymized Vehicle number, and Vehicle type from the `vehicle-data.csv` file and save them into a file named `csv_data.csv`.



- Create a task named `extract_data_from_tsv` to extract the fields Number of axles, Tollplaza id, and Tollplaza code from the `tollplaza-data.tsv` file and save it into a file named `tsv_data.csv`.



- Create a task named `extract_data_from_fixed_width` to extract the fields Type of Payment code, and Vehicle Code from the fixed width file `payment-data.txt` and save it into a file named `fixed_width_data.csv`.



- Create a task named `consolidate_data` to consolidate data extracted from previous tasks. This task should create a single csv file named `extracted_data.csv` by combining data from the following files:
 - `csv_data.csv`
 - `tsv_data.csv`
 - `fixed_width_data.csv`

The final csv file should use the fields in the order given below:

- Rowid
- Timestamp
- Anonymized Vehicle number
- Vehicle type
- Number of axles
- Tollplaza id
- Tollplaza code
- Type of Payment code
- Vehicle Code

SABs Network Labs

https://sabs.cognitivelabs.ai/v2/tools/visual-ide-subprocess?id=task-402162622add4a80a9b0a27406217d6b2a1cf

4. Create a task named `extract_data_from_fixed_width` to extract the fields `type of payment code` and `vehicle code` from the fixed-width file `payment-data.txt` and save it into a file named `fixed_width_data.csv`.

Take a screenshot of the task code. Name the screenshot `extract_data_from_fixed_width.jpg`.

5. Create a task named `consolidate_data` to consolidate data extracted from previous tasks. This task should create a single csv file named `extracted_data.csv` by combining data from the following files:

- `csv_data.csv`
- `txt_data.csv`
- `fixed_width_data.csv`

The final csv file should use the fields in the order given below:

- `Brand`
- `Timestamp`
- `Anonymized vehicle number`
- `Vehicle type`
- `Number of axes`
- `Vehicle id`
- `Vehicle code`

File Editor Selection View Go Run Terminal Help

DATAFRAME

CSV DATA

CODE EDITOR

FILE EXPLORER

SEARCH

DEBUG

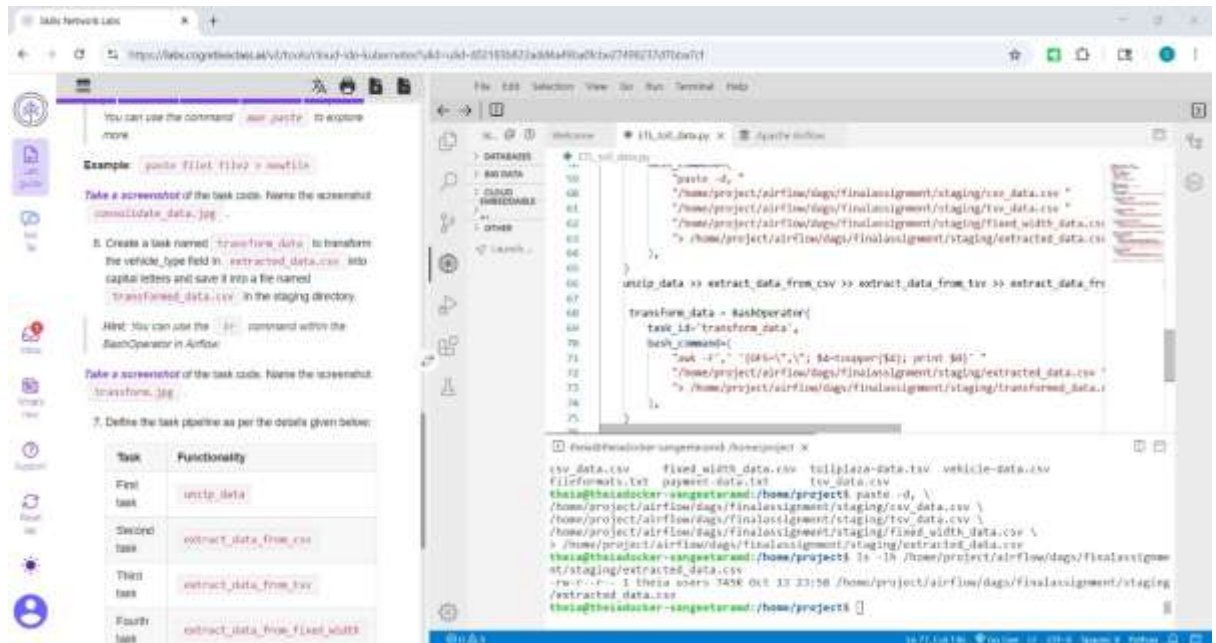
VTLSOL_data.py

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```
th@theladocker-sangsterand:/home/project$  
fileformats.txt payment-data.txt tollplaza-data.txt vehicle-data.csv  
th@theladocker-sangsterand:/home/project$ ls /home/project/airflow/dags/finalassignment/s  
tagging/payment-data.txt  
th@theladocker-sangsterand:/home/project$ ls /home/project/airflow/dags/finalassignment/s  
tagging  
fileformats.txt payment-data.txt tollplaza-data.txt vehicle-data.csv  
th@theladocker-sangsterand:/home/project$ /home/project/airflow/dags/finalassignment/stag  
ing/extracted_data.csv  
ls: cannot access /home/project/airflow/dags/finalassignment/staging/extracted_data.csv: No such file or  
directory  
th@theladocker-sangsterand:/home/project$
```


- Create a task named `transform_data` to transform the `vehicle_type` field in `extracted_data.csv` into capital letters and save it into a file named `transformed_data.csv` in the staging directory.



- Define the task pipeline as per the details given below:

Task	Functionality
First task	unzip_data
Second task	extract_data_from_csv
Third task	extract_data_from_tsv
Fourth task	extract_data_from_fixed_width
Fifth task	consolidate_data
Sixth task	transform_data

The screenshot shows the Apache Airflow web interface. On the left, there is a sidebar with navigation icons. The main area displays a DAG named 'task_pipeline' with six tasks: 'unzip_data', 'extract_data_from_csv', 'extract_data_from_csv', 'extract_data_from_fixed_width', 'transform_data', and 'consolidate_data'. The 'transform_data' task is highlighted. The DAG is in a 'Success' state. The 'transform_data' task is a BashOperator with a command that uses 'awk' to transform data from a CSV file into a fixed-width format.

```

1. unzip_data.py
2. extract_data_from_csv.py
3. extract_data_from_csv.py
4. extract_data_from_fixed_width.py
5. transform_data.py
6. consolidate_data.py

```

Task 4: Getting the DAG operational

- Submit the DAG. Use CLI or Web UI to show that the DAG has been properly submitted.

The screenshot displays the Airflow web interface on the left and a terminal window on the right. The web interface shows the 'airflow dags list-report-errors' command in the console, and the terminal shows the execution of 'airflow dags list' and 'airflow dags report-errors' commands, resulting in a list of DAGs and their status.

Exercise 4: Getting the DAG operational

- Submit the DAG. Use CLI or Web UI to show that the DAG has been properly submitted.
Take a screenshot showing that the DAG you created is in the list of DAGs. Name the screenshot `submit_dag.png`.
- Use CLI or Web UI to show that the DAG has been properly submitted.
Note: If you don't find your DAG in the list, you can check for errors using the following command in the terminal:
- Use CLI or Web UI to show that the DAG has been properly submitted.
Take a screenshot of the DAG unparsed on CLI or the GUI. Name the screenshot `unparsed_dag.png`.
- Use CLI or Web UI to show that the DAG has been properly submitted.
Take a screenshot of the tasks in the DAG run through CLI or Web UI. Name the screenshot `dag_tasks.png`.
- Use CLI or Web UI to show that the DAG has been properly submitted.
Take a screenshot of the DAG runs for the Airflow console through CLI or Web UI. Name the screenshot `dag_runs.png`.

Screenshot checklist

You should have the following screenshots with `.png` or `.jpg` extension:

- `submit_dag.png`
- `unparsed_dag.png`
- `dag_tasks.png`
- `dag_runs.png`

- Unpause and trigger the DAG through CLI or Web UI.

operational

- Submit the DAG. Use CLI or Web UI to allow that the DAG has been properly submitted.
- Take a screenshot showing that the DAG you created is in the list of DAGs. Name the screenshot: `submit_dag.jpg`
- Note: If you don't find your DAG in the list, you can check for errors using the following command in the terminal:


```
airflow dags list-import-errrors
```
- Upgrade and trigger the DAG through CLI or Web UI
- Take a screenshot of DAG unpause on CLI or the GUI. Name the screenshot: `upgrade_trigger_dag.jpg`
- Take a screenshot of the tasks in the DAG but through CLI or Web UI. Name the screenshot: `dag_tasks.jpg`
- Take a screenshot the DAG runs for the Airflow console through CLI or Web UI. Name the screenshot: `dag_run.jpg`

Screenshot checklist

You should have the following screenshots with extension: `.jpg` or `.png`

- submit_dag.jpg
- upgrade_trigger_dag.jpg

DAG Configuration:

```

graph LR
    subgraph DAG_DEFINITION
        direction TB
        A["etl_tutorial_data"]
        B["etl_tutorial_data"]
        C["etl_tutorial_data"]
        D["etl_tutorial_data"]
        E["etl_tutorial_data"]
        F["etl_tutorial_data"]
        G["etl_tutorial_data"]
        H["etl_tutorial_data"]
        I["etl_tutorial_data"]
        J["etl_tutorial_data"]
        K["etl_tutorial_data"]
        L["etl_tutorial_data"]
        M["etl_tutorial_data"]
        N["etl_tutorial_data"]
        O["etl_tutorial_data"]
        P["etl_tutorial_data"]
        Q["etl_tutorial_data"]
        R["etl_tutorial_data"]
        S["etl_tutorial_data"]
        T["etl_tutorial_data"]
        U["etl_tutorial_data"]
        V["etl_tutorial_data"]
        W["etl_tutorial_data"]
        X["etl_tutorial_data"]
        Y["etl_tutorial_data"]
        Z["etl_tutorial_data"]
    end
  
```

task_id	fileloc	owners	is_paused
etl_tutorial_data	/home/project/airflow/dags/etl_tutorial_data.py	targetata &	False
conditional_dataset_and_time_based_timetable	/home/airflow/.local/lib/python3.8/site-packages/airflow/example_dags/example_dataset.py	airflow	True
consume_1_and_3_with_dataset_expressions	/home/airflow/.local/lib/python3.8/site-packages/airflow/example_dags/example_dataset.py	airflow	True

The screenshot shows a web browser window with a URL bar displaying a GitHub repository link. The main content area is titled "Screenshot checklist" and lists five tasks for a user to complete. To the right of the text is a terminal window showing the output of a command, which includes a list of files and directories.

Screenshot checklist

You should have the following screenshots with `curl` or `http` extension:

1. `subnet_dag.jpg`
2. `unpause_trigger_dag.jpg`
3. `dag_tasks.jpg`
4. `dag_runs.jpg`

This action concludes the assignment.

The terminal window on the right shows the output of a command, likely `ls -la`, listing files and directories in a directory. The output includes files like `airflow`, `dag`, `tasks`, `runs`, and `logs`.

