Dynamic Workflows with Airflow and Python

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PyLadies Dublin
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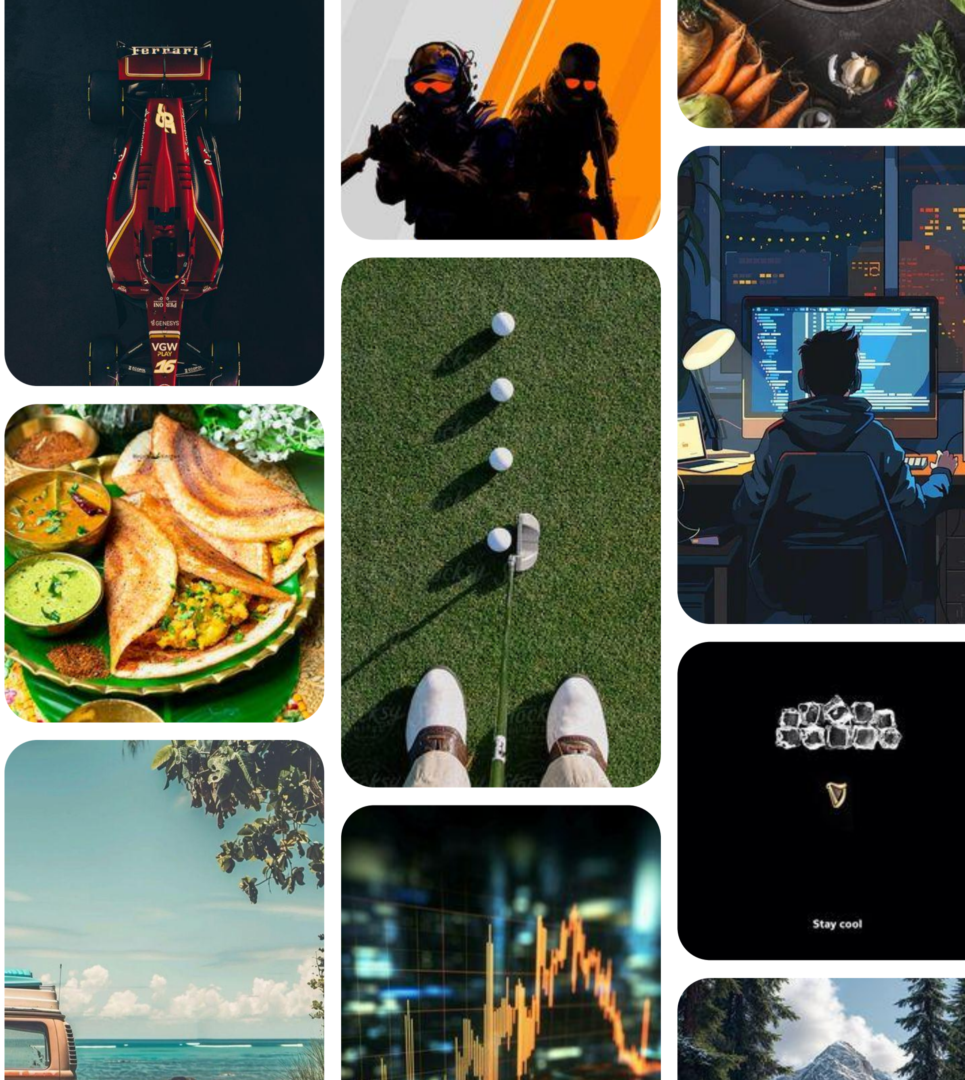


Agenda

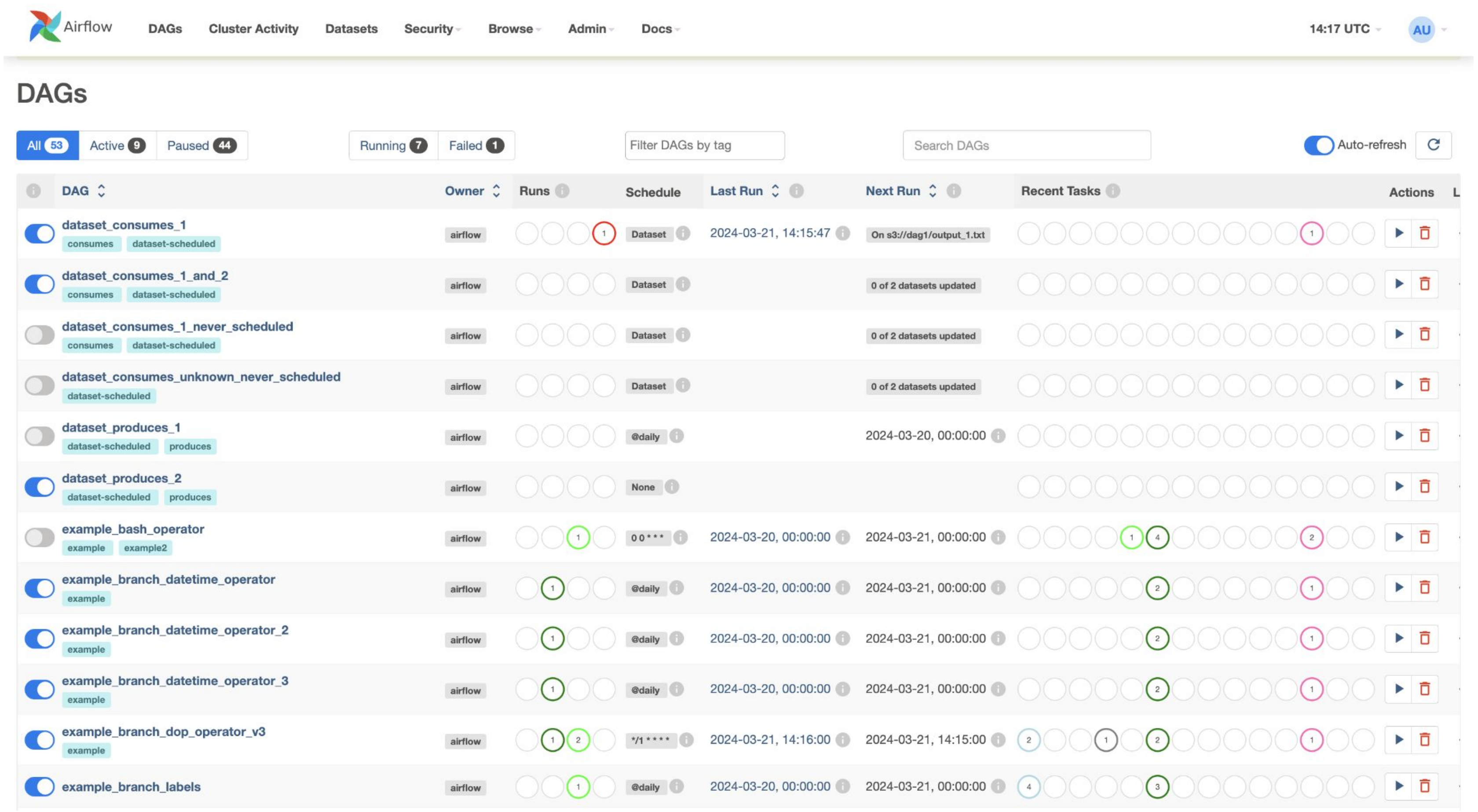
Apache Airflow is a platform created by the community to programmatically author, schedule and monitor workflows.

Features

Pure python & flexibility

Useful UI & integrations

Ease of use & open source community

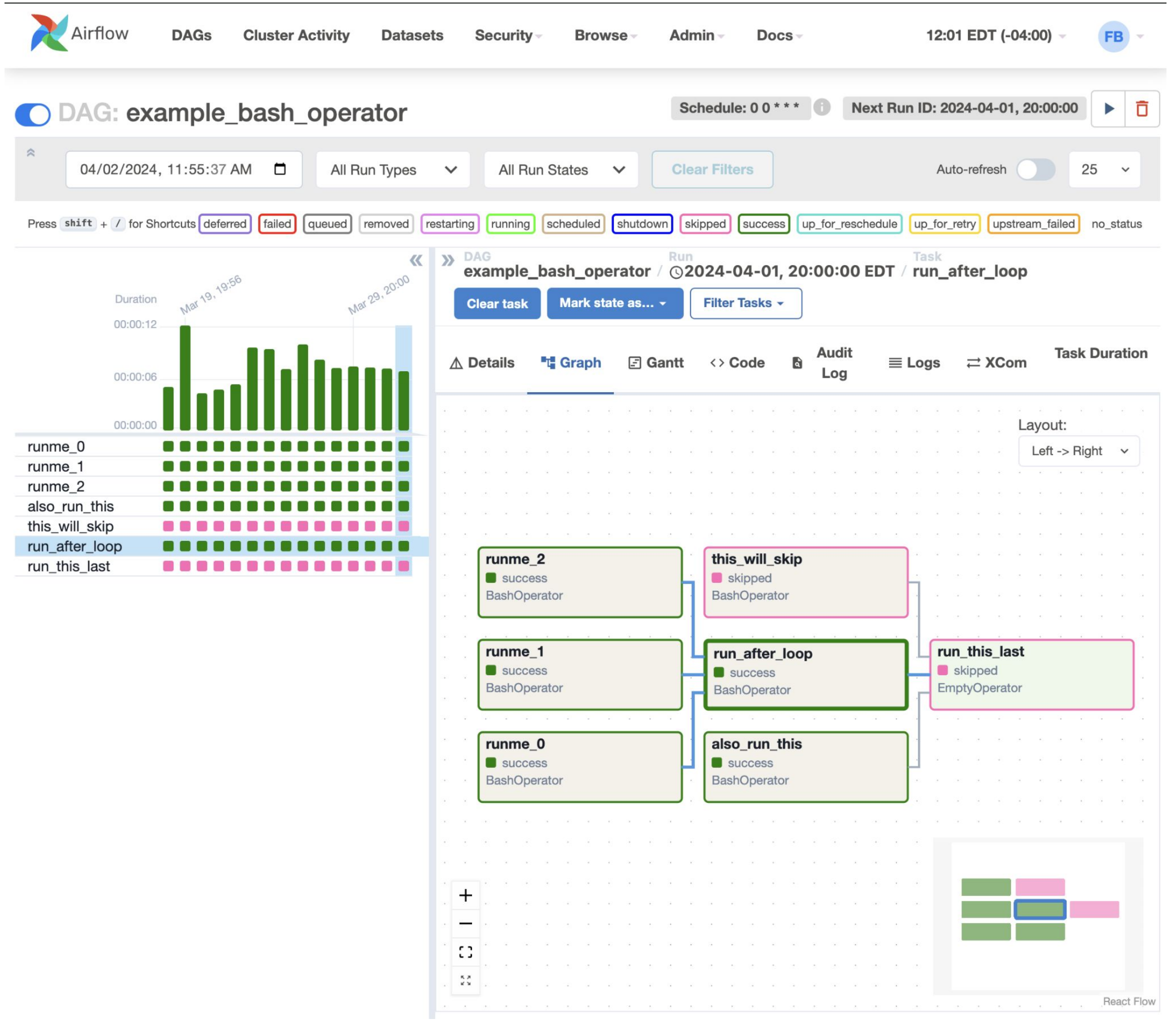


DAGs

All 53 | Active 9 | Paused 44 | Running 7 | Failed 1

Filter DAGs by tag | Search DAGs | Auto-refresh

DAG	Owner	Runs	Schedule	Last Run	Next Run	Recent Tasks	Actions
dataset_consumes_1 consumes dataset-scheduled	airflow	1	Dataset	2024-03-21, 14:15:47	On s3://dag1/output_1.txt	1	
dataset_consumes_1_and_2 consumes dataset-scheduled	airflow		Dataset		0 of 2 datasets updated		
dataset_consumes_1_never_scheduled consumes dataset-scheduled	airflow		Dataset		0 of 2 datasets updated		
dataset_consumes_unknown_never_scheduled dataset-scheduled	airflow		Dataset		0 of 2 datasets updated		
dataset_produces_1 dataset-scheduled produces	airflow		@daily		2024-03-20, 00:00:00		
dataset_produces_2 dataset-scheduled produces	airflow		None				
example_bash_operator example example2	airflow	1	0 0 * * *	2024-03-20, 00:00:00	2024-03-21, 00:00:00	1 4 2	
example_branch_datetime_operator example	airflow	1	@daily	2024-03-20, 00:00:00	2024-03-21, 00:00:00	2 1	
example_branch_datetime_operator_2 example	airflow	1	@daily	2024-03-20, 00:00:00	2024-03-21, 00:00:00	2 1	
example_branch_datetime_operator_3 example	airflow	1	@daily	2024-03-20, 00:00:00	2024-03-21, 00:00:00	2 1	
example_branch_dop_operator_v3 example	airflow	1 2	*/1 * * * *	2024-03-21, 14:16:00	2024-03-21, 14:15:00	2 1 2 1	
example_branch_labels	airflow	1	@daily	2024-03-20, 00:00:00	2024-03-21, 00:00:00	4 3	



DAG: example_bash_operator

Schedule: 0 0 * * *

Next Run ID: 2024-04-01, 20:00:00

04/02/2024, 11:55:37 AM
All Run Types
All Run States
Clear Filters
Auto-refresh
25

Press shift + / for Shortcuts deferred failed queued removed restarting running scheduled shutdown skipped success up_for_reschedule up_for_retry upstream_failed no_status

DAG example_bash_operator / Run 2024-04-01, 20:00:00 EDT / Task run_after_loop

runme_2 success BashOperator
runme_1 success BashOperator
runme_0 success BashOperator
this_will_skip skipped BashOperator
run_after_loop success BashOperator
also_run_this success BashOperator
run_this_last skipped EmptyOperator

2024 Pinterest
Reference

Spinner at Pinterest

1.3k+ active users

14k+ daily DAG runs

131k+ daily task instances

160K+ daily UI/API requests

Ref: Airflow Summit 2022

Workflows as Code

The main characteristic of Airflow workflows is that all workflows are defined in Python code.

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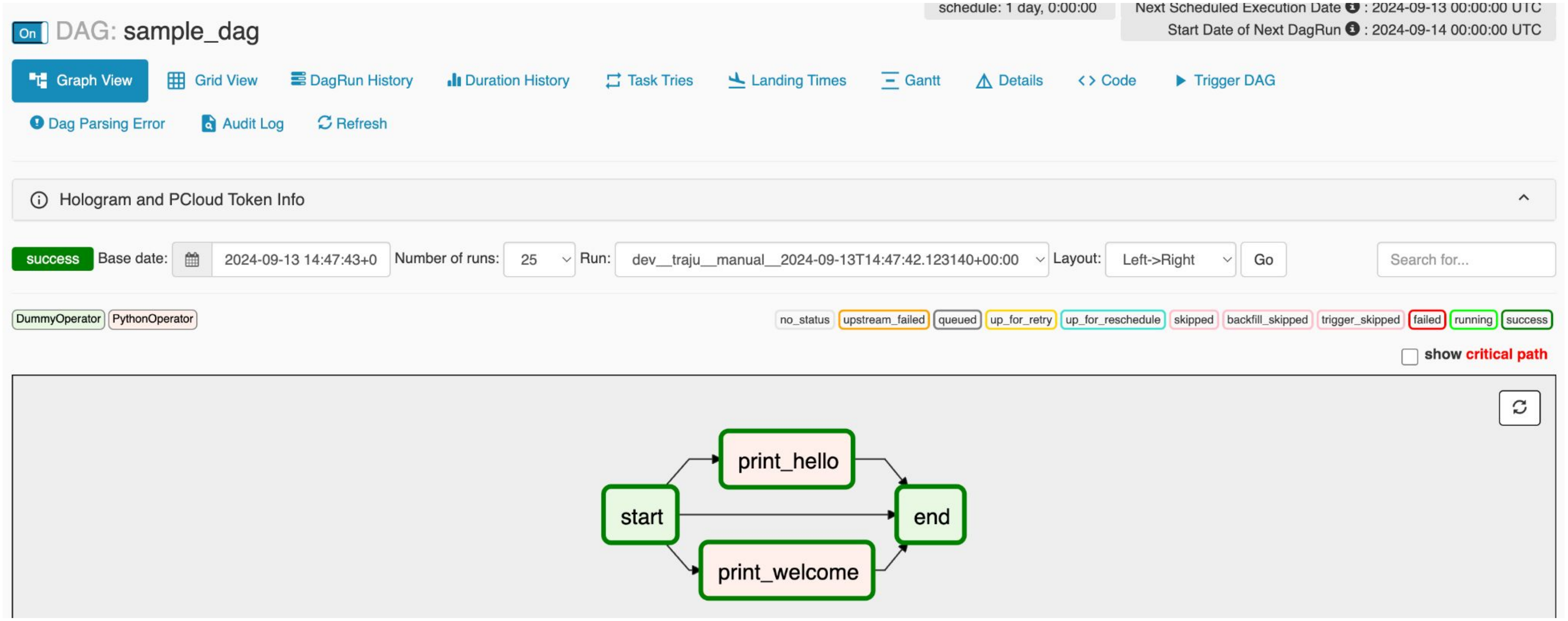
Directed Acyclic Graphs (DAG)

A DAG is a collection of all the tasks you want to run, organized in a way that explicitly lays out their dependencies and execution order in a workflow.

Tasks, Operators, and Dependencies

Tasks are the individual units of work, operators define specific types of tasks, and dependencies are the relationships determining the order in which tasks run.

```
from airflow import DAG
from airflow.operators.dummy_operator import DummyOperator
from airflow.operators.python_operator import PythonOperator
from datetime import datetime

with DAG('sample_dag', start_date=datetime(2024, 9, 10)) as dag:

    start = DummyOperator(task_id='start')

    print_hello = PythonOperator(task_id='print_hello',
python_callable=lambda: print('Hello PyLadies Dublin!'))

    print_welcome = PythonOperator(task_id='print_welcome',
python_callable=lambda: print('Welcome to Pinterest!'))

    end = DummyOperator(task_id='end')

    start >> [print_hello, print_welcome] >> end
    start >> end
```



schedule: 1 day, 0:00:00

Next Scheduled Execution Date : 2024-09-13 00:00:00 UTC

Start Date of Next DagRun : 2024-09-14 00:00:00 UTC

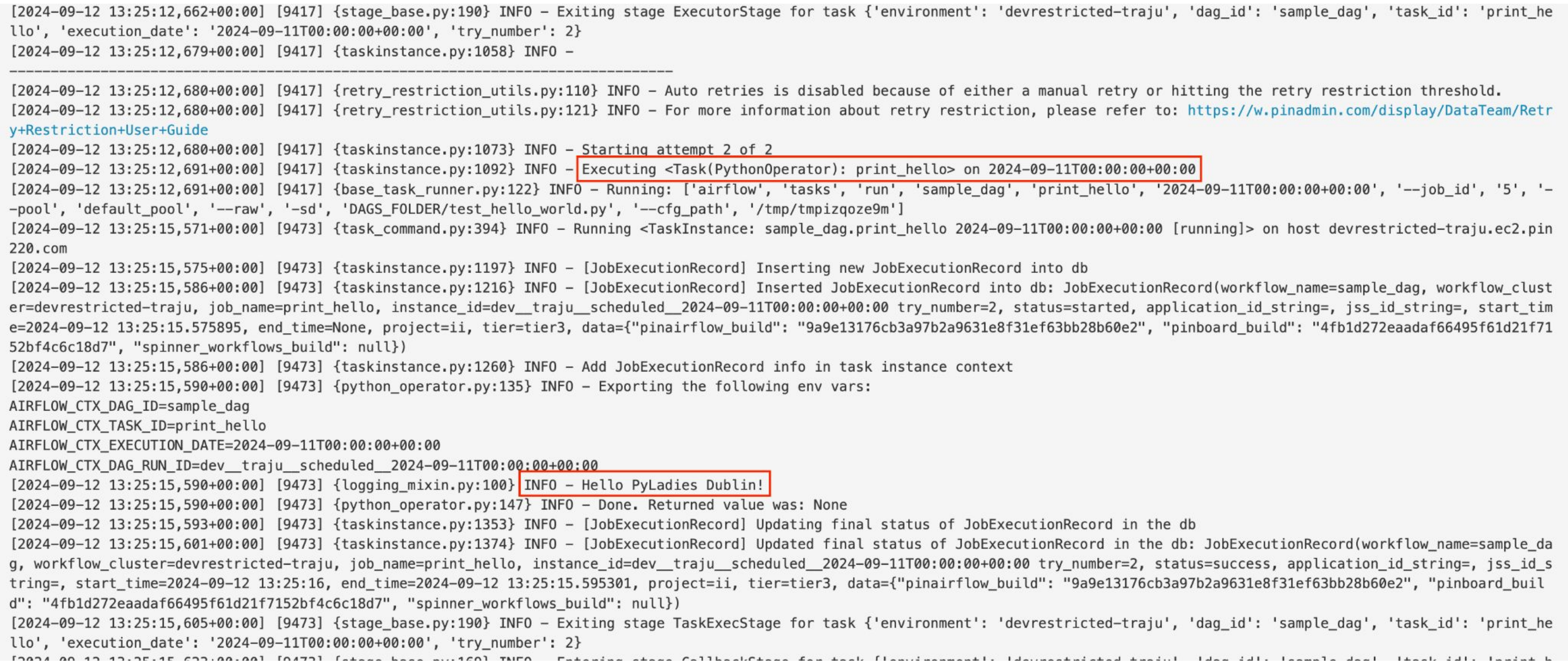
On DAG: sample_dag

Base date: 2024-09-13 14:47:43+0

Number of runs: 25

Run: dev__traju__manual__2024-09-13T14:47:42.123140+00:00

Layout: Left->Right



```
[2024-09-12 13:25:12,662+00:00] [9417] {stage_base.py:190} INFO - Exiting stage ExecutorStage for task {'environment': 'devrestricted-traju', 'dag_id': 'sample_dag', 'task_id': 'print_he
llo', 'execution_date': '2024-09-11T00:00:00+00:00', 'try_number': 2}
[2024-09-12 13:25:12,679+00:00] [9417] {taskinstance.py:1058} INFO -
--------------------------------------------------------------------------------
[2024-09-12 13:25:12,680+00:00] [9417] {retry_restriction_utils.py:110} INFO - Auto retries is disabled because of either a manual retry or hitting the retry restriction threshold.
[2024-09-12 13:25:12,680+00:00] [9417] {retry_restriction_utils.py:121} INFO - For more information about retry restriction, please refer to: https://w.pinadmin.com/display/DataTeam/Retr
y+Restriction+User+Guide
[2024-09-12 13:25:12,680+00:00] [9417] {taskinstance.py:1073} INFO - Starting attempt 2 of 2
[2024-09-12 13:25:12,691+00:00] [9417] {taskinstance.py:1092} INFO - Executing <Task(PythonOperator): print_hello> on 2024-09-11T00:00:00+00:00
[2024-09-12 13:25:12,691+00:00] [9417] {base_task_runner.py:122} INFO - Running: ['airflow', 'tasks', 'run', 'sample_dag', 'print_hello', '2024-09-11T00:00:00+00:00', '--job_id', '5', '-
-pool', 'default_pool', '--raw', '-sd', 'DAGS_FOLDER/test_hello_world.py', '--cfg_path', '/tmp/tmpizqoze9m']
[2024-09-12 13:25:15,571+00:00] [9473] {task_command.py:394} INFO - Running <TaskInstance: sample_dag.print_hello 2024-09-11T00:00:00+00:00 [running]> on host devrestricted-traju.ec2.pin
220.com
[2024-09-12 13:25:15,575+00:00] [9473] {taskinstance.py:1197} INFO - [JobExecutionRecord] Inserting new JobExecutionRecord into db
[2024-09-12 13:25:15,586+00:00] [9473] {taskinstance.py:1216} INFO - [JobExecutionRecord] Inserted JobExecutionRecord into db: JobExecutionRecord(workflow_name=sample_dag, workflow_clust
er=devrestricted-traju, job_name=print_hello, instance_id=dev__traju__scheduled__2024-09-11T00:00:00+00:00 try_number=2, status=started, application_id_string=, jss_id_string=, start_tim
e=2024-09-12 13:25:15.575895, end_time=None, project=ii, tier=tier3, data={"pinairflow_build": "9a9e13176cb3a97b2a9631e8f31ef63bb28b60e2", "pinboard_build": "4fb1d272eaadaf66495f61d21f71
52bf4c6c18d7", "spinner_workflows_build": null})
[2024-09-12 13:25:15,586+00:00] [9473] {taskinstance.py:1260} INFO - Add JobExecutionRecord info in task instance context
[2024-09-12 13:25:15,590+00:00] [9473] {python_operator.py:135} INFO - Exporting the following env vars:
AIRFLOW_CTX_DAG_ID=sample_dag
AIRFLOW_CTX_TASK_ID=print_hello
AIRFLOW_CTX_EXECUTION_DATE=2024-09-11T00:00:00+00:00
AIRFLOW_CTX_DAG_RUN_ID=dev__traju__scheduled__2024-09-11T00:00:00+00:00
[2024-09-12 13:25:15,590+00:00] [9473] {logging_mixin.py:100} INFO - Hello PyLadies Dublin!
[2024-09-12 13:25:15,590+00:00] [9473] {python_operator.py:147} INFO - Done. Returned value was: None
[2024-09-12 13:25:15,593+00:00] [9473] {taskinstance.py:1353} INFO - [JobExecutionRecord] Updating final status of JobExecutionRecord in the db
[2024-09-12 13:25:15,601+00:00] [9473] {taskinstance.py:1374} INFO - [JobExecutionRecord] Updated final status of JobExecutionRecord in the db: JobExecutionRecord(workflow_name=sample_da
g, workflow_cluster=devrestricted-traju, job_name=print_hello, instance_id=dev__traju__scheduled__2024-09-11T00:00:00+00:00 try_number=2, status=success, application_id_string=, jss_id_s
tring=, start_time=2024-09-12 13:25:16, end_time=2024-09-12 13:25:15.595301, project=ii, tier=tier3, data={"pinairflow_build": "9a9e13176cb3a97b2a9631e8f31ef63bb28b60e2", "pinboard_buil
d": "4fb1d272eaadaf66495f61d21f7152bf4c6c18d7", "spinner_workflows_build": null})
[2024-09-12 13:25:15,605+00:00] [9473] {stage_base.py:190} INFO - Exiting stage TaskExecStage for task {'environment': 'devrestricted-traju', 'dag_id': 'sample_dag', 'task_id': 'print_he
llo', 'execution_date': '2024-09-11T00:00:00+00:00', 'try_number': 2}
[2024-09-12 13:25:15,623+00:00] [9473] {stage_base.py:169} INFO - Entering stage CallbackStage for task {'environment': 'devrestricted-traju', 'dag_id': 'sample_dag', 'task_id': 'print_h
```

Principles

Scalable

Elegant

Extensible

Dynamic

Dynamic Workflows

Workflows that can automatically adjust and scale based on varying inputs, conditions, or external triggers.

Input-based Dynamic Workflows

Using environment variables

```
deployment = os.environ.get("DEPLOYMENT",
"PROD")

if deployment == "PROD":
    task = Operator(param="prod-param")
elif deployment == "DEV":
    task = Operator(param="dev-param")

// DAG code
```

Example of an **unsafe** approach:

keeping both the dev and prod data in the same location puts you at risk of overwriting prod data. This behavior will be blocked in the future.

```
prod_database = 'default'
dev_database = os.environ.get('user')

table_name = 'very_important_table'

output_dev_location = f's3://   bucket-name   /project/{dev_database}/{table_name}'
output_prod_location = 's3://   bucket-name   /project/{prod_database}/{table_name}'

...
```

Use Case: S3ResourceSpec

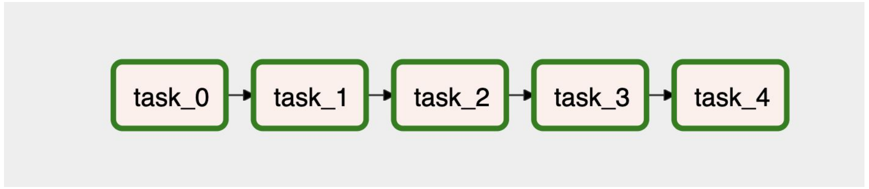
Input-based Dynamic Workflows at Pinterest

S3ResourceSpec

```
from airflow.lineage.pinterest.s3_resource
import S3ResourceSpec

# define the s3 url for the output table
output_s3_resource = S3ResourceSpec(
base_url='s3://bucket-name/retention-30days/
prefix_name/number_of_buckets',
test_resource_retention_days=30,
)

output_s3_resource_entity =
output_s3_resource.get_resource_entity()
```

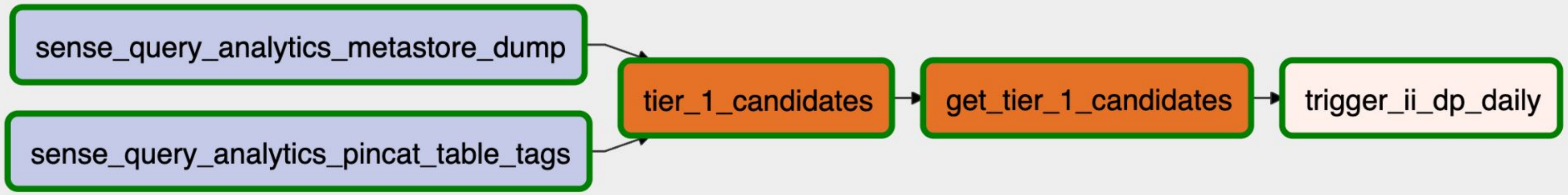
Condition-based Dynamic Workflows

Using iteration to generate tasks dynamically



```
from airflow import DAG
from airflow.operators.python_operator
import PythonOperator
from datetime import datetime

with DAG('sample_dag',
start_date=datetime(2024, 9, 10)) as dag:
    previous_task = None
    for i in range(5):
        task =
PythonOperator(task_id=f'task_{i}',
python_callable=lambda: print(f'Hello from
task {i}'))
        if previous_task:
            previous_task >> task
        previous_task = task
```

Use Case: Data Profiling


sense_query_analytics_metastore_dump
sense_query_analytics_pincat_table_tags
tier_1_candidates
get_tier_1_candidates
trigger_ii_dp_daily

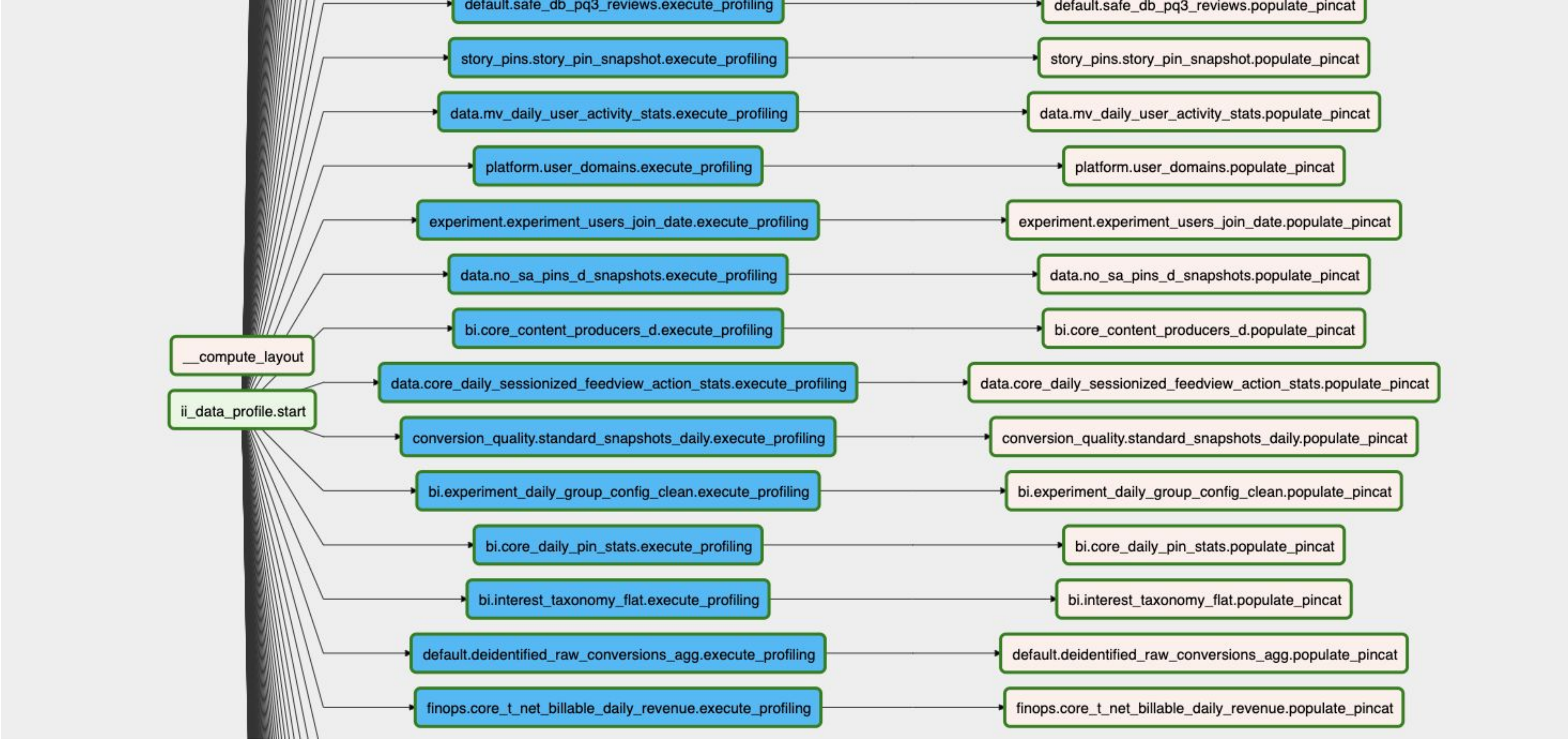
```
def _push_tables_to_xcoms(context):
    resolved = []
    for row in context['job_output']:
        dataset_name = row[0]

        if dataset_name not in resolved:
            resolved.append(dataset_name)

    context['task_instance'].xcom_push(key='datasets',
value=resolved)

context['task_instance'].xcom_push(key='wf_exec_date',
value=context['execution_date'].add(days=6)

.strftime('%Y-%m-%d'))
```

```
def _set_config(context, dag_run_obj):
    """Set the dag_run.config to pass downstream."""
    dag_run_obj.payload = {
        'datasets':
context['task_instance'].xcom_pull(task_ids='get_tier_1
_candidates', key='datasets'),
        'wf_exec_date':
context['task_instance'].xcom_pull(task_ids='get_tier_1
_candidates', key='wf_exec_date')
    }
    LOG.info(dag_run_obj)
    LOG.info(dag_run_obj.payload)
    return dag_run_obj
```

Triggered DAG: ii_dp_daily

```
from
airflow.providers.pinterest.models.dynamic_dag
import DynamicDAG


dag = DynamicDAG(
    dag_id='ii_data_profile',
    schedule_interval=None,
    default_args=default_args,
    concurrency=20,
    compute_layout=compute_layout,
    max_active_runs=3,
)
```

```
def compute_layout(dynamic_dag: DynamicDAG,
                   execution_date: datetime = None,
                   dagrun_conf: dict = None) -> None:

    dag_name = dynamic_dag.dag_id

    start = dynamic_dag.add_task_into_dynamic_dag(DummyOperator,
task_id='{}.start'.format(dag_name))

    data_profiling_task = {}
    populate_pincat_task = {}

    if isinstance(dagrun_conf, dict) and "datasets" in dagrun_conf and
isinstance(dagrun_conf["datasets"], list):

        exec_dt = dagrun_conf["wf_exec_date"]

        for dataset_name in dagrun_conf["datasets"]:

             start >> data_profiling_task[dataset_name] >>
populate_pincat_task[dataset_name]
```



default.safe_db_pq3_reviews.execute_profiling
default.safe_db_pq3_reviews.populate_pincat
story_pins.story_pin_snapshot.execute_profiling
story_pins.story_pin_snapshot.populate_pincat
data.mv_daily_user_activity_stats.execute_profiling
data.mv_daily_user_activity_stats.populate_pincat
platform.user_domains.execute_profiling
platform.user_domains.populate_pincat
experiment.experiment_users_join_date.execute_profiling
experiment.experiment_users_join_date.populate_pincat
data.no_sa_pins_d_snapshots.execute_profiling
data.no_sa_pins_d_snapshots.populate_pincat
bi.core_content_producers_d.execute_profiling
bi.core_content_producers_d.populate_pincat
__compute_layout
ii_data_profile.start
data.core_daily_sessionized_feedview_action_stats.execute_profiling
data.core_daily_sessionized_feedview_action_stats.populate_pincat
conversion_quality.standard_snapshots_daily.execute_profiling
conversion_quality.standard_snapshots_daily.populate_pincat
bi.experiment_daily_group_config_clean.execute_profiling
bi.experiment_daily_group_config_clean.populate_pincat
bi.core_daily_pin_stats.execute_profiling
bi.core_daily_pin_stats.populate_pincat
bi.interest_taxonomy_flat.execute_profiling
bi.interest_taxonomy_flat.populate_pincat
default.deidentified_raw_conversions_agg.execute_profiling
default.deidentified_raw_conversions_agg.populate_pincat
finops.core_t_net_billable_daily_revenue.execute_profiling
finops.core_t_net_billable_daily_revenue.populate_pincat

Advantages

Flexibility

Scalability

Efficiency

Best Practices

Best Practices

Optimize DAG parsing

Manage number of tasks and parallelism

Leverage XComs strategically

Conclusion

Conclusion

- Airflow's capabilities provide extensive control over workflow automation and scheduling.
- Dynamically generating workflows can enhance adaptability and operational efficiency.
- Following best practices is essential for optimizing performance and maintainability.

Questions?

Thank you!

Thejas Raju

Data Engineering at Pinterest

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Appendix

- Spinner: Pinterest’s Workflow Platform
- Airflow at Pinterest: Airflow Summit 2022
- Apache Airflow: Quick Start