Apache Airflow

Iuliia Volkova, xnuinside@gmail.com

Agenda (Day 1)

1. What is Apache Airflow?
2. What is Workflow Manager (orchestrator) and what is ETL
3. Server Components & basic installation, cli
4. DAG, basic DAG params & DAGFile, Tasks
5. DAG Run & Task Instance
6. Operators, Sensors
7. Schedule interval & catch up & execution date
8. Junja2 Templating,
9. Task Statuses
10. Files to play with (homework)
11. Q&A session

Agenda (Day 2)

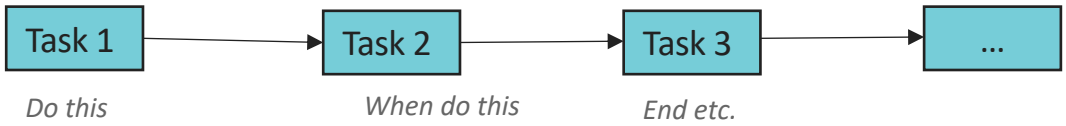
1. Macros, User Defined Marcos, Xcom
2. SLAs, Alerts, Retries
3. BranchOperator, TriggerRules
4. Hooks, Connections
5. Executors
6. Configuration (let's add Celery Executor & PostgreSQL)
7. Workers & Flower
8. Variables, Run DAG with Params
9. Backfill
10. Customization: UI plugins
11. Airflow in clouds: Google Compose (Airflow in GCP), Astronomer.io
12. Q&A session

What is Apache Airflow?

What is Apache Airflow?

It is an workflow manager!
(or orchestrator)

What is workflow or pipeline or DAG (Direct Acyclic Graph)



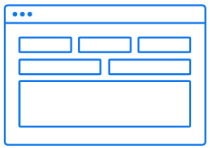
Alternatives (Orchestrators)

For DS & ML

Similar things for Ops/DevOps/non data workflows

and etc.

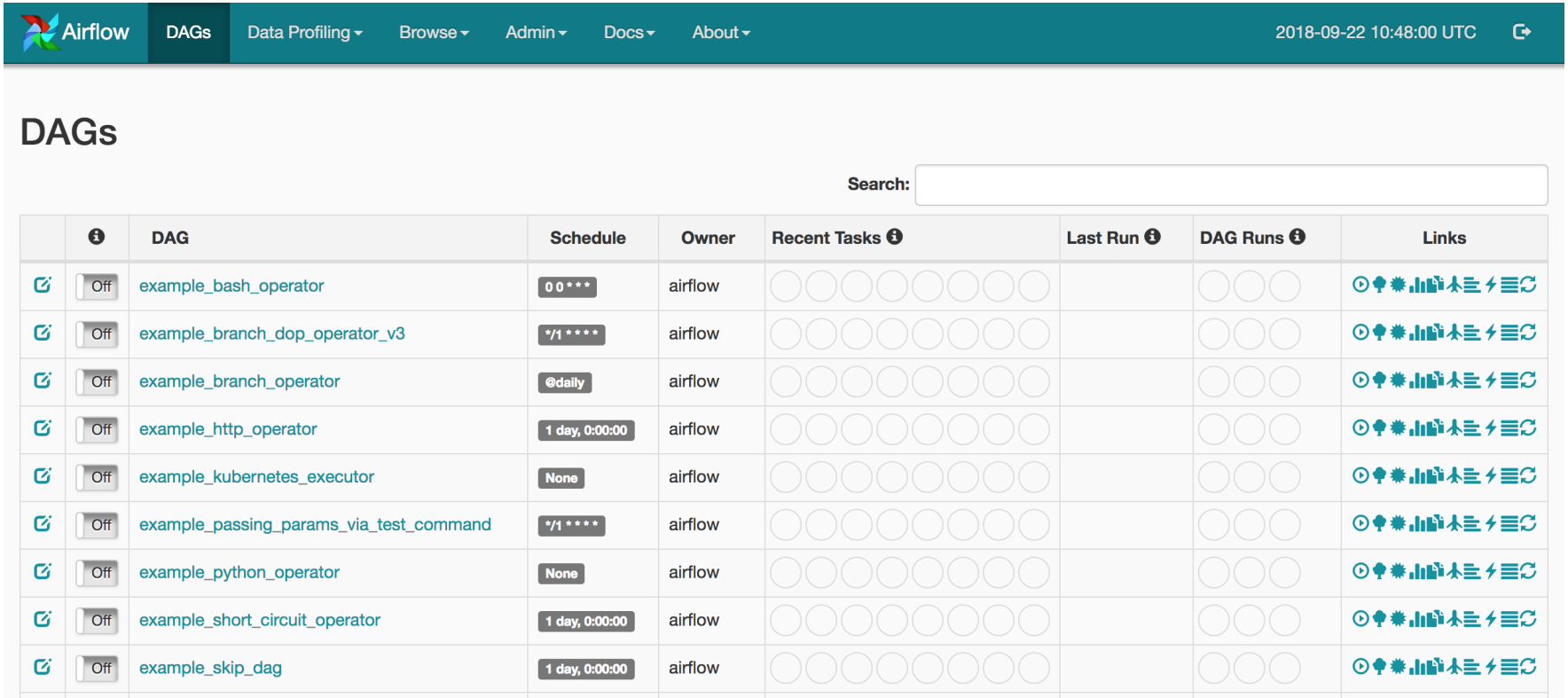
Main Features



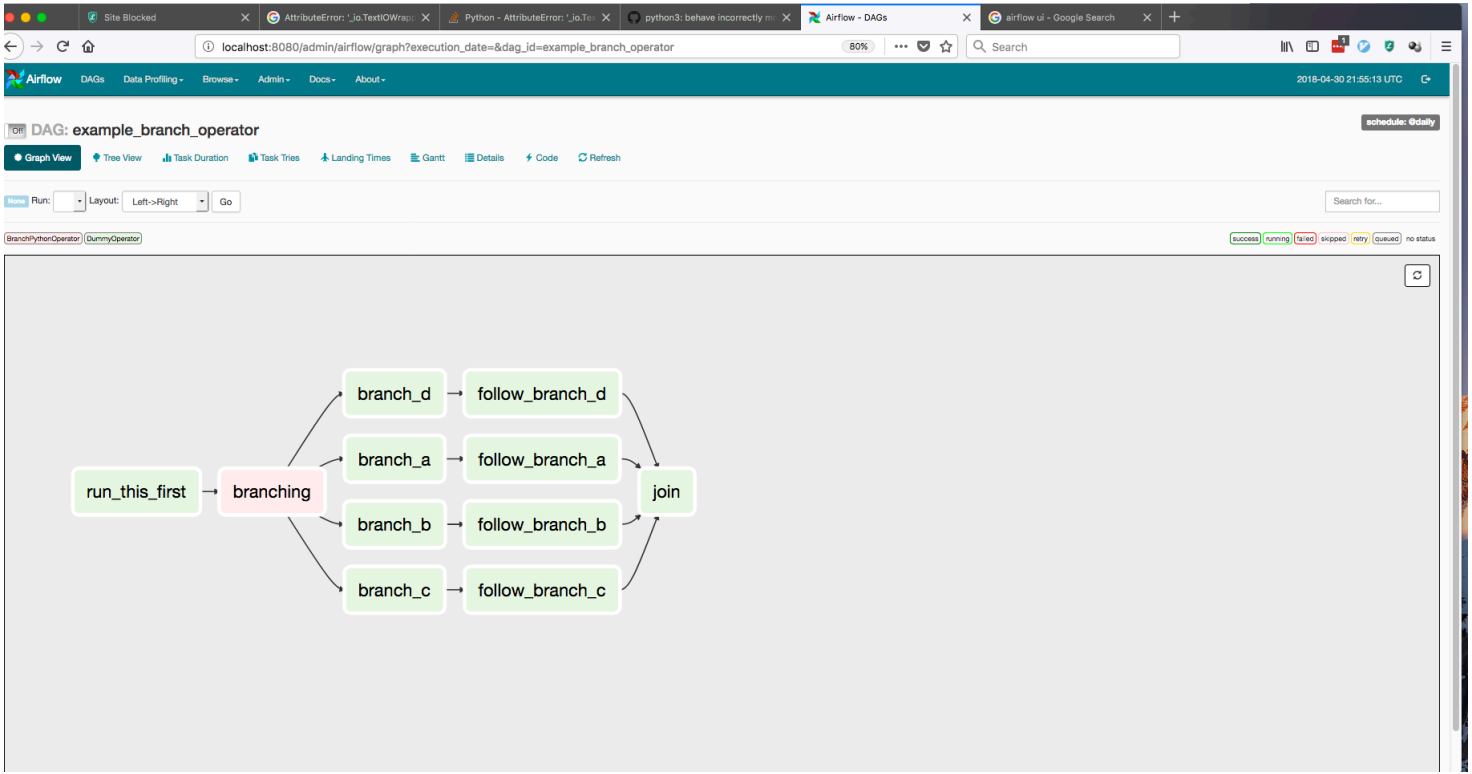
Useful UI

Monitor, schedule and manage your workflows via a robust and modern web application. No need to learn old, cron-like interfaces. You always have full insight into the status and logs of completed and ongoing tasks.

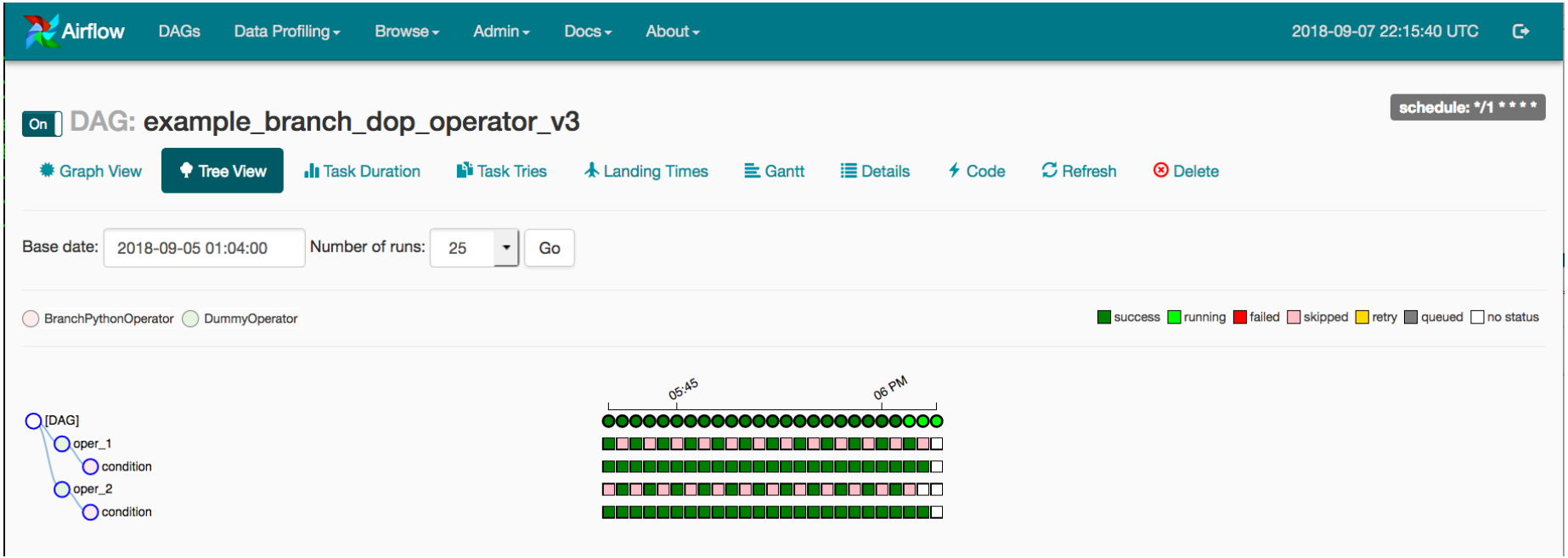
UI Screens – DAGs List



UI Screens – DAGs View



UI Screens – DAGs Runs, Tree View



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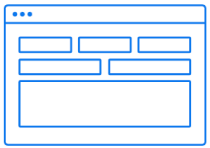

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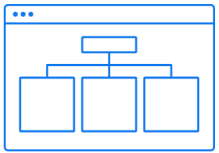
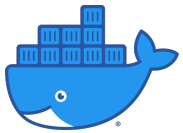


Robust Integrations

Airflow provides many plug-and-play operators that are ready to execute your tasks on Google Cloud Platform, Amazon Web Services, Microsoft Azure and many other third-party services. This makes Airflow easy to apply to current infrastructure and extend to next-gen technologies.

Main Features

Integrations from the box (*Operators, Sensors, Connectors & Hooks*)



https://airflow.apache.org/docs/apache-airflow/stable/_api/airflow/operators/index.html
https://airflow.apache.org/docs/apache-airflow/stable/_api/airflow/contrib/operators/

Main Features

Pure Python

No more command-line or XML black-magic! Use standard Python features to create your workflows, including date time formats for scheduling and loops to dynamically generate tasks. This allows you to maintain full flexibility when building your workflows.

DAG Code Example

```
import uuid
from datetime import datetime
from airflow import DAG
from airflow.utils.trigger_rule import TriggerRule
from airflow.operators.postgres_operator import PostgresOperator


dag_params = {
    'dag_id': 'PostgresOperator_dag',
    'start_date': datetime(2019, 10, 7),
    'schedule_interval': None
}


with DAG(**dag_params) as dag:

    create_table = PostgresOperator(
        task_id='create_table',
        sql='''CREATE TABLE new_table(
            custom_id integer NOT NULL, timestamp TIMESTAMP NOT NULL, user_id VARCHAR (50) NOT NULL
            );''',
    )

    insert_row = PostgresOperator(
        task_id='insert_row',
        sql='INSERT INTO new_table VALUES(%s, %s, %s)',
        trigger_rule=TriggerRule.ALL_DONE,
        parameters=(uuid.uuid4().int % 123456789, datetime.now(), uuid.uuid4().hex[:10])
    )

    create_table >> insert_row
```

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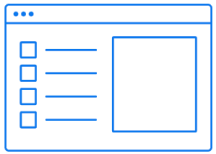

Easy to Use

Anyone with Python knowledge can deploy a workflow. Apache Airflow does not limit the scope of your pipelines; you can use it to build ML models, transfer data, manage your infrastructure, and more.

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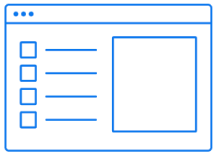

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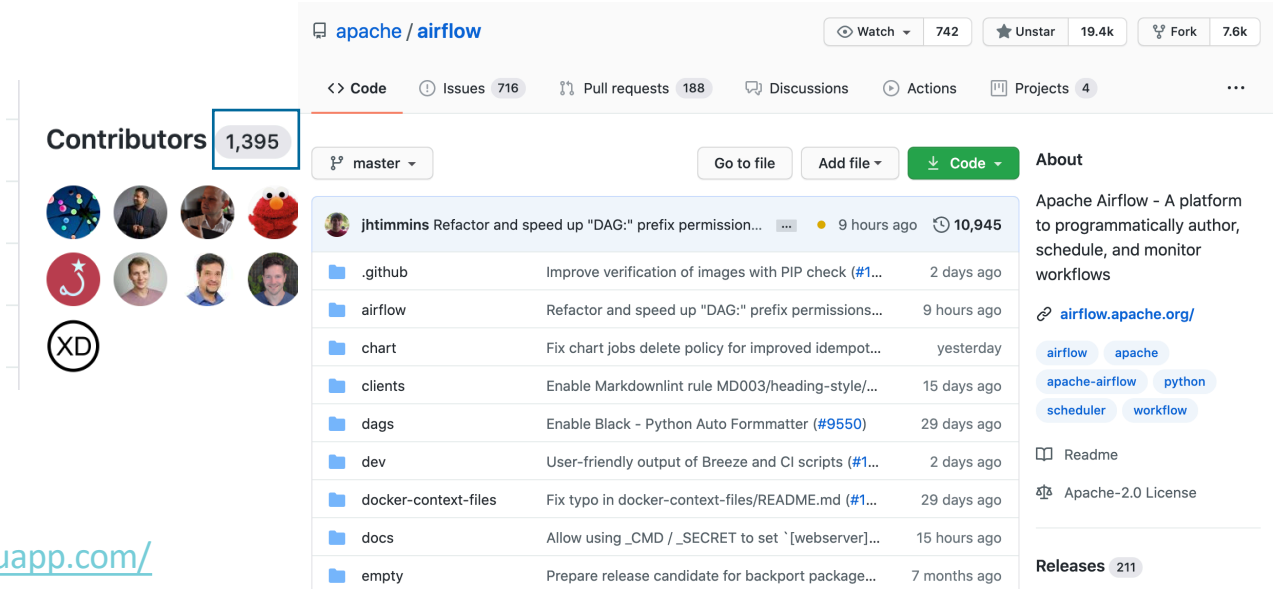
Open Source

Wherever you want to share your improvement you can do this by opening a PR. It's simple as that, no barriers, no prolonged procedures. Airflow has many active users who willingly share their experiences. Have any questions? Check out our buzzing slack.

Apache Airflow Community

https://github.com/apache/airflow

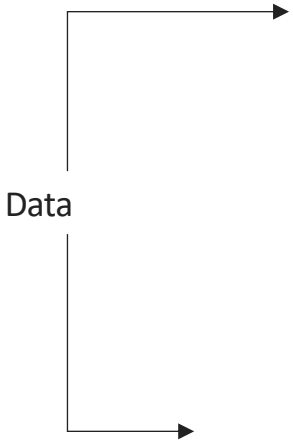


Official community Slack:
https://apache-airflow-slack.herokuapp.com/

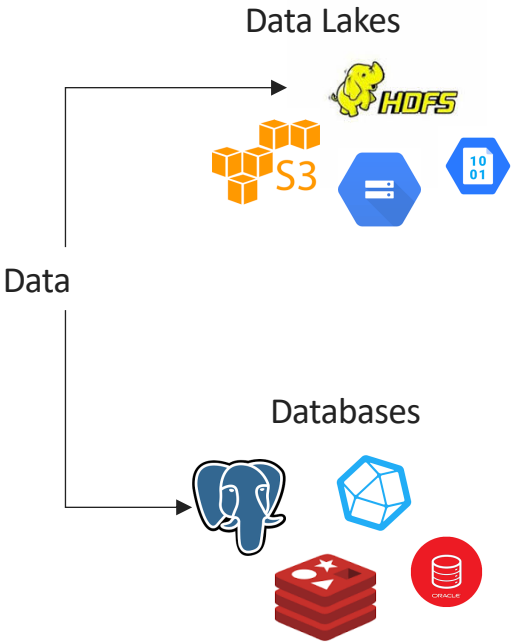
List of committers (maintainers):
https://people.apache.org/committers-by-project.html#airflow (about 40 people)

What is a workflow manager? (or orchestrator)

Data Flow



Data Flow



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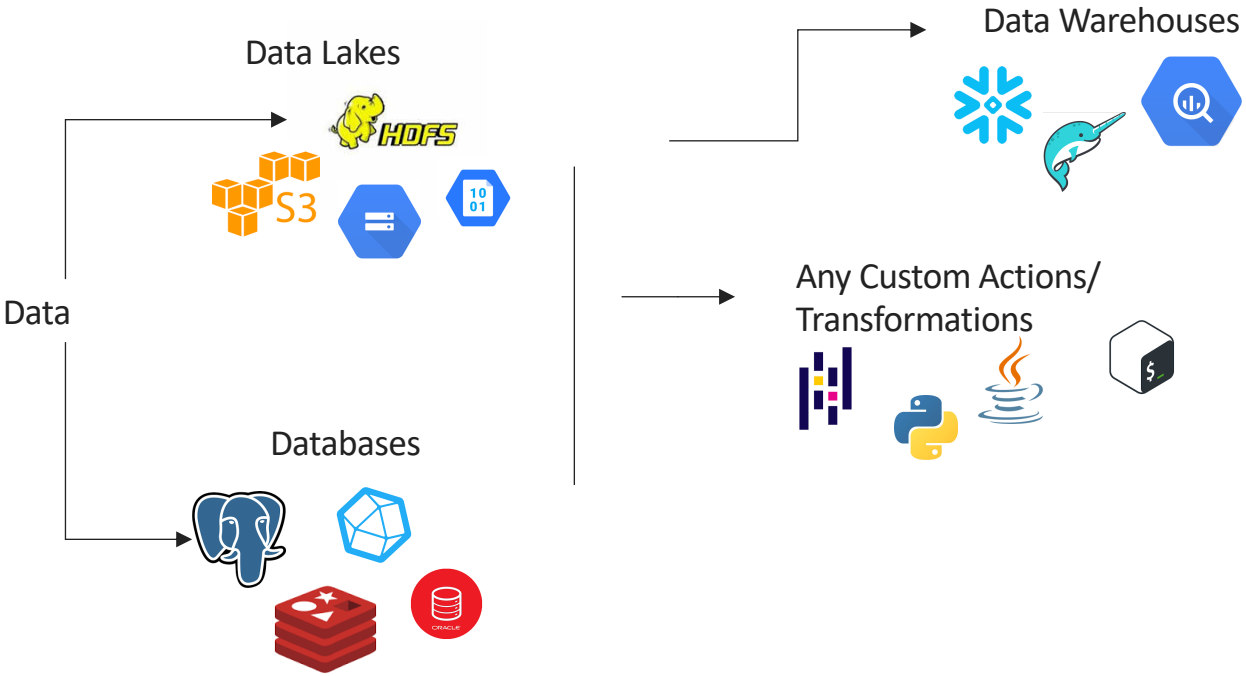
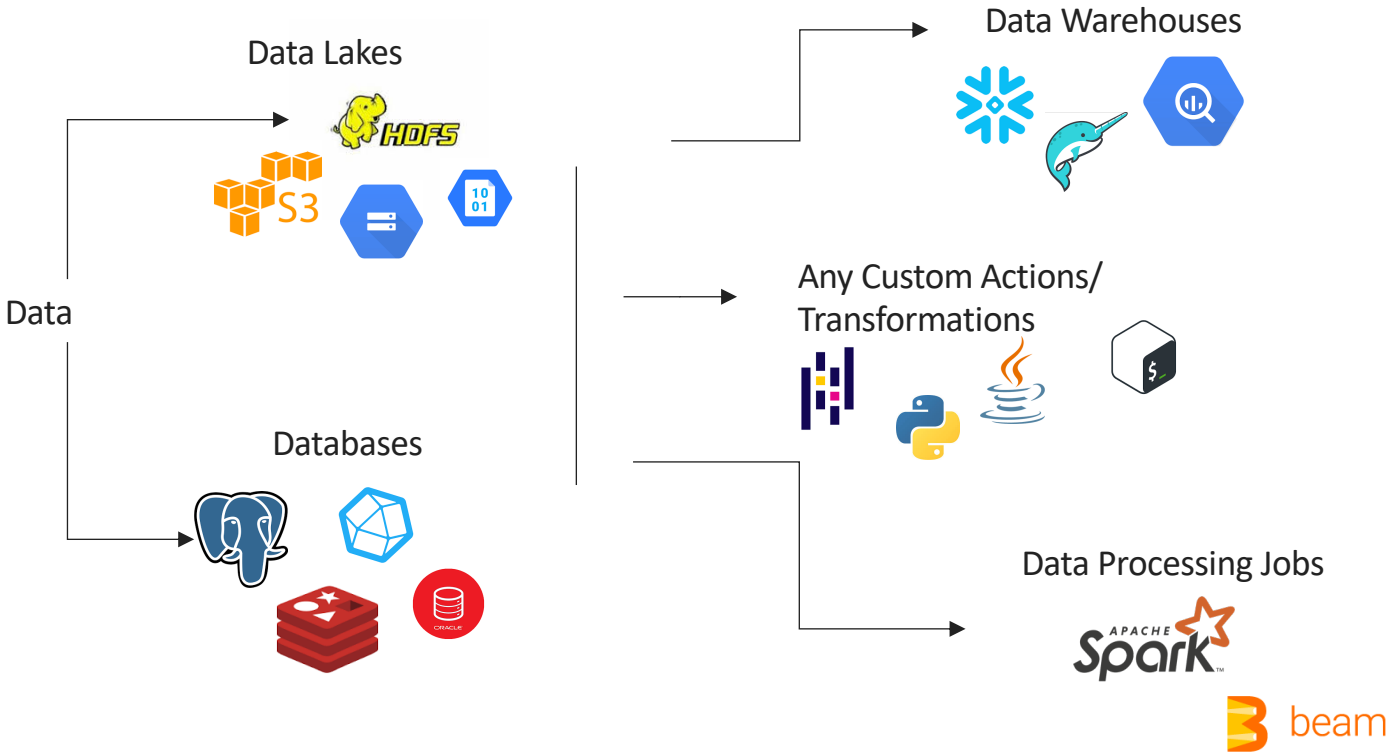
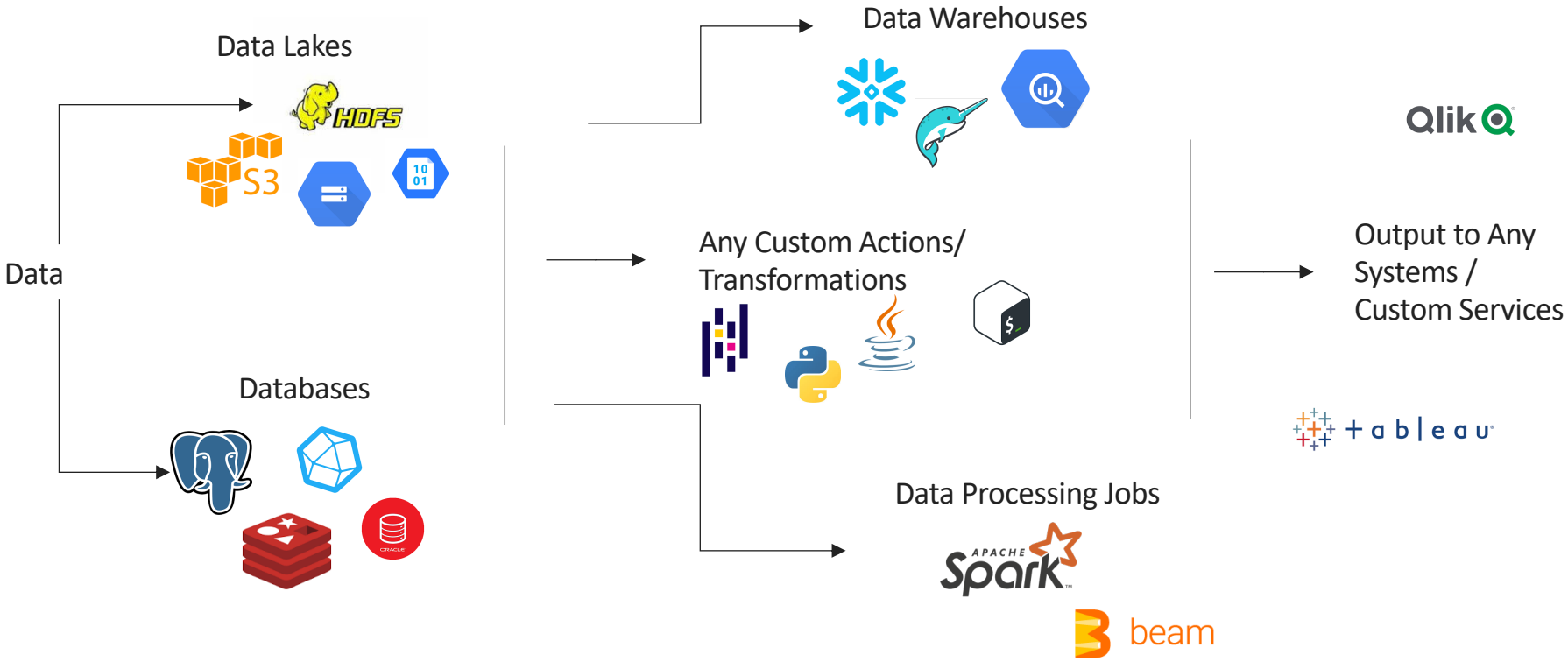

Data Lakes
HDFS
S3
Data Warehouses
Data
Any Custom Actions/
Transformations
Databases

Data Flow


Data Lakes
HDFS
S3
Data
Databases
Data Warehouses
Any Custom Actions/
Transformations
Data Processing Jobs
APACHE
Spark
beam

Data Flow


Data Lakes
HDFS
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Data
Databases
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Any Custom Actions/
Transformations
Data Processing Jobs
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Spark
beam
Output to Any
Systems /
Custom Services
Qlik
+ableau

Orchestrator or **Workflow manager**
Allows you to create Data Pipelines
& describe all steps of your Data Flow:

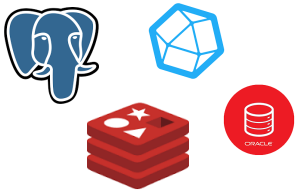
from **where** to where, **what**, **when** and **how**
– multiple task in **any** sequence (not only classical ETL)

Extract, transform, load

Extract

Data Lakes

Databases



Transform

Any Custom Actions/
Transformations

Data Processing Jobs

Load

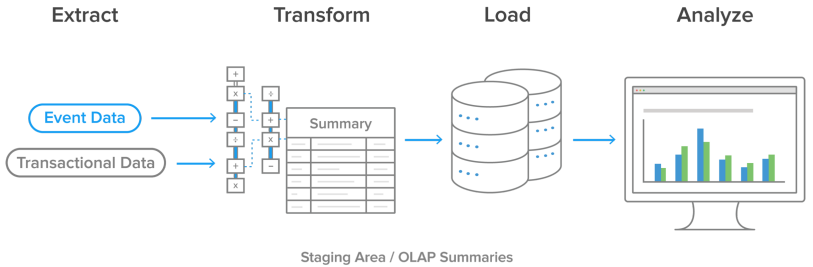
Data Warehouses

Output to Any
Systems /
Custom Services

Workflow Capabilities that we needs

1. **Monitoring Dashboard** (what's going on with our pipeline?)
2. **Alerts** (if something wrong
   – I must know about it quick)
3. **SLAs** (if we don't have data for the day
   – do we have the problem?)
4. **Way to make customization**

And etc.



Pipeline Example in Words

Let’s imagine. We work in Data Engineering Team in The Stationery Shop (pens, papers and etc).
We have about 1500 offline shops, online shop and direct sales.

We work on the Data Pipeline that assume information about our clients from different sources.

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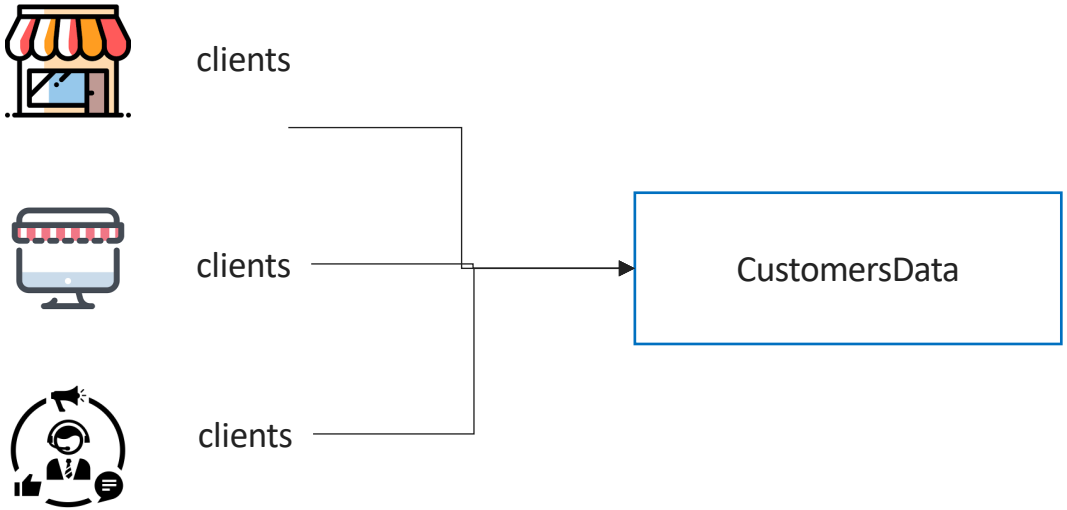

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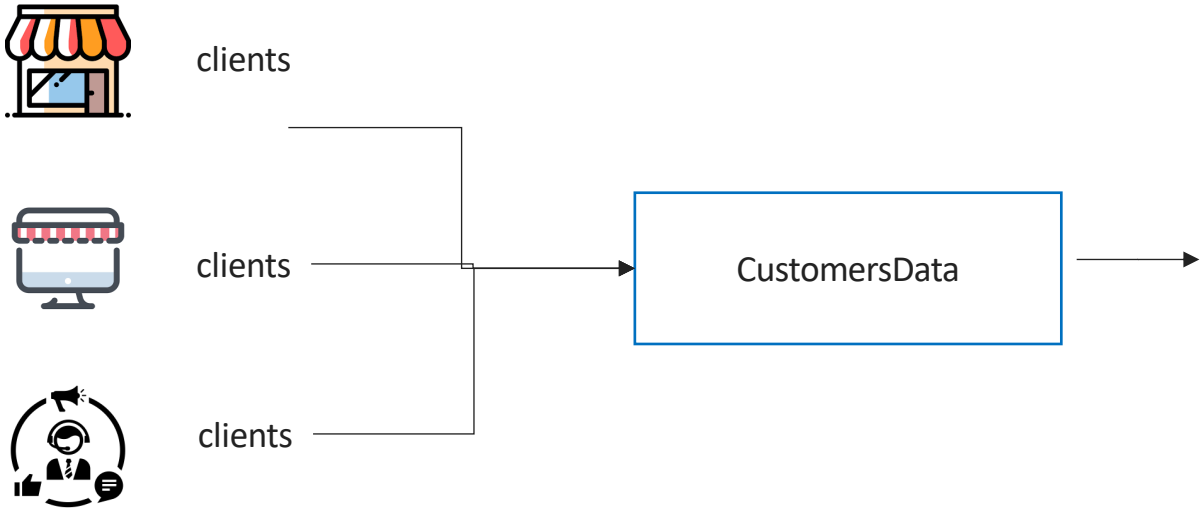

1. Is it a new client?

2. What we already know about this client?

3. Try to map client by some ‘ criteria’ based on already existed information

4. Update Data (Data Changed in Timeline – orders, marketing activities …)
… etc

Pipeline – find the client by credit card number

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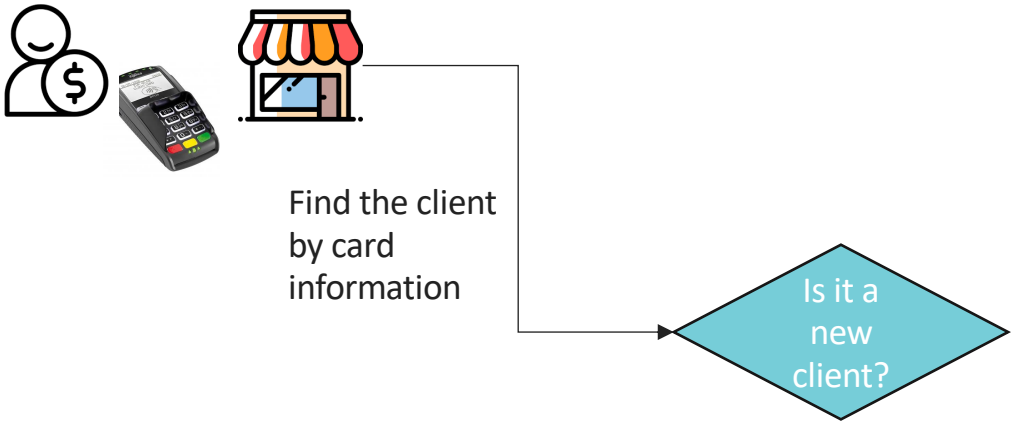
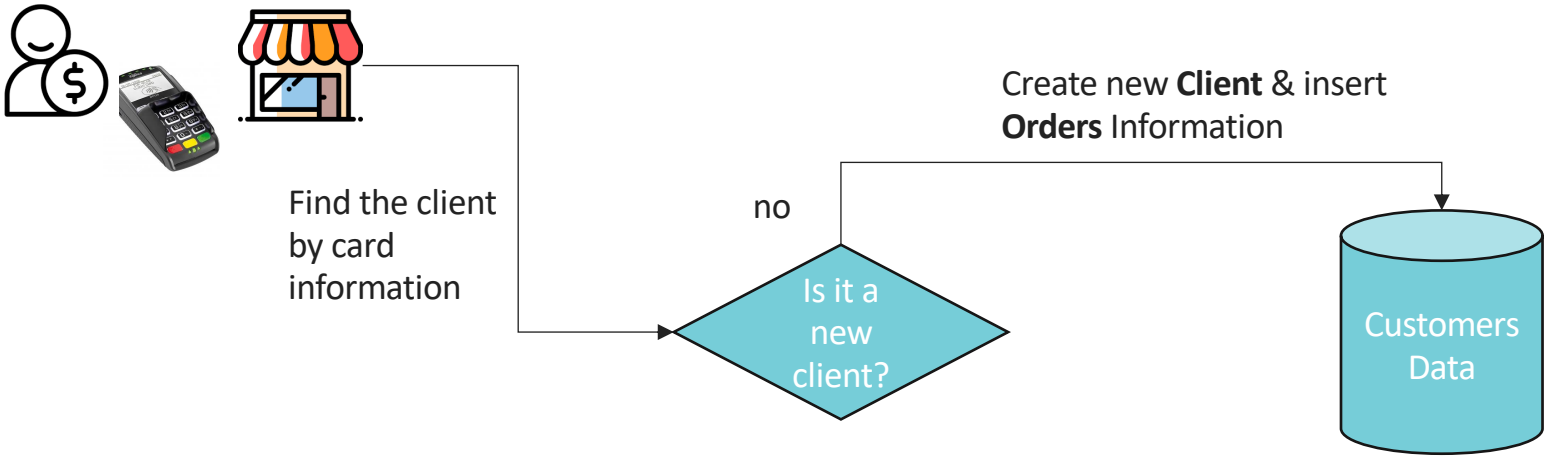


Pipeline – find the client by credit card number



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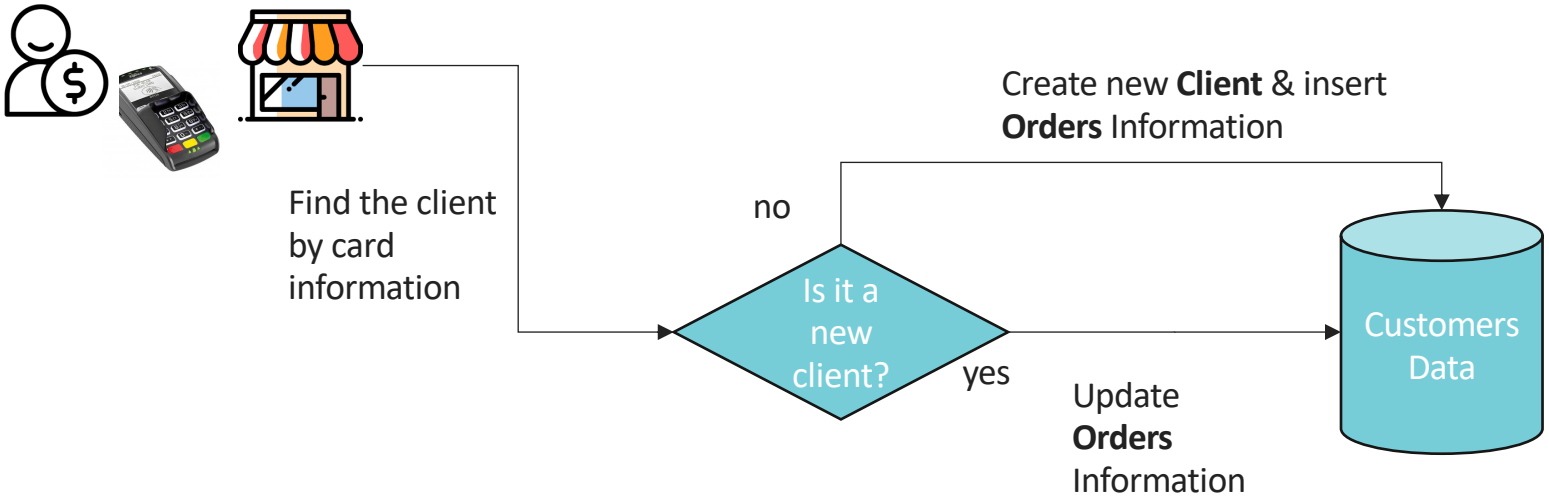

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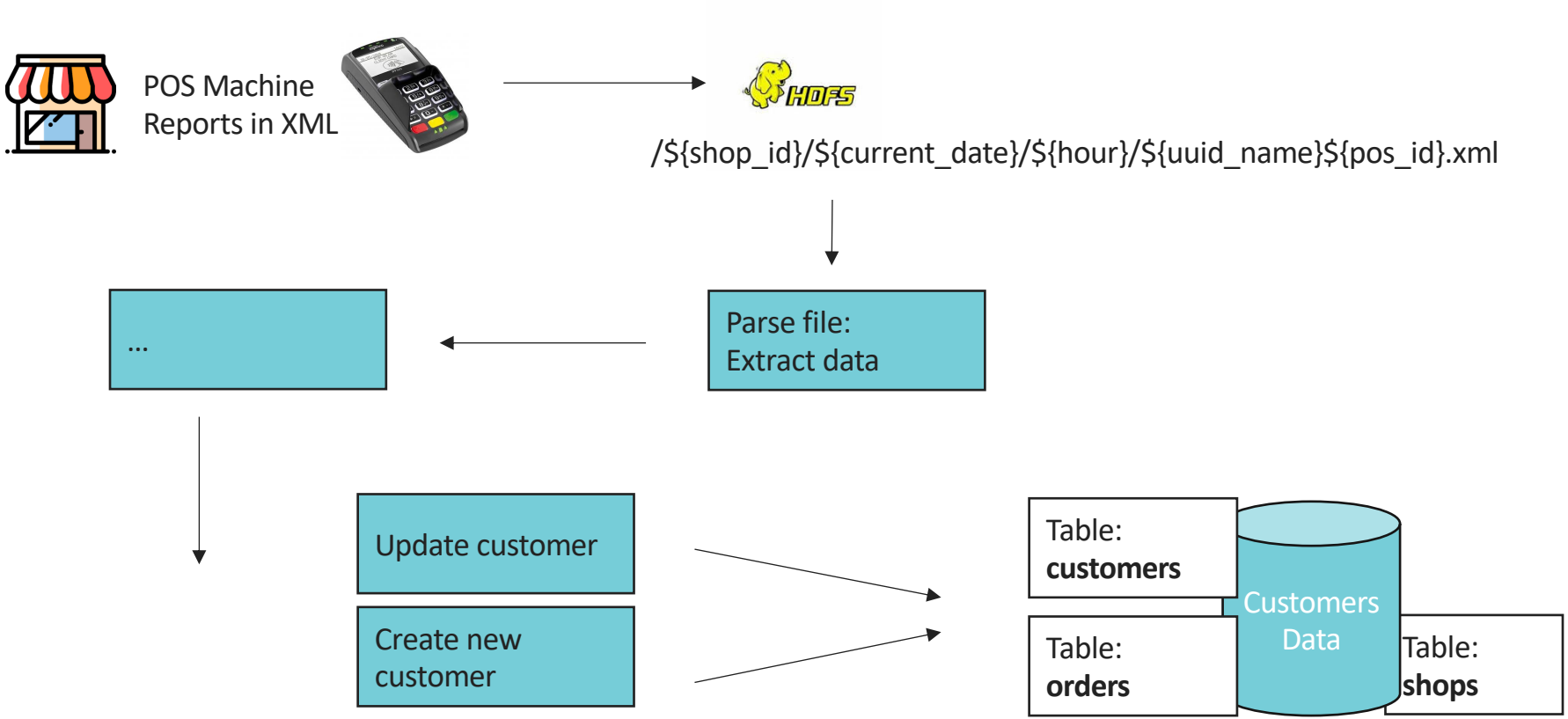
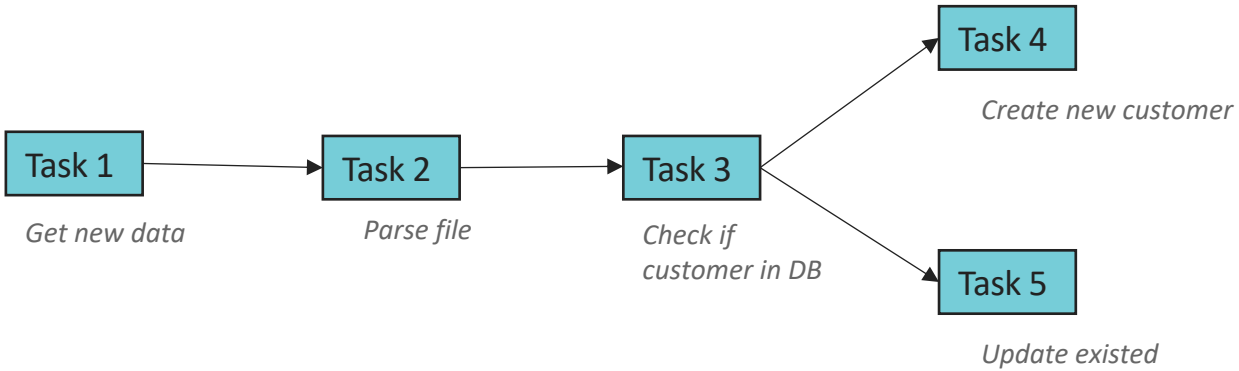


Abstract visualization



Congratulations!

We just described a **Workflow** or a **Pipeline…**

Or **DAG** – main concept
of Apache Airflow

Some key characteristic of Pipelines

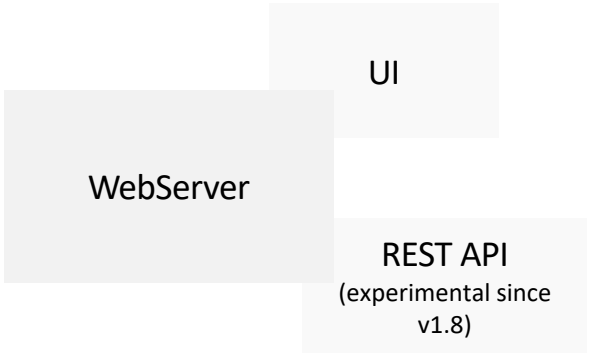
1. **Schedule:** They run in time with different schedule, duration, etc
2. **Triggers:** Pipelines can have Triggers that cause need to run the pipeline
3. **Fails:** Pipelines can fail. We need 1) to know about it 2) to get possible start it from failed place – and this is why you task must be atomic and small
4. **Re-processing:** Sometimes you need reprocess data for whole long periods in past
5. Sometimes fails can be because of network or system issues and you want to have auto **retries**

Before we will create our first DAG –
let's **up & run Apache Airflow Server**

Disclaimer:

all information relative to Apache Airflow
actual on **version 1.10.12** and can be different on ver 2.0+

High-level overview of Apache Airflow components



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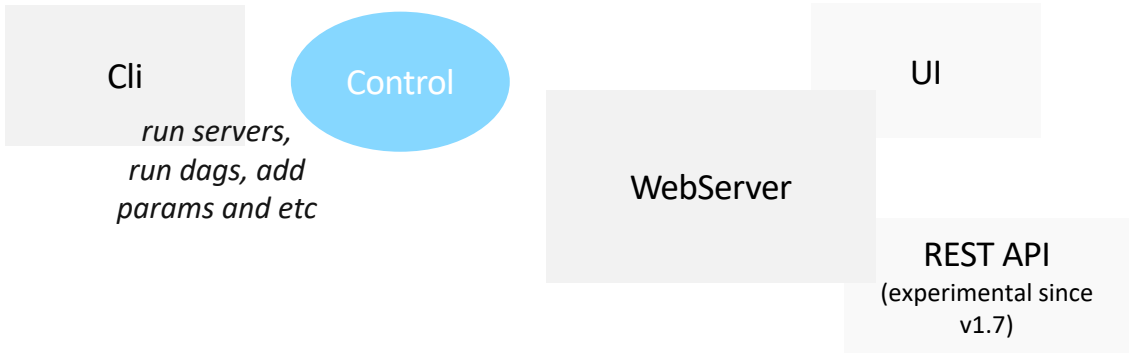

CLI

https://airflow.apache.org/docs/apache-airflow/stable/cli-ref

Server commands:

`airflow initdb`
airflow webserver
`airflow scheduler and etc.`

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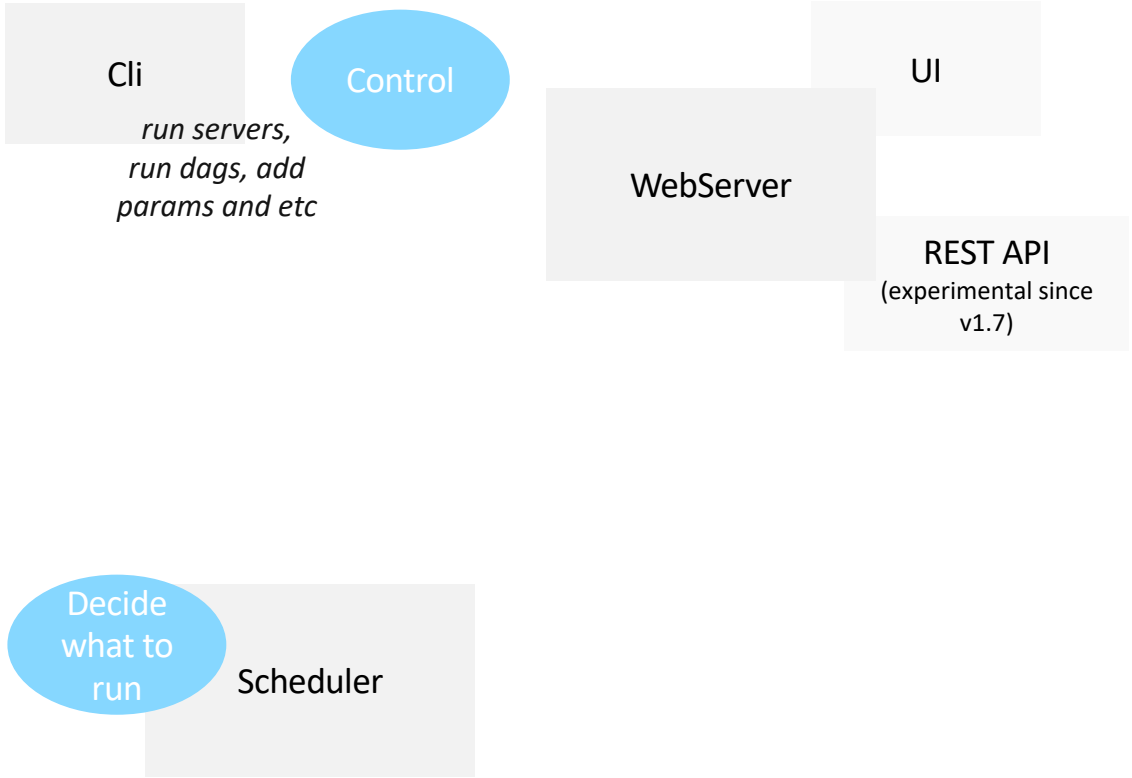

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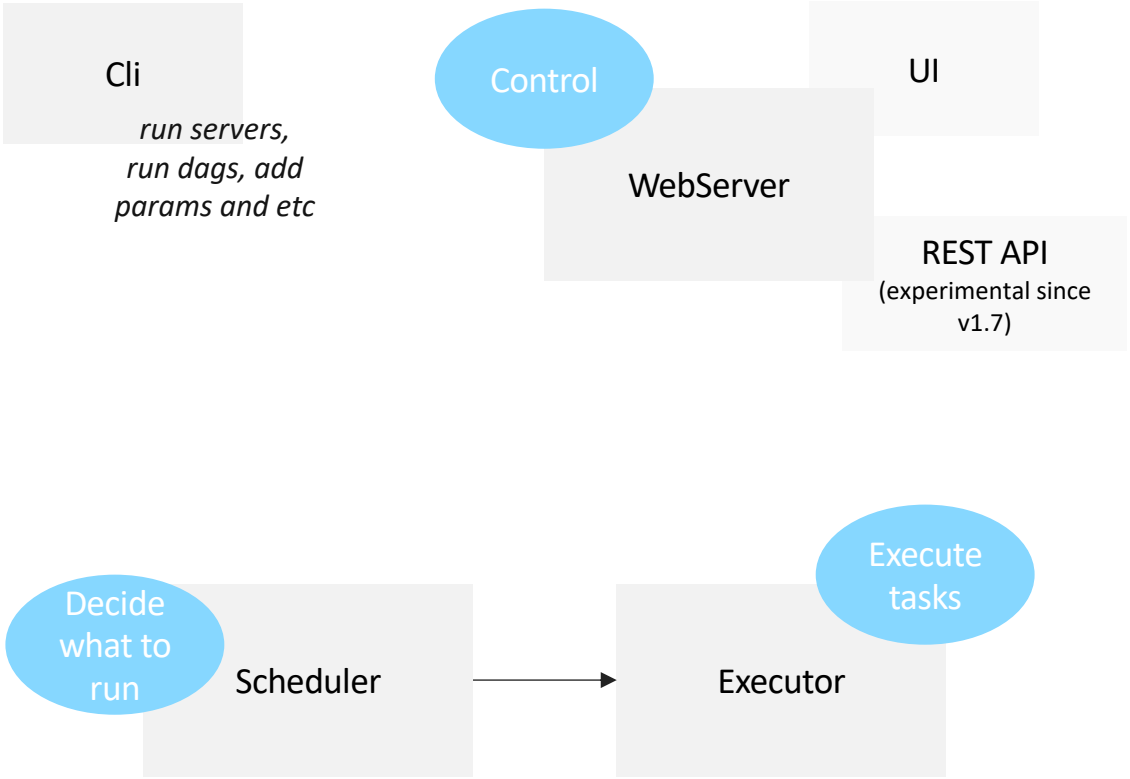

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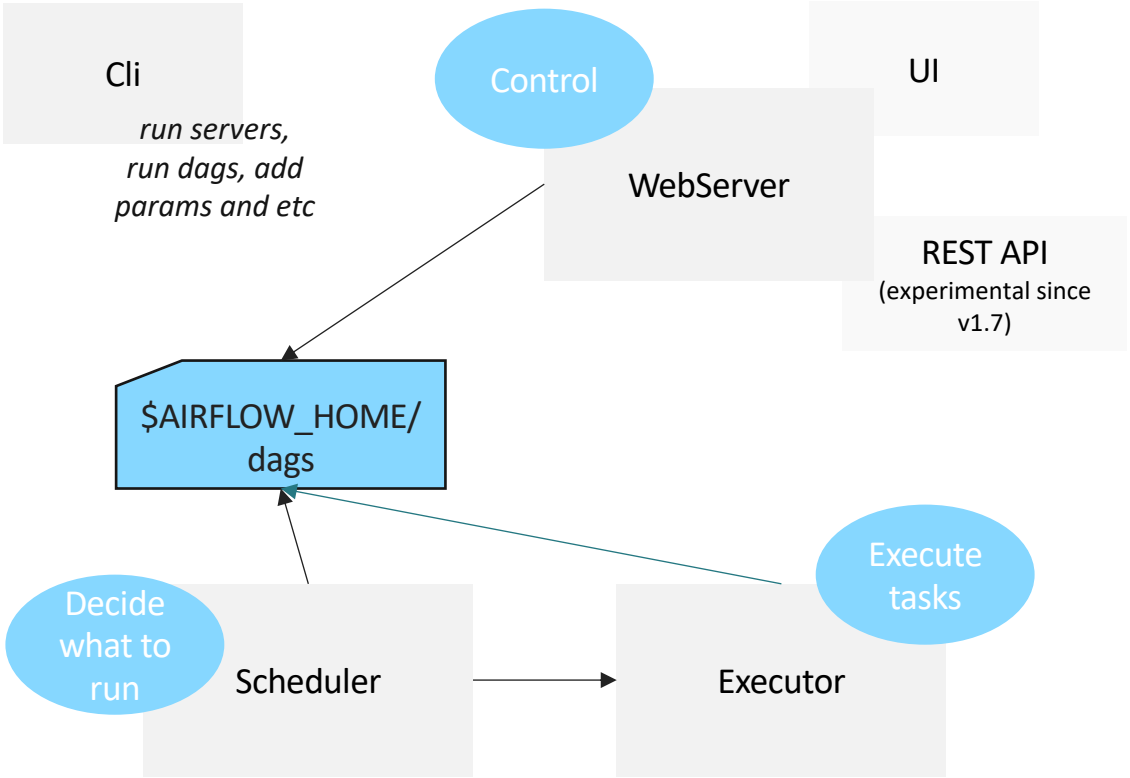

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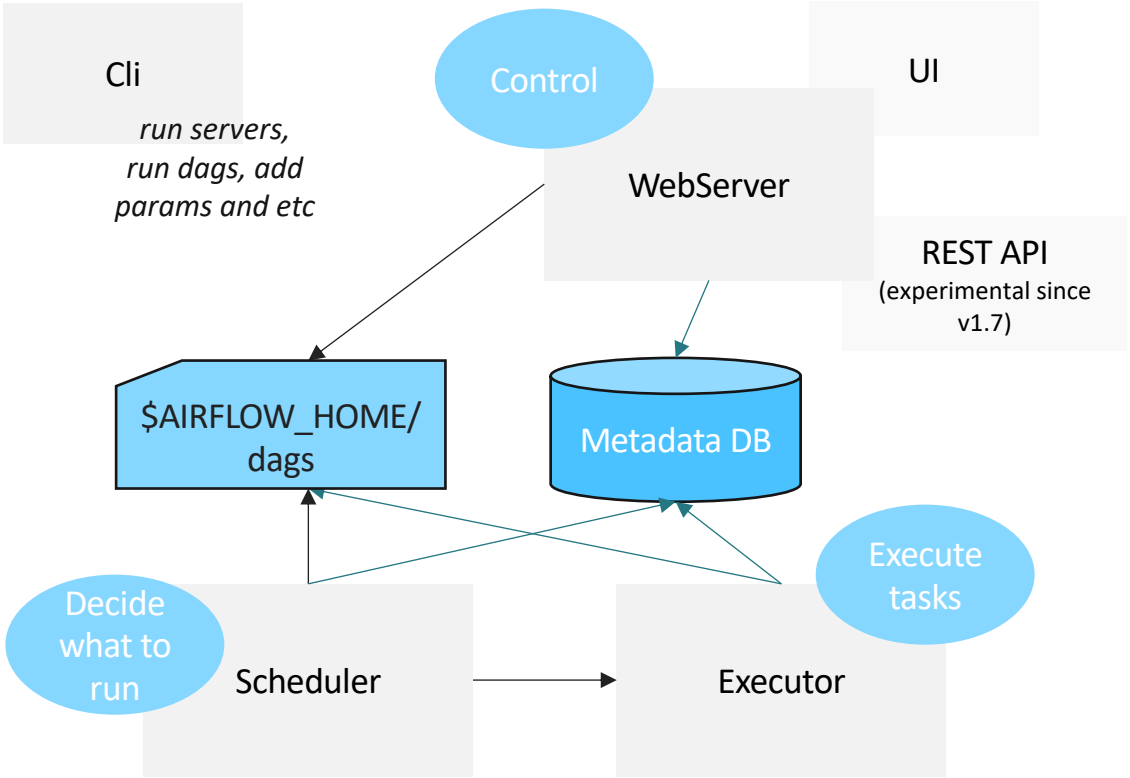
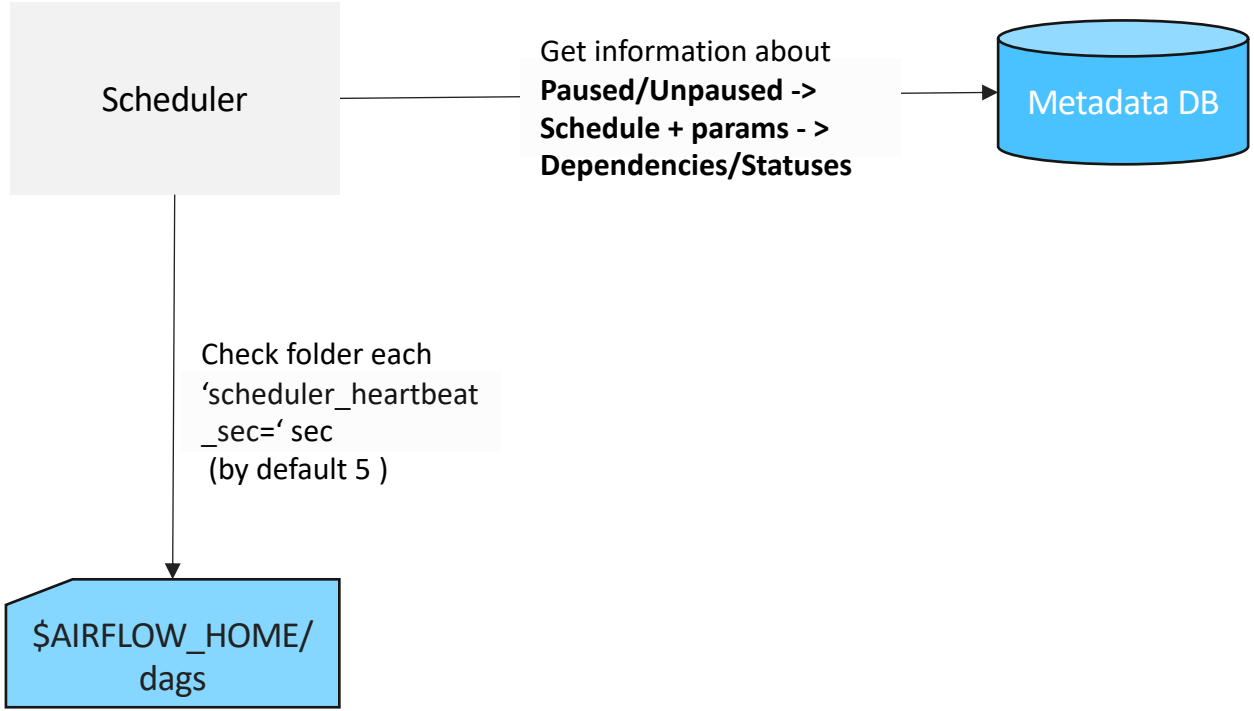


Process of DAG execution



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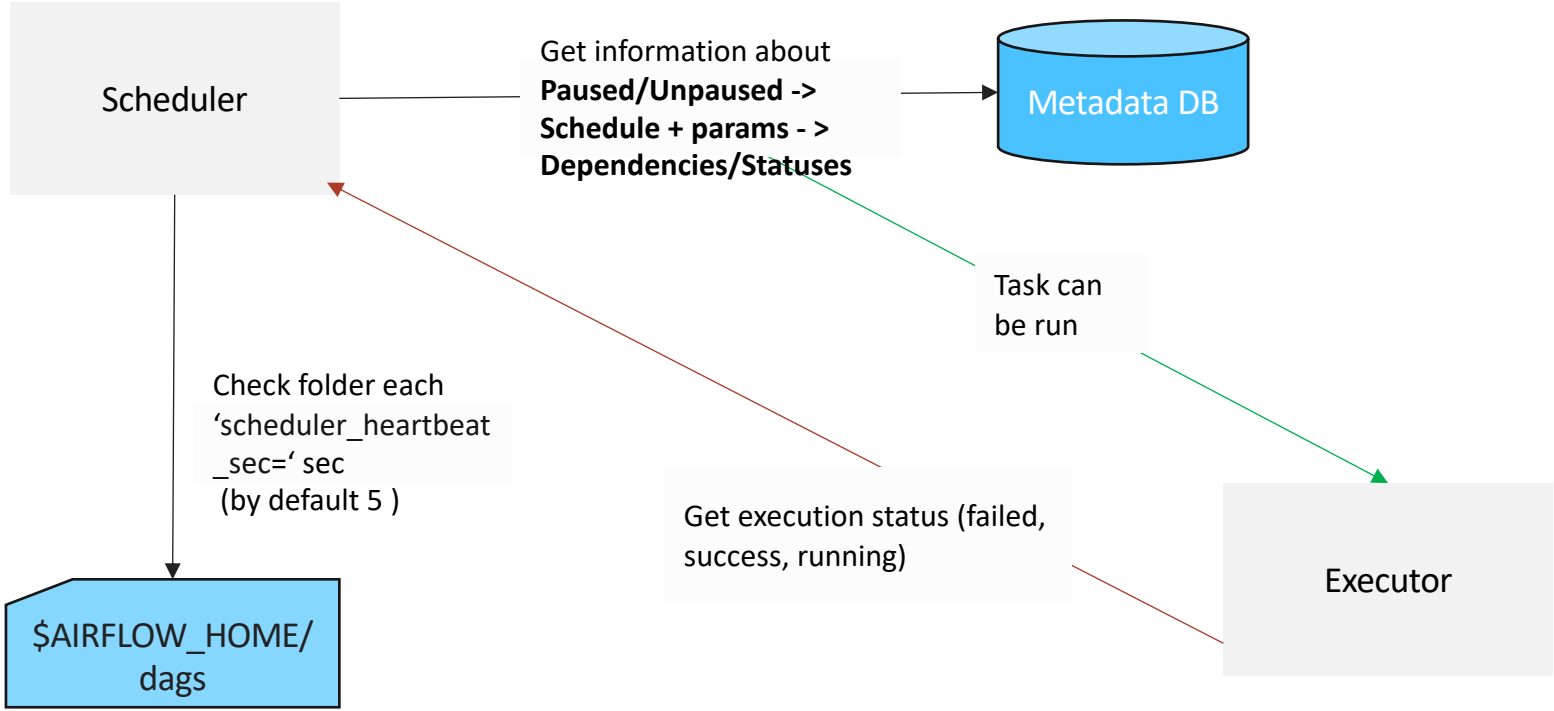

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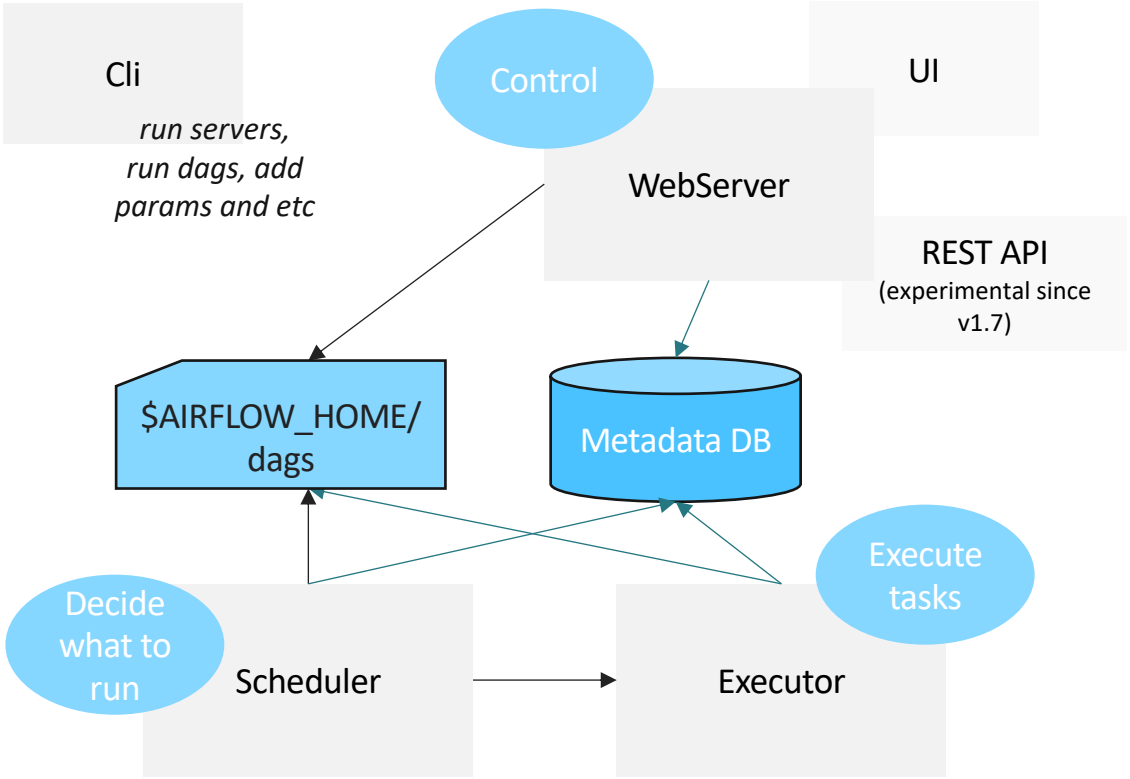

If you work with CeleryExecutor

Worker

Celery Worker

Flower

Monitor for CeleryWorkers

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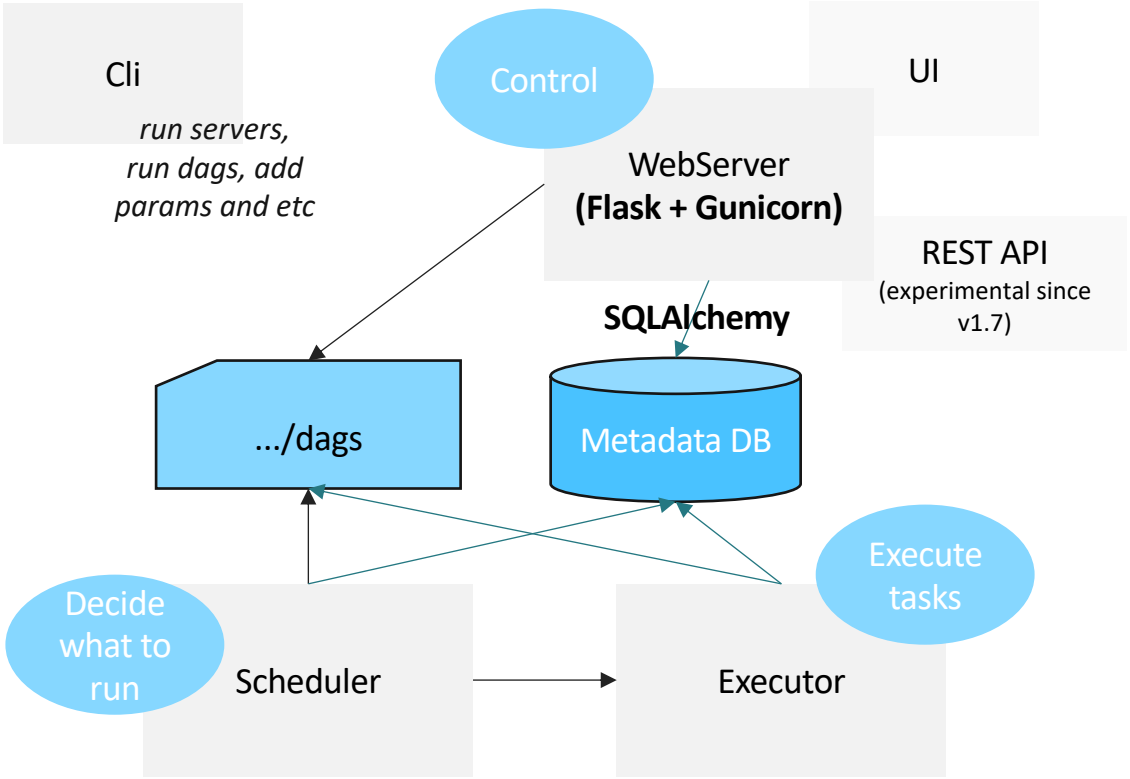


If you work with CeleryExecutor

Worker

Celery Worker

Flower

Monitor for CeleryWorkers

Quick Start

https://airflow.apache.org/docs/stable/start.html#quick-start

```
# install from pypi using pip

pip install apache-airflow

# initialize the database (create all needed tables)


airflow initdb

# start the web server, default port is 8080
airflow webserver -p 8080
# start the scheduler
airflow scheduler
```

```
# airflow needs a home, ~/airflow is the default, # but you can lay foundation somewhere else if you prefer # (optional)

export AIRFLOW_HOME=~/airflow
```

Errors

In **November 2020** after install apache-airflow==1.10.12 if you will try to run '**airflow initdb**' you will get an error:

from attr import fields, resolve_types
ImportError: cannot import name 'resolve_types' from 'attr'

To solve it you need install cattrs==1.1.0:

```
$ pip install cattrs==1.1.0
```

Remove DAG examples

1. Set in config option “load_examples = False“ before **airflow initdb**

If you already did ‘airflow initdb’ and want to remove example DAGs

1. Set in config option “load_examples = False“
2. Run **“airflow resetdb”**

Airflow by default

executor = SequentialExecutor

sql_alchemy_conn = sqlite:////Users/iuliia_volkova2/airflow/airflow.db – **only 1 connection**

Extra packages in Installation:

https://airflow.apache.org/docs/apache-airflow/stable/installation.html#extra-packages

Let’s define our first DAG

Create a **DAGFile** in **$AIRFLOW_HOME/dags** directory

DAGFile – file with **.py** that contains words **‘airflow’** and **‘DAG’**

If you don’t want Apache Airflow to parse your files:
add it to **.airflowignore** in DAGs folder

Let’s define our first DAG

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


with DAG(
  dag_id="consume_new_data_from_pos",
  start_date=datetime(2020, 12, 1),
  schedule_interval=None
  ) as dag:
```

dag_id – unique dag_id (dag name)
start_date – date from that we start process the date
schedule_interval – schedule how we plan to run DAG (daily, hourly and etc)

Let’s define our first DAG

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


with DAG(
  dag_id="consume_new_data_from_pos",
  start_date=datetime(2020, 12, 1),
  schedule_interval=None
  ) as dag:
```

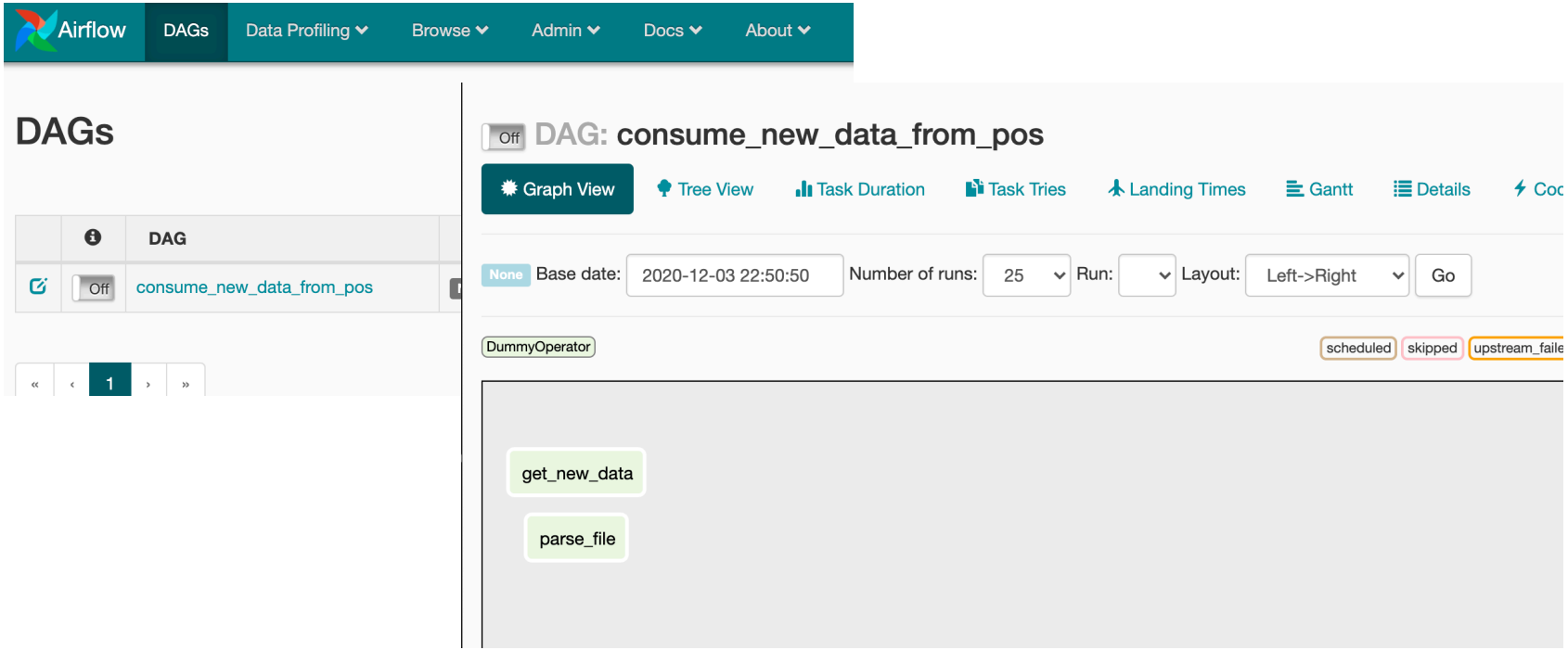
dag_id – unique dag_id (dag name)
start_date – date from that we start process the date
schedule_interval – schedule how we plan to run DAG (daily, hourly and etc)

Add tasks to the DAG

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


with DAG(
  dag_id="consume_new_data_from_pos",
  start_date=datetime(2020, 12, 1),
  schedule_interval=None
  ) as dag:

  get_new_data = DummyOperator(task_id="get_new_data")

  parse_file = DummyOperator(task_id="parse_file")
```

task_id – unique task_id, mandatory to all Operators
DummyOperator – operator that **does nothing** (useful to prototype pipeline)

Let’s check the UI

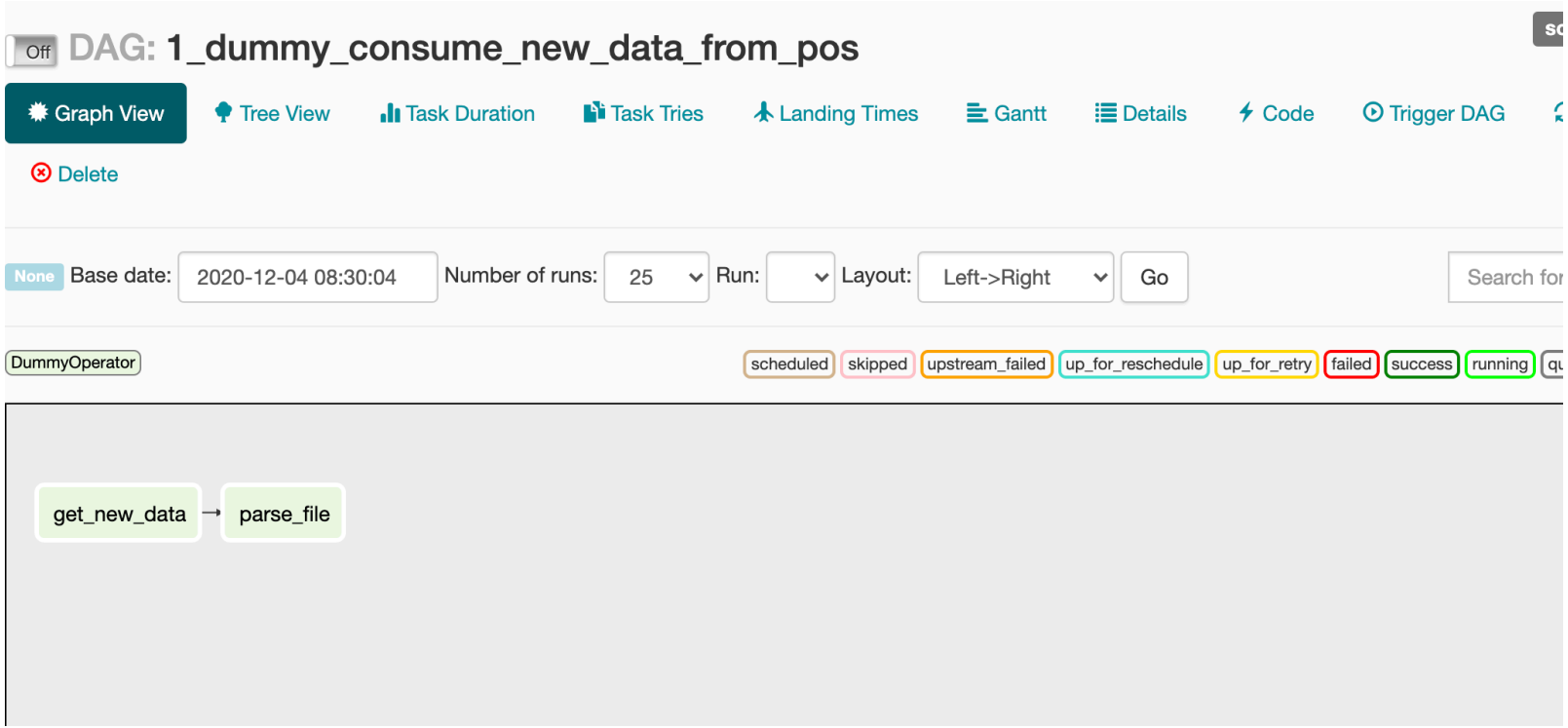


Define a sequence of tasks

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


with DAG(
  dag_id="consume_new_data_from_pos",
  start_date=datetime(2020, 12, 1),
  schedule_interval=None
  ) as dag:

  get_new_data = DummyOperator(task_id="get_new_data")

  parse_file = DummyOperator(task_id="parse_file")

  get_new_data >> parse_file
```

set_downstream	>>
set_upstream	<<

Define a sequence of tasks



Define a sequence of tasks

```
[task1, task2, task3]   >>  task4 - allowed

task4  >> [task1, task2, task3] – allowed
task5  >> [task1, task2, task3]
```

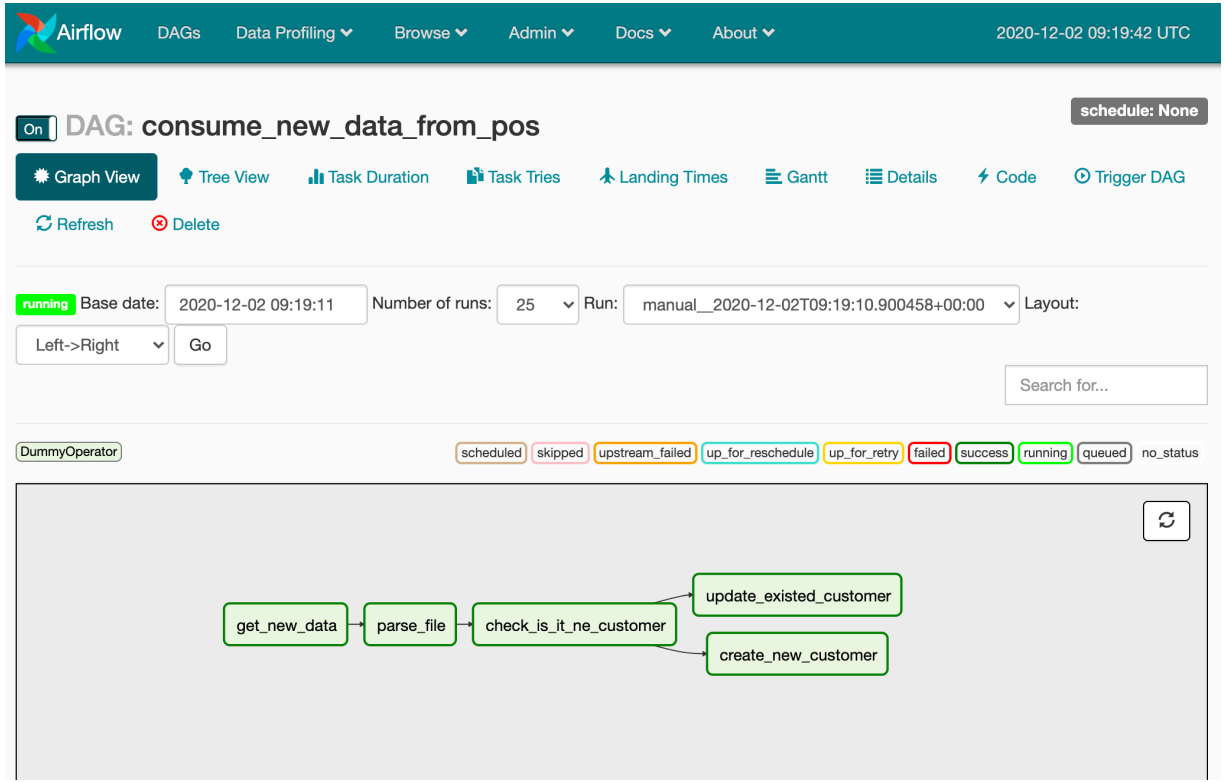
```
[task1, task2, task3] >> [task4, task5] – not allowed

[task4, task5] >> [task1, task2, task3] – not allowed
```

unsupported operand type(s) for >>: 'list' and 'list'

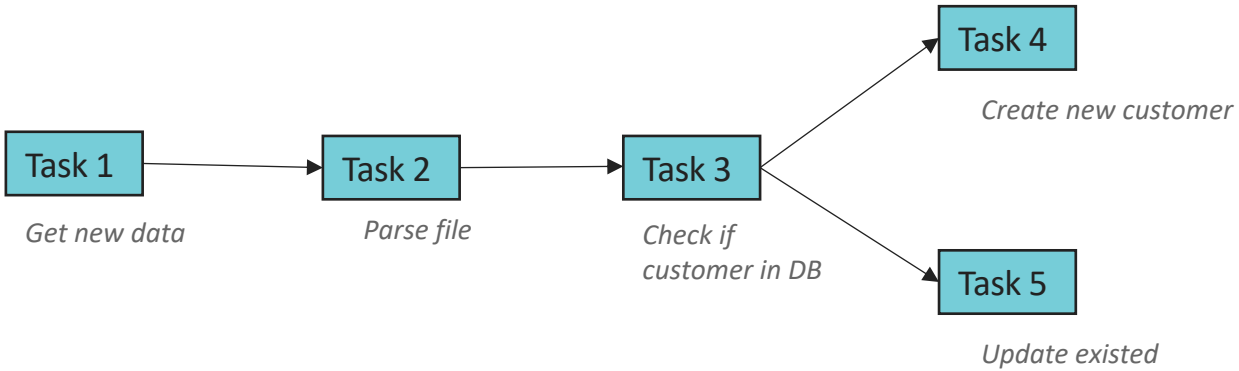
Let’s define the full DAG

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


with DAG(
  dag_id="consume_new_data_from_pos",
  start_date=datetime(2020, 12, 1),
  schedule_interval=None
  ) as dag:
  get_new_data = DummyOperator(task_id="get_new_data")

  parse_file = DummyOperator(task_id="parse_file")

  check_is_it_ne_customer = DummyOperator(task_id="check_is_it_ne_customer")

  create_new_customer = DummyOperator(task_id="create_new_customer")

  update_existed_customer = DummyOperator(task_id="update_existed_customer")

  get_new_data >> parse_file >> check_is_it_ne_customer >> [create_new_customer,
update_existed_customer]
```

Apache Airflow UI



DAG – Directed Acyclic Graph



What can be a Task?

Operators

Just DO right now
– report **about completion**

Sensors

Poke(wait) condition
until try

What can be a Task?

Operators

Just DO right now
– report **about completion**

Examples:

- FileToGoogleCloudStorageOperator
- MySqlOperator
- AWSAthenaOperator

…

Sensors

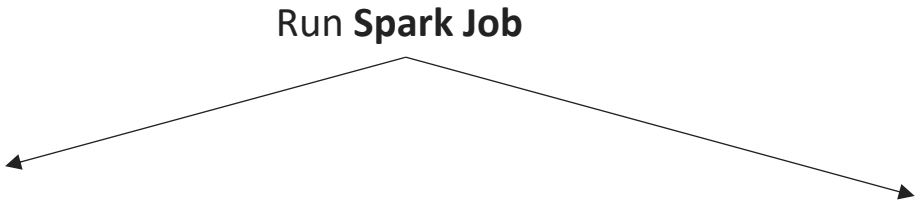
Poke(wait) condition
until try

Examples:

- HdfsSensor
- HttpSensor
- SqlSensor

…

Moment of Task Completion



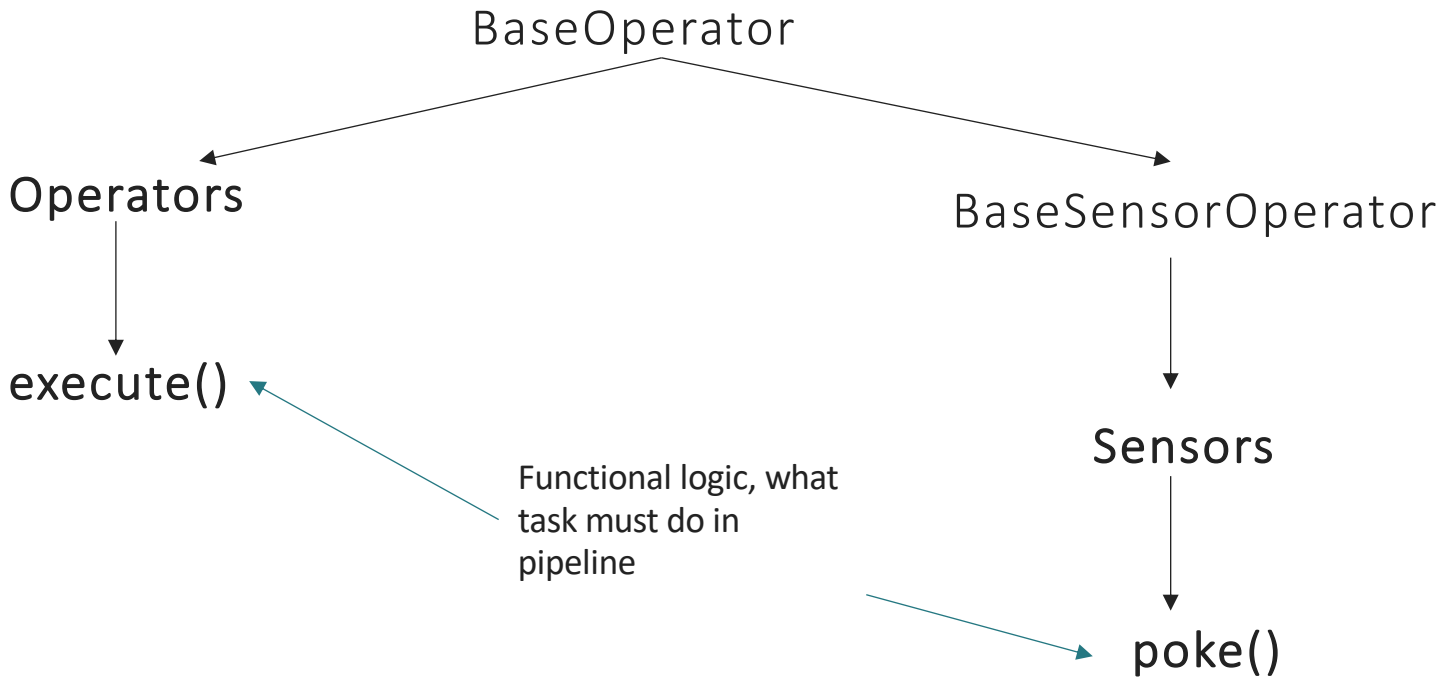
- run as background process
- By ssh in another server
- By REST

(Task **is 'success'** after
send a command to run job)

– Run as a java command
in current server, wait until it finish

(Task in **'running'**
status until complete)

What can be a Task?



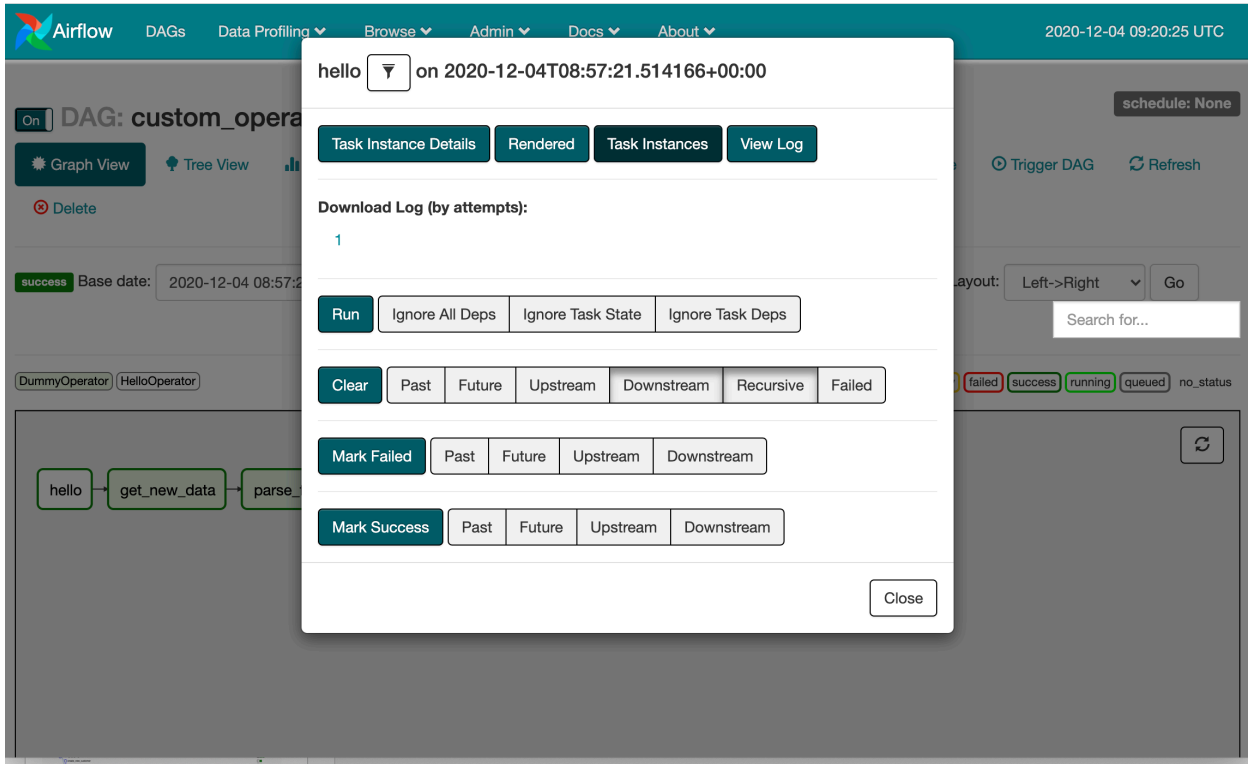
Let’s define our primitive Operator

```python
from typing import Union, Iterable, Dict

from airflow.models import BaseOperator, SkipMixin


class HelloOperator(BaseOperator, SkipMixin):

  def execute(self, context):
      self.logger.info("Hello, World!")
```

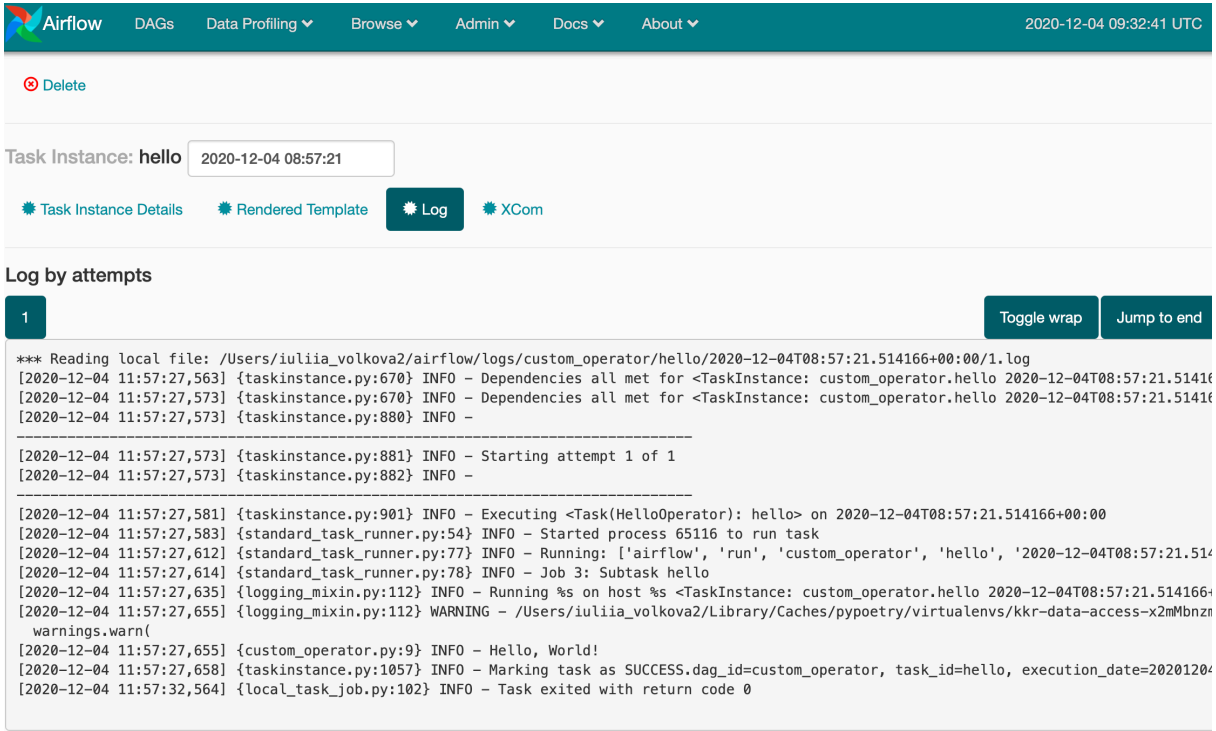
And put module with it to $AIRFLOW_HOME/dags directory

Airflow add $AIRFLOW_HOME/dags to PYTHONPATH
so everything inside it you can use with import

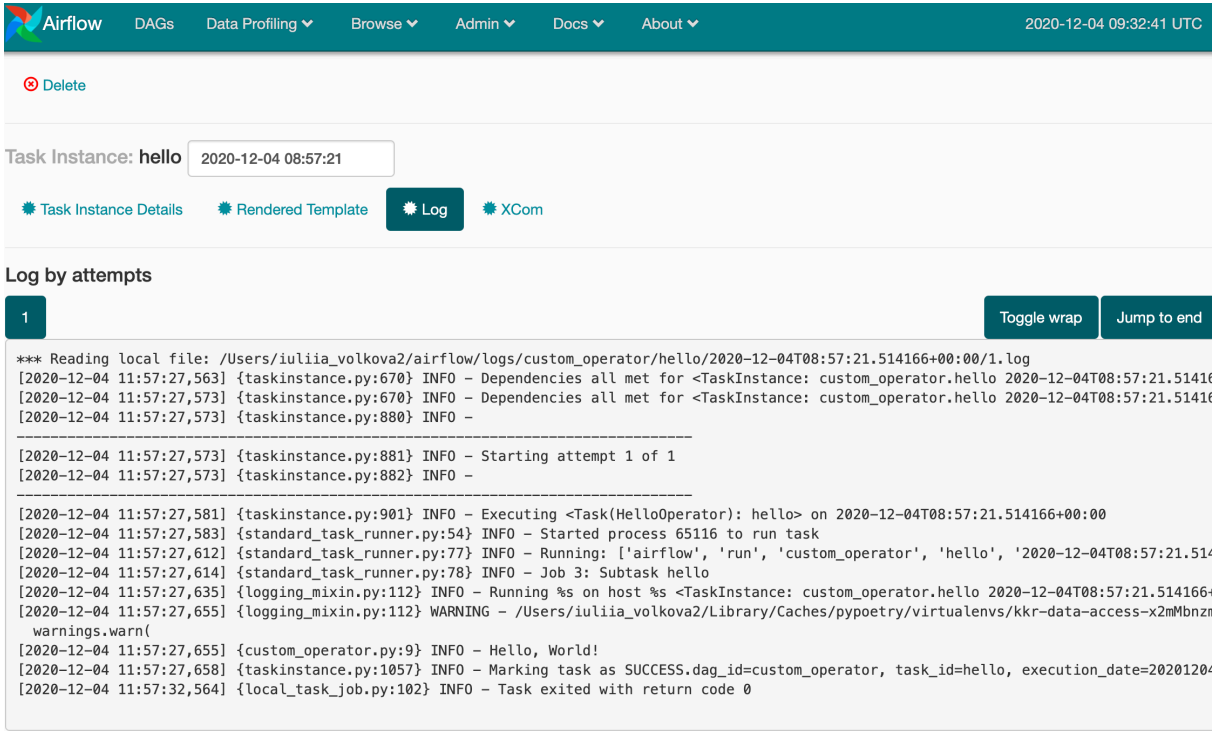
Check the UI that all works good



Check the UI that all works good



Check the UI that all works good



Let’s play with Tasks menu

1. Task Details
2. Task logs
3. Task clean up / change status
4. Let’s check **Browse** menu also

What we already saw in Airflow

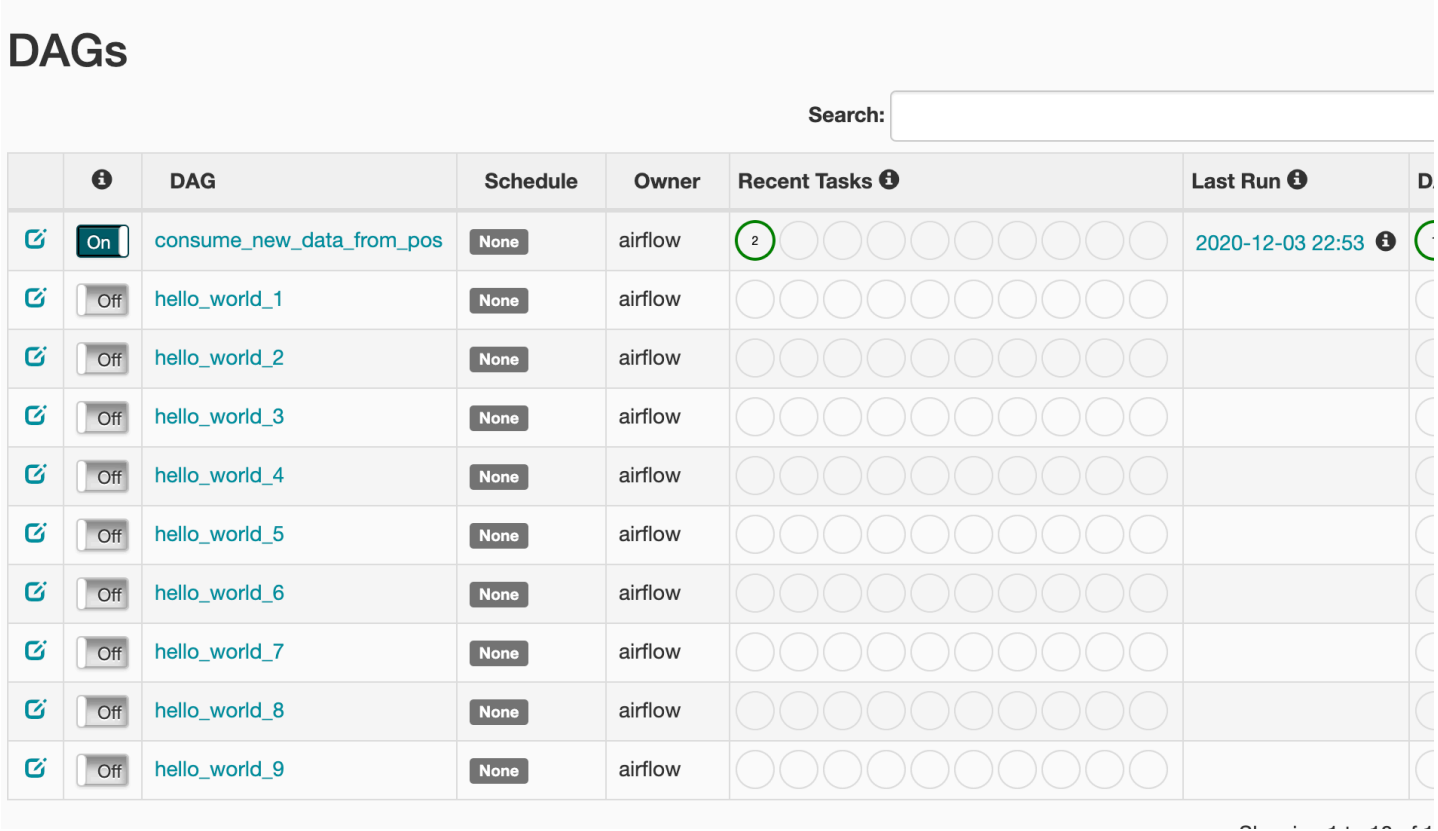
1. Server components
2. How to define DAG with minimal params
3. How to define tasks
4. What is Operator & Sensors
5. How to define custom Operator
6. Tasks Details & Logs in UI
7. Browse menu in UI

Dynamical DAGs generation: DAGFile & multiple DAGs in one file

DAGFile != DAG

```
…


def create_dag( ... ) -> DAG:
     …

# build a dag for each number in range(10)
for n in range(1, 10):
  dag_id = 'hello_world_{}'.format(str(n))
  params = {'dag_id': dag_id,
            'schedule_interval': None,
            'start_date': datetime(2020, 12, 1)}
  dag_number = n
  globals()[dag_id] = create_dag(dag_number, params)
```

DAGFile & multiple DAGs in one file



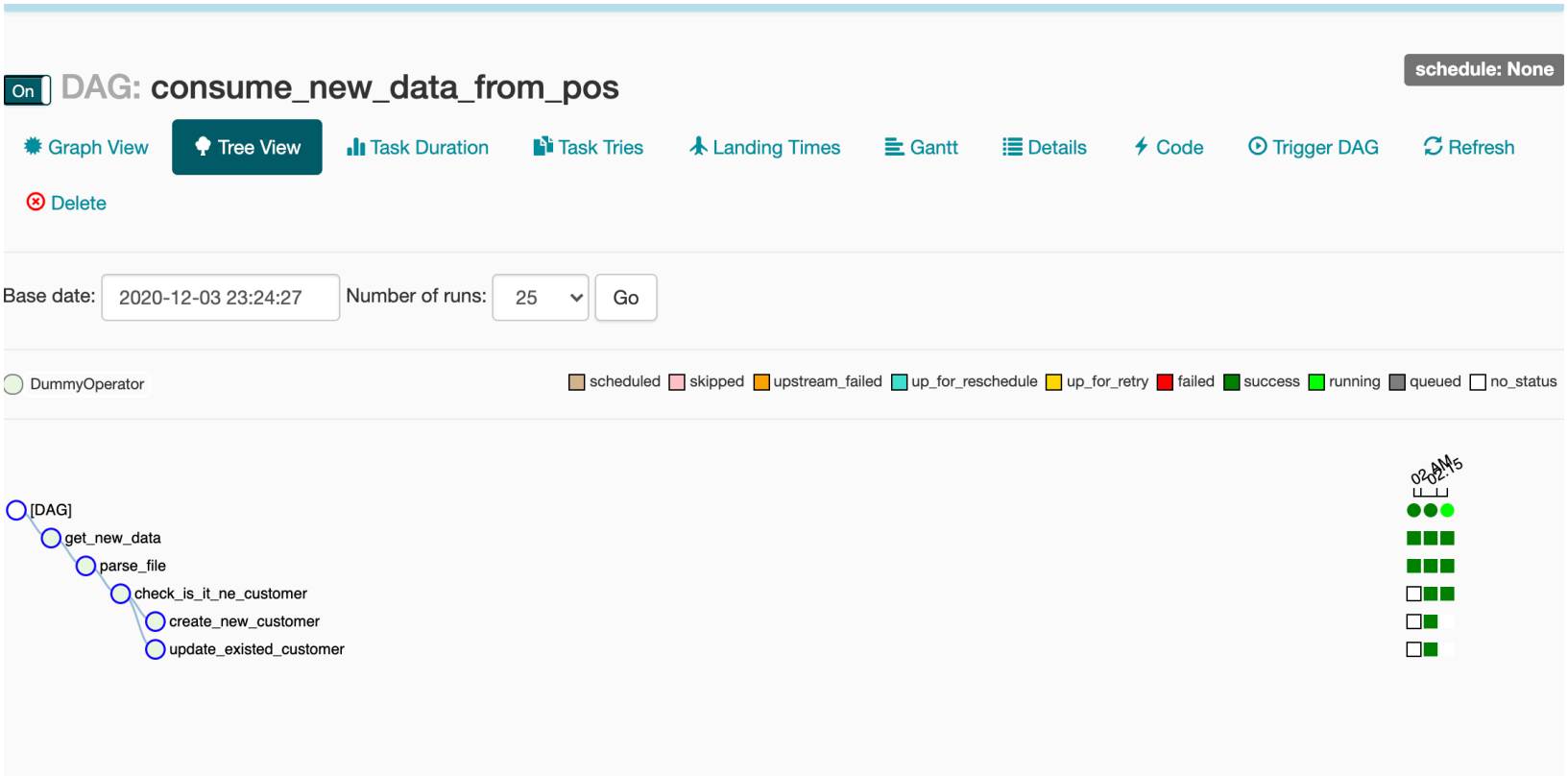
Dynamical DAGs generation: read properties from yaml or JSON

1. Simple read & parse with Pure Python code – custom config/DAG readers

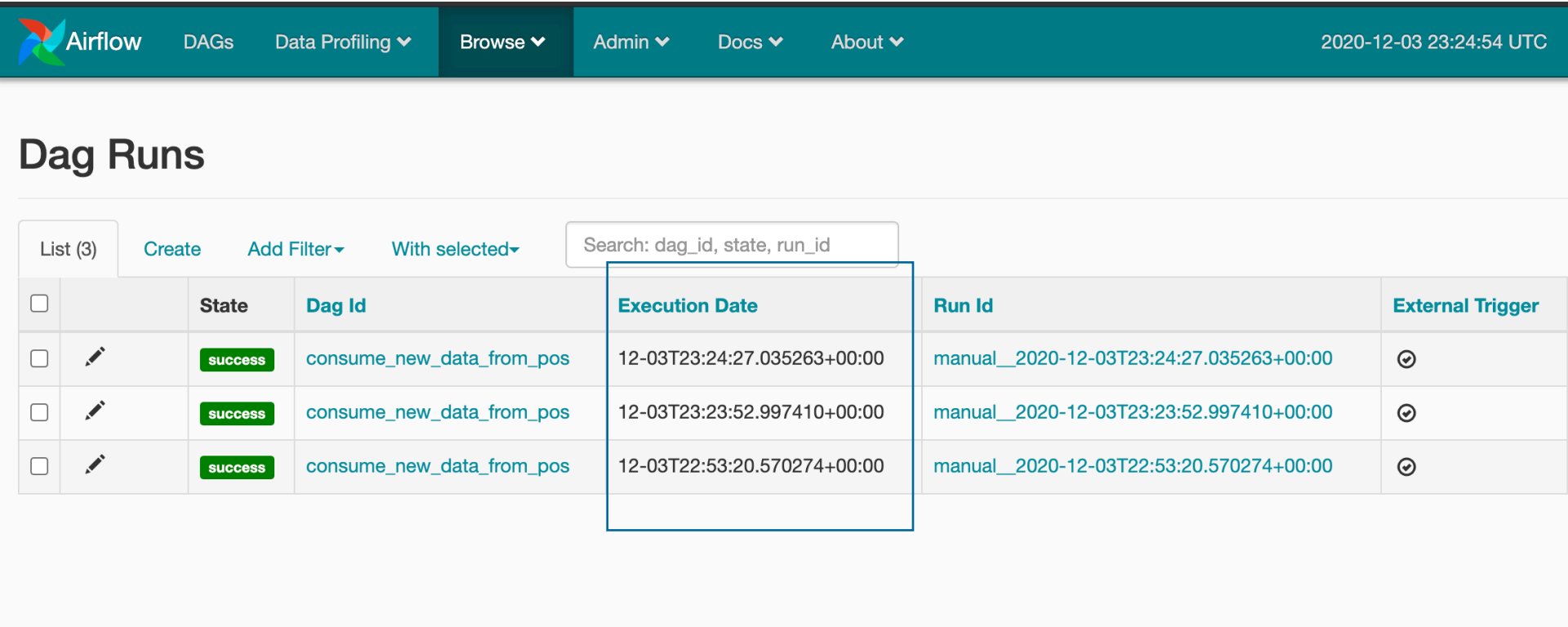
2. Existed third-party libraries/solutions, for example:

   https://github.com/rambler-digital-solutions/airflow-declarative

DAG Runs & Task Instances



DAG Runs & Task Instances



http://localhost:8080/admin/dagrun/

Let’s change the schedule_interval

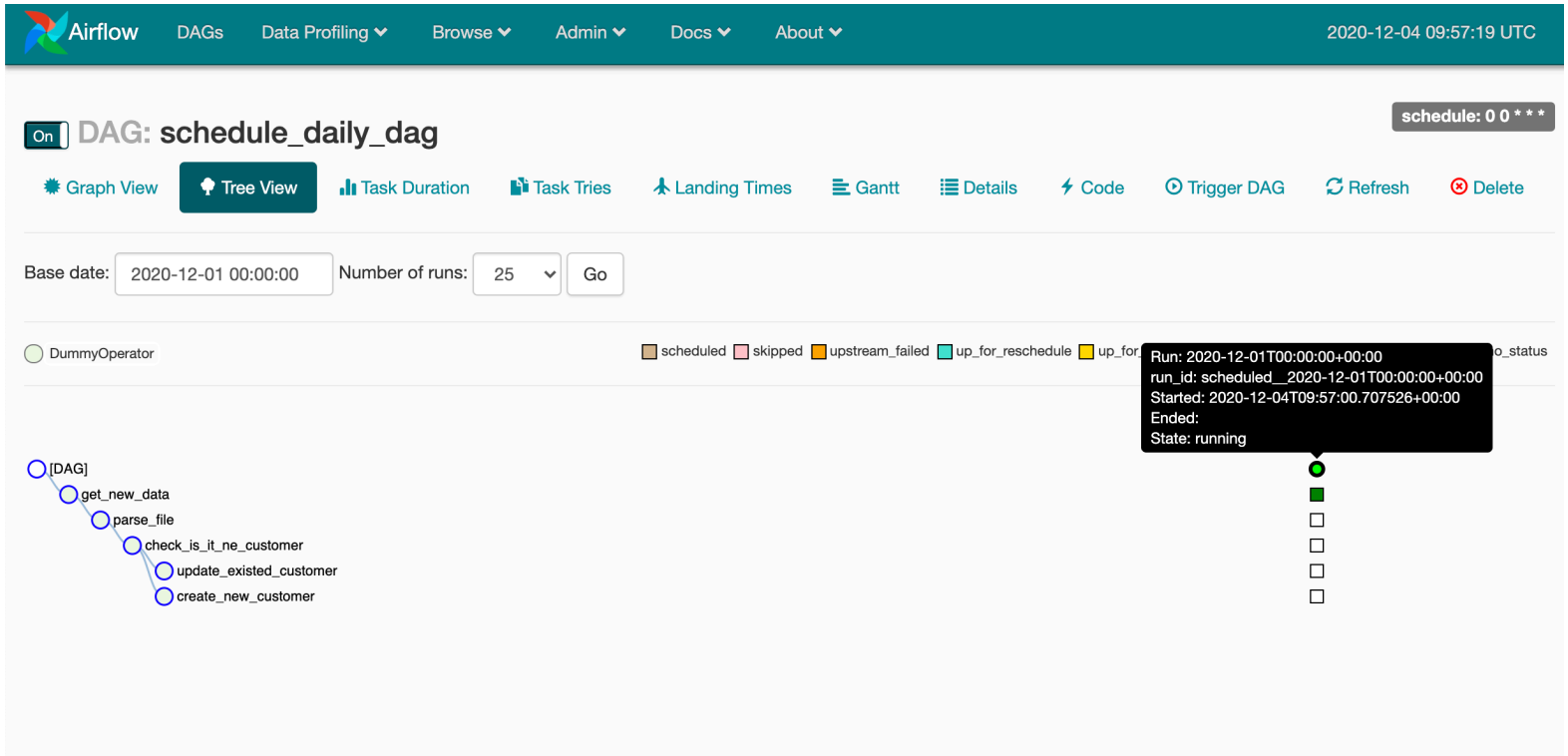
Set schedule_interval=“@daily” or “0 0 * * *”

Airflow support **CRON** expressions:

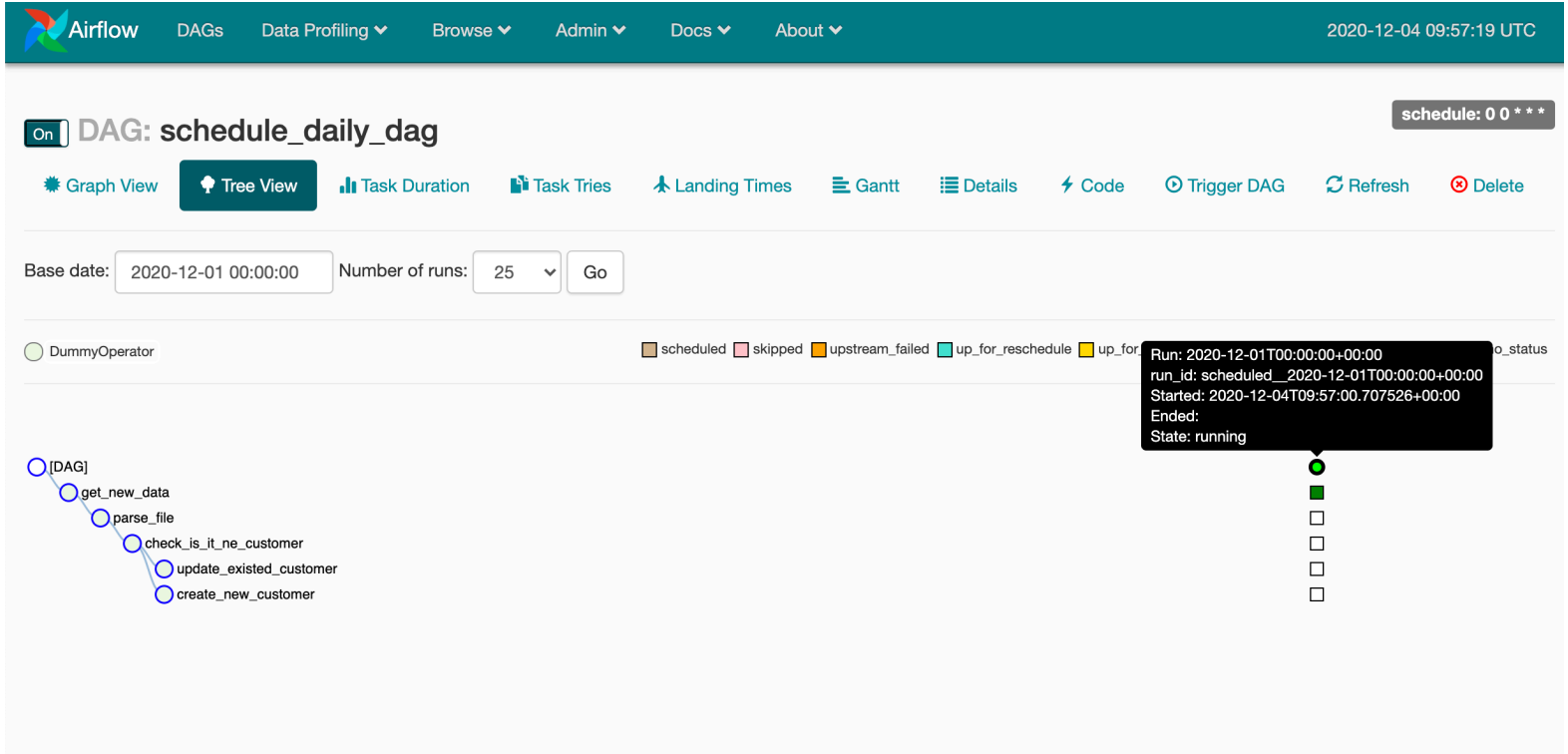
https://airflow.apache.org/docs/apache-airflow/stable/dag-run.html#cron-presets

@daily – just cron preset from Airflow

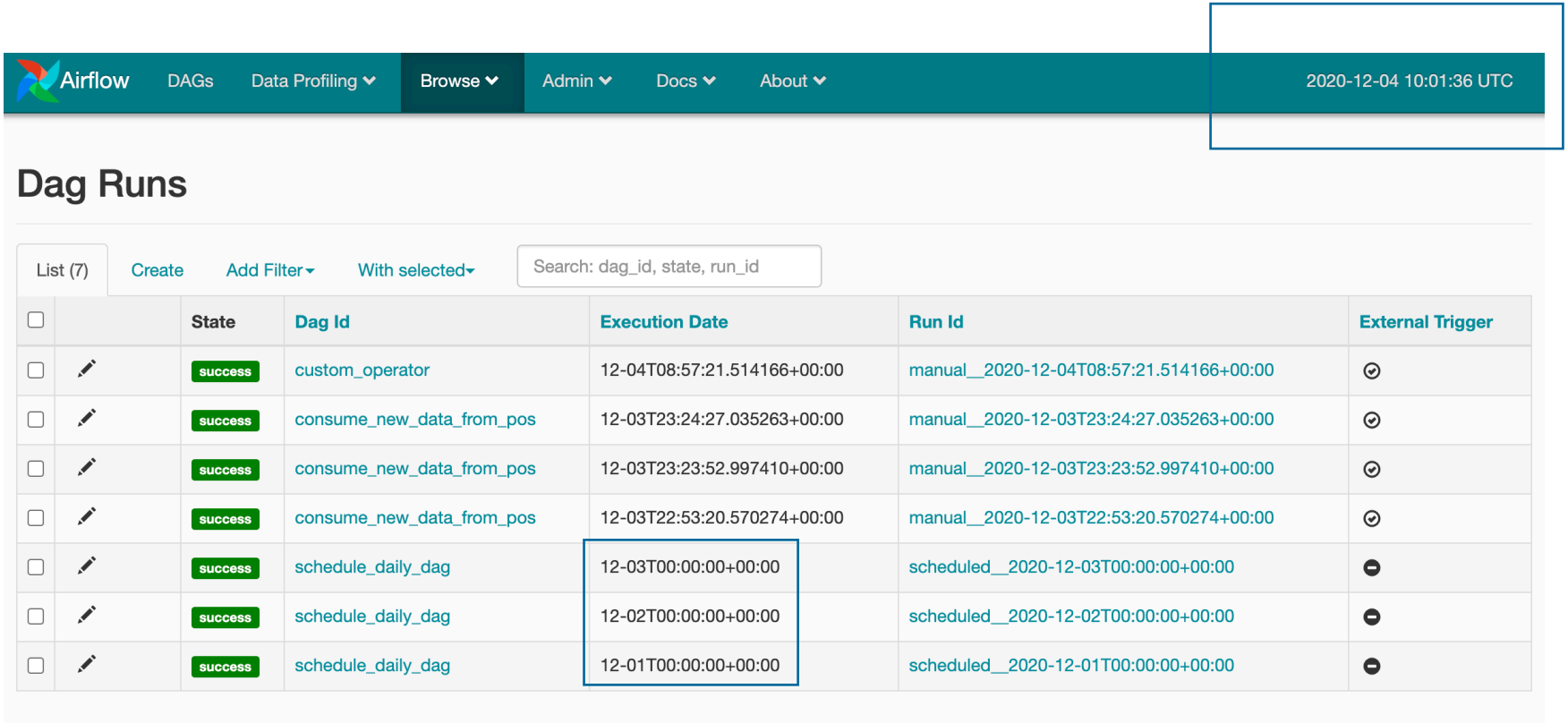
Let’s change the schedule_interval



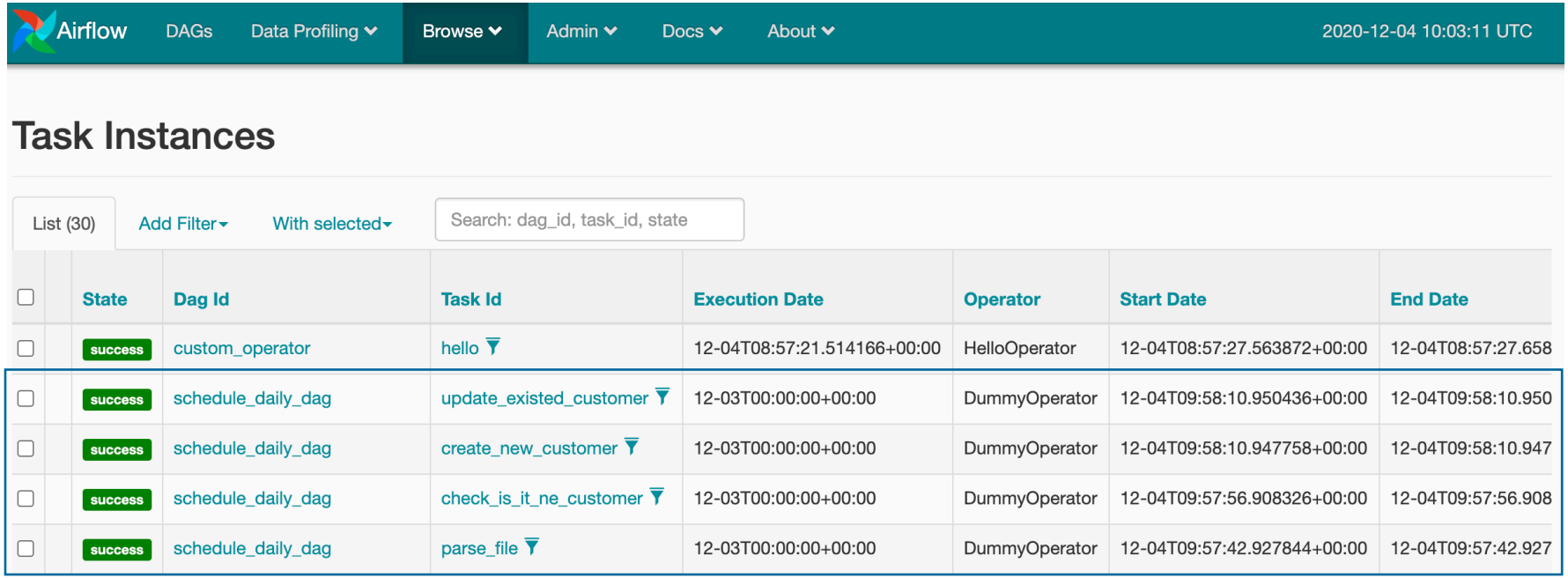
Let’s change the schedule_interval



Let’s change the schedule_interval



Let’s change the schedule_interval



Execution_date, start_date & schedule_interval

Triggered Manually:

execution_date - triggering datetime (if DAG was triggered manually)

Scheduled:

execution_date - date for that we process the **Data**, not real start or task

start_date - date of data that we want to process

if start_date (2020, 12, 1) and schedule “@daily” “@hourly” 00:01

For the first time DAG will run on 2020, 12, 2, execution_date will be 2020, 12, 1, but start_date of tasks will contain real execution datetime

Let’s change the schedule_interval

Set schedule_interval=“@daily” or “0 0 * * *”

Airflow support **CRON** expressions:

https://airflow.apache.org/docs/apache-airflow/stable/dag-run.html#cron-presets

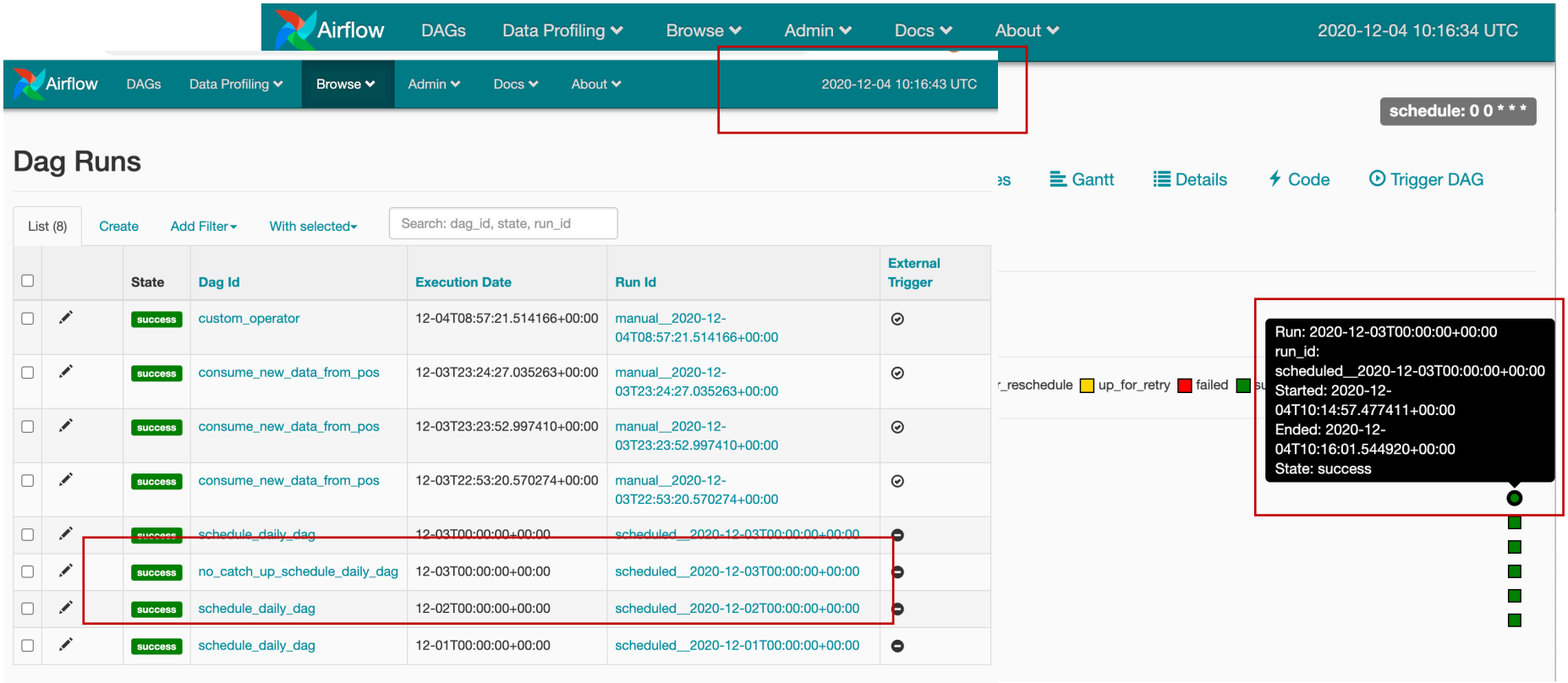
@daily – just cron preset from Airflow

Catch Up

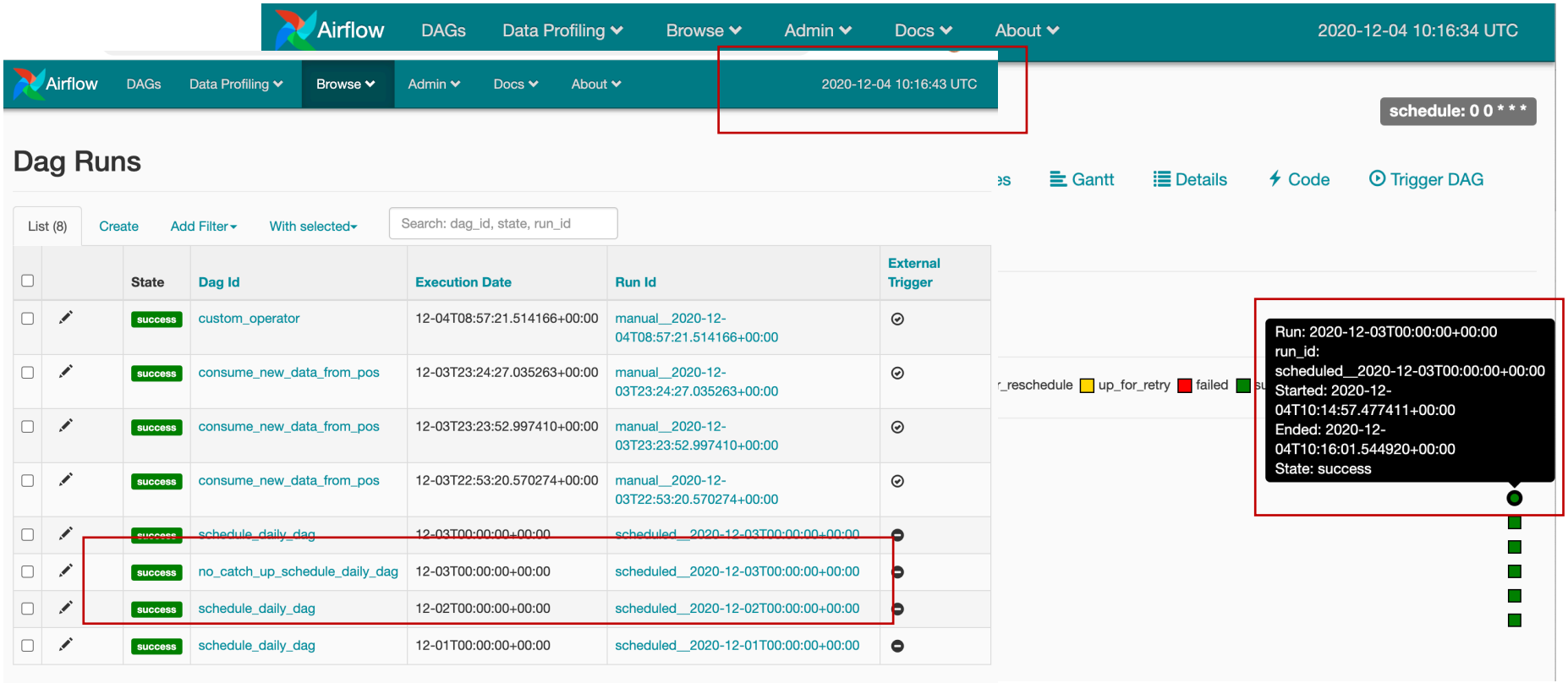
```
from datetime import datetime
from airflow import DAG
from airflow.operators.dummy_operator import DummyOperator


with DAG(
   dag_id="no_catch_up_schedule_daily_dag",
   start_date=datetime(2020, 12, 1),
   schedule_interval="0 0 * * *",
   catchup=False
   ) as dag:
```

:param **catchup**: Perform scheduler catchup (or only run latest)?
Defaults to True

Catch Up

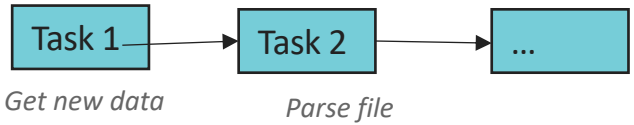

Airflow
DAGs
Data Profiling
Browse
Admin
Docs
About
2020-12-04 10:16:34 UTC
Airflow
DAGs
Data Profiling
Browse
Admin
Docs
About
2020-12-04 10:16:43 UTC
schedule: 0 0 * * *
Dag Runs
Gantt
Details
Code
Trigger DAG
List (8)
Create
Add Filter
With selected
Search: dag_id, state, run_id
State
Dag Id
Execution Date
Run Id
External Trigger
success custom_operator 12-04T08:57:21.514166+00:00 manual__2020-12-04T08:57:21.514166+00:00
success consume_new_data_from_pos 12-03T23:24:27.035263+00:00 manual__2020-12-03T23:24:27.035263+00:00
success consume_new_data_from_pos 12-03T23:23:52.997410+00:00 manual__2020-12-03T23:23:52.997410+00:00
success consume_new_data_from_pos 12-03T22:53:20.570274+00:00 manual__2020-12-03T22:53:20.570274+00:00
success schedule_daily_dag 12-03T00:00:00+00:00 scheduled__2020-12-03T00:00:00+00:00
success no_catch_up_schedule_daily_dag 12-03T00:00:00+00:00 scheduled__2020-12-03T00:00:00+00:00
success schedule_daily_dag 12-02T00:00:00+00:00 scheduled__2020-12-02T00:00:00+00:00
success schedule_daily_dag 12-01T00:00:00+00:00 scheduled__2020-12-01T00:00:00+00:00
_reschedule
up_for_retry
failed
Run: 2020-12-03T00:00:00+00:00
run_id: scheduled__2020-12-03T00:00:00+00:00
Started: 2020-12-04T10:14:57.477411+00:00
Ended: 2020-12-04T10:16:01.544920+00:00
State: success

Catch Up


Airflow
DAGs
Data Profiling
Browse
Admin
Docs
About
2020-12-04 10:16:34 UTC
Airflow
DAGs
Data Profiling
Browse
Admin
Docs
About
2020-12-04 10:16:43 UTC
schedule: 0 0 * * *
Dag Runs
Gantt
Details
Code
Trigger DAG
List (8)
Create
Add Filter
With selected
Search: dag_id, state, run_id
State
Dag Id
Execution Date
Run Id
External Trigger
success custom_operator 12-04T08:57:21.514166+00:00 manual__2020-12-04T08:57:21.514166+00:00
success consume_new_data_from_pos 12-03T23:24:27.035263+00:00 manual__2020-12-03T23:24:27.035263+00:00
success consume_new_data_from_pos 12-03T23:23:52.997410+00:00 manual__2020-12-03T23:23:52.997410+00:00
success consume_new_data_from_pos 12-03T22:53:20.570274+00:00 manual__2020-12-03T22:53:20.570274+00:00
success schedule_daily_dag 12-03T00:00:00+00:00 scheduled__2020-12-03T00:00:00+00:00
success no_catch_up_schedule_daily_dag 12-03T00:00:00+00:00 scheduled__2020-12-03T00:00:00+00:00
success schedule_daily_dag 12-02T00:00:00+00:00 scheduled__2020-12-02T00:00:00+00:00
success schedule_daily_dag 12-01T00:00:00+00:00 scheduled__2020-12-01T00:00:00+00:00
_reschedule
up_for_retry
failed
Run: 2020-12-03T00:00:00+00:00
run_id: scheduled__2020-12-03T00:00:00+00:00
Started: 2020-12-04T10:14:57.477411+00:00
Ended: 2020-12-04T10:16:01.544920+00:00
State: success

Parametrize tasks – Jinja2 Template

/${shop_id}/${current_date}/${hour}/${uuid_name}${pos_id}.xml



Let simplify it for study pipeline:

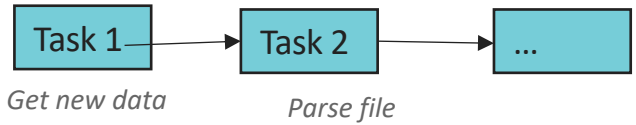
Use - FS, not HDFS and fix shop_id and file name data.**json** :

../shop123/{{ current_date }}/${hour}/data.json

{'param_name': value}

Parametrize tasks – Jinja2 Template

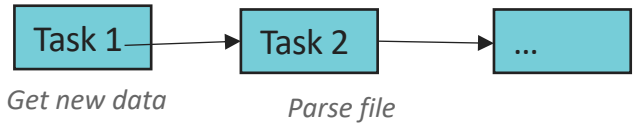
Get new data – Sensor that wait for the file,
to avoid failed ('parse_file') task




```
from airflow.contrib.sensors.file_sensor import FileSensor

from airflow.operators.dummy_operator import DummyOperator
```

Parametrize tasks – Jinja2 Template

Get new data – Sensor that wait for the file,
to avoid failed ('parse_file') task




```
from airflow.contrib.sensors.file_sensor import FileSensor

from airflow.operators.dummy_operator import DummyOperator
```

`FileSensor expect` **filepath** arg with path to poke

Parametrize tasks – Jinja2 Template

```
from datetime import datetime
from airflow import DAG
from airflow.operators.dummy_operator import DummyOperator
from airflow.contrib.sensors.file_sensor import FileSensor


with DAG(
  dag_id="consume_new_data_from_pos_read_and_parse",
  start_date=datetime(2020, 12, 1),
  schedule_interval="0 * * * *"
  ) as dag:
  get_new_data = FileSensor(task_id="get_new_data",
                            filepath="../shop123/${current_date}/${hour}/data.json")
```

${current_date} & ${hour} – we need somehow send dynamic variables inside it

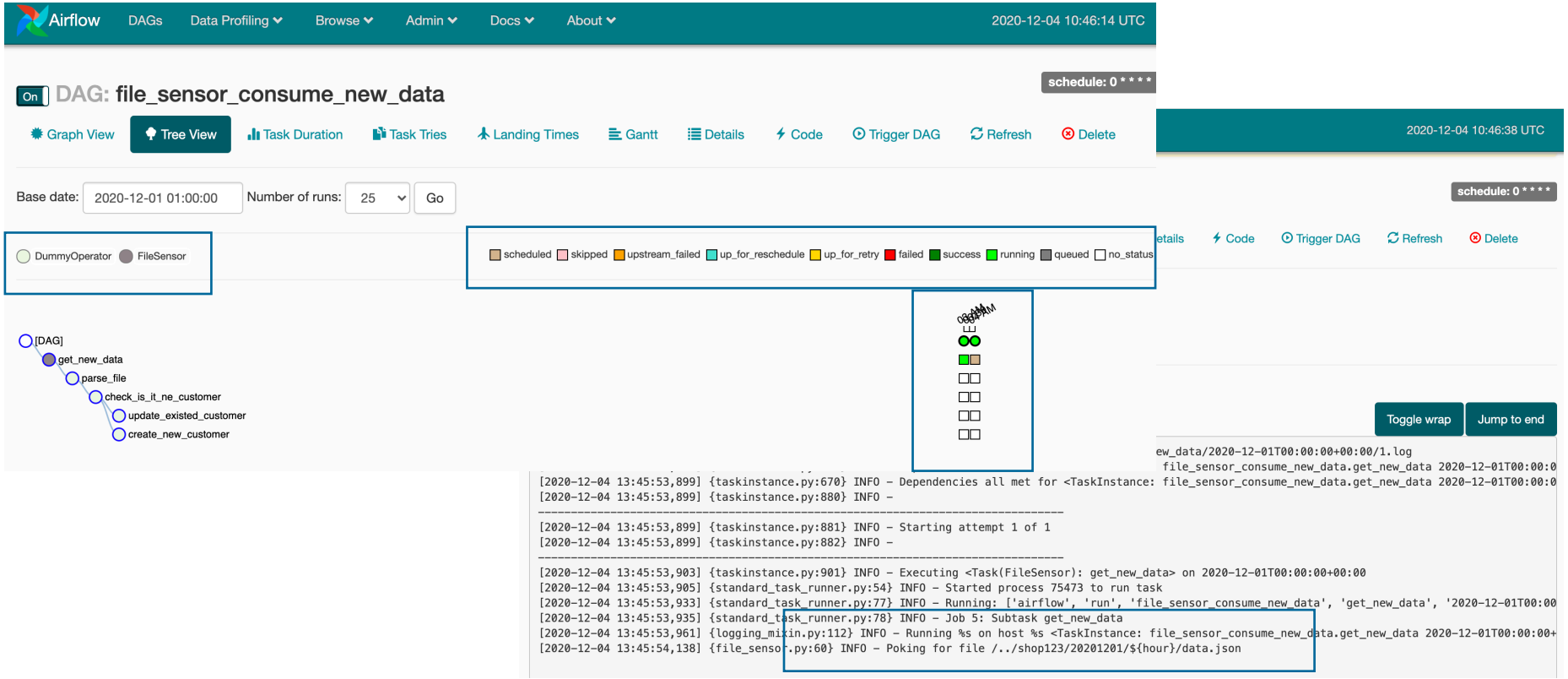
Parametrize tasks – Jinja2 Template

Use Jinja2 Templates!

https://airflow.apache.org/docs/apache-airflow/stable/concepts.html#jinja-templating

Available macros: https://airflow.apache.org/docs/apache-airflow/stable/macros-ref.html#macros-reference

Parametrize tasks – Jinja2 Template



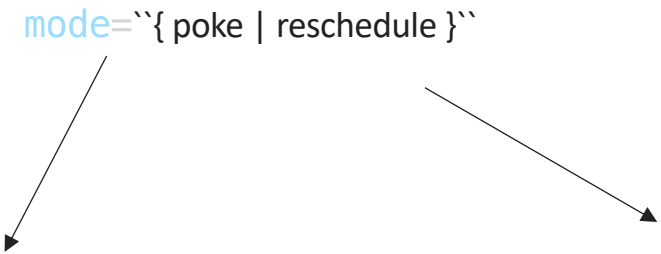
Last questions of Day 1

1. UI view changes (Operators colorizing)
2. Statuses - what are they mean?
3. What to do with **hours**?

Statuses

Sensors status

Statuses



Task is running non-stop on worker

Task re-schedule
(free worker cpu, free pool to other tasks)

Let’s try it & knows that to do with hours in the Day2

The end of the Day 1

Homework

- Check Apache Airflow docs web-site https://airflow.apache.org/docs/stable/start.html#quick-start
- Do apache airflow Quick install (see links on the slides) & copy lecture DAGs in DAG folder – unpause them and see different behaviour
- Run through Apache Aiflow source code & invistigare Dag, Task and Base Operator classes

Lecture DAGs:

https://github.com/xnuinside/airflow_lectures

Clone Airflow in Docker Compose with Celery:

https://github.com/xnuinside/airflow_in_docker_compose

Check that components are in docker-compose and needed to be defined to run with CeleryExecutor & try to up & run.