EECS E6893 Big Data Analytics
HW4: Data Analytics Pipeline

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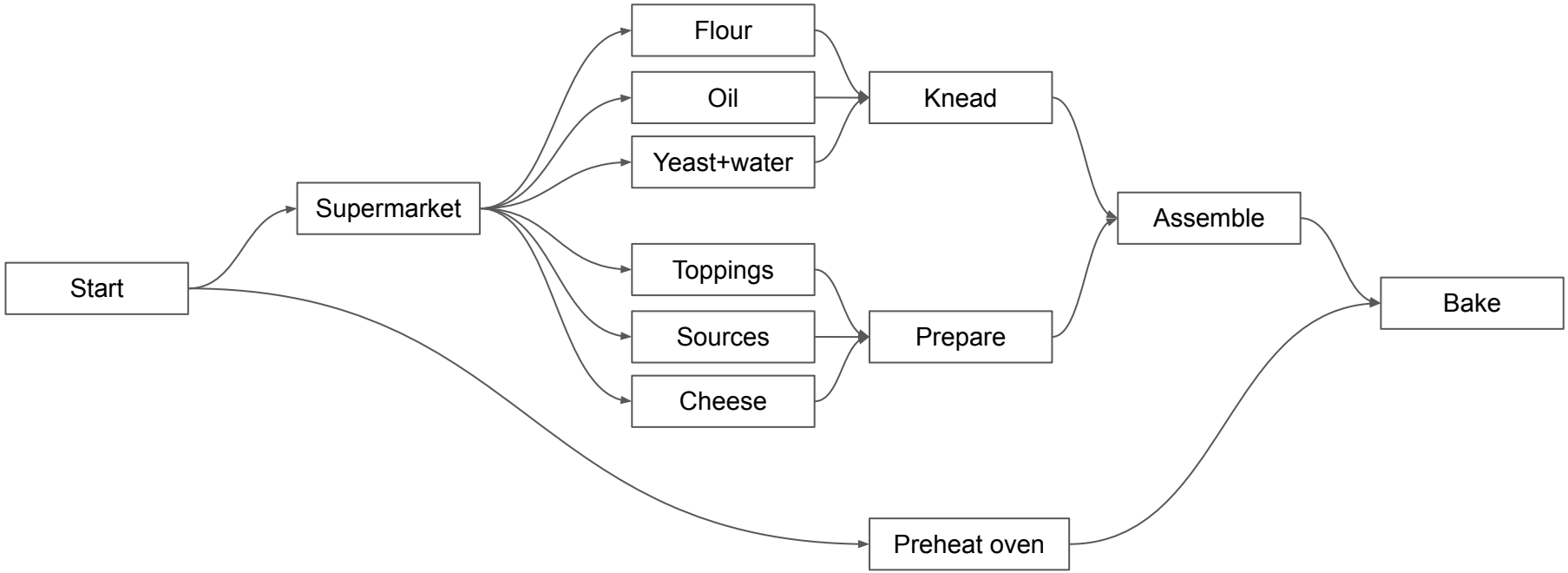
Workflow

- A sequence of tasks involved in moving from the beginning to the end of a working process
- Started on a schedule or triggered by an event

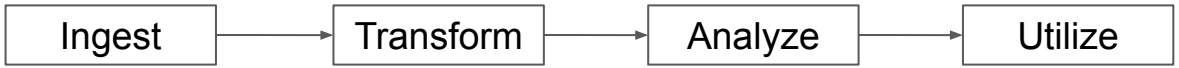
Workflow

- Cook a pizza



Workflow

- Data analytics



- A platform let you create, schedule, monitor and manage workflows

Principles:

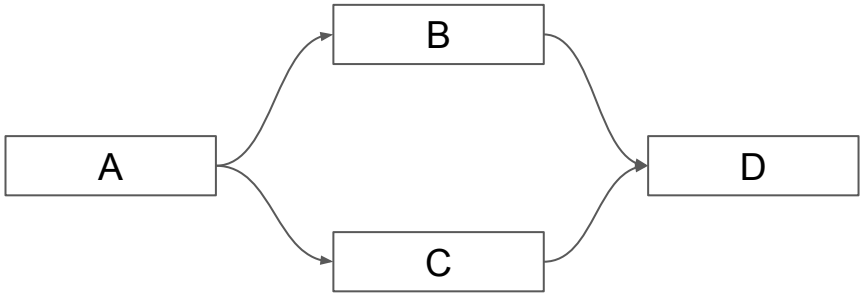
- Scalable
- Dynamic
- Extensible
- Elegant

Features:

- Pure Python
- Useful UI
- Robust Integrations
- Easy to Use
- Open Source

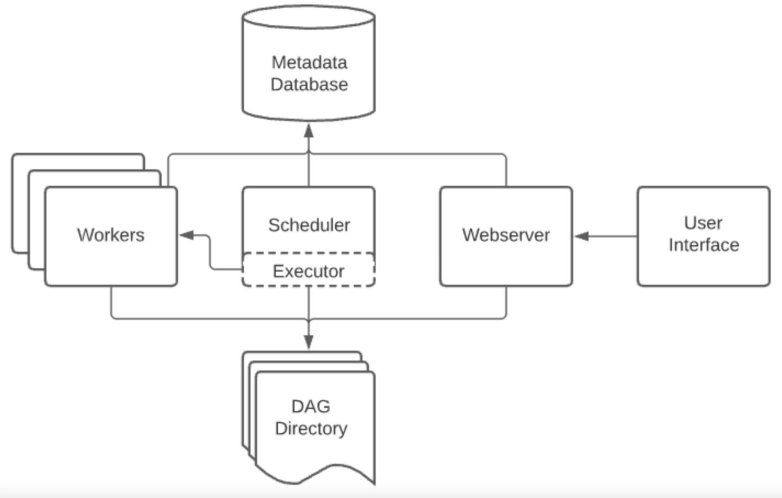
DAG (Directed Acyclic Graph)

- In Airflow, workflows are created using DAGs
- A DAG is a collection of tasks that you want to schedule and run, organized in a way that reflects their relationships and dependencies
- The tasks describe what to do, e.g., fetching data, running analysis, triggering other systems, or more
- A DAG ensures that each task is executed at the right time, in the right order, or with the right issue handling
- A DAG is written in Python



Airflow architecture

- **Scheduler:** handles both triggering scheduled workflows, and submitting Tasks to the executor to run.
- **Executor**: handles running tasks.
- **Webserver**: a handy user interface to inspect, trigger and debug the behaviour of DAGs and tasks.
- **A folder of DAG files**: read by the scheduler and executor
- **A metadata database**: used by the scheduler, executor and webserver to store state



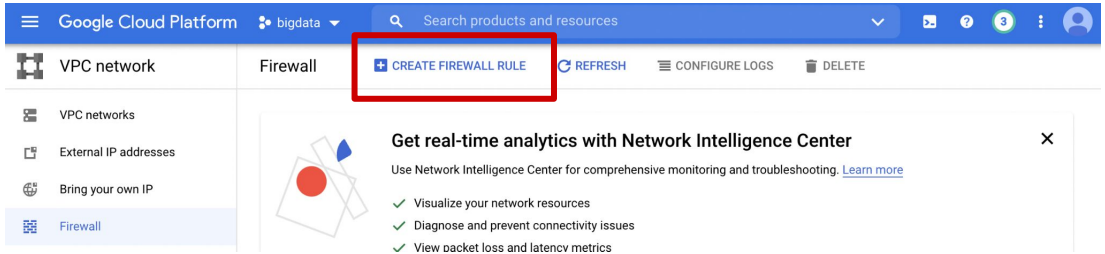
Airflow installation

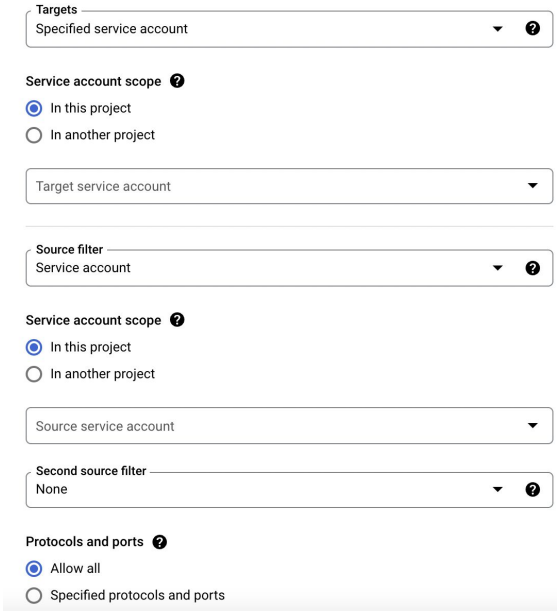
Three choices

1. **Install and use Airflow in the VM of GCP**
2. Install and use airflow in your local machines
3. Google composer

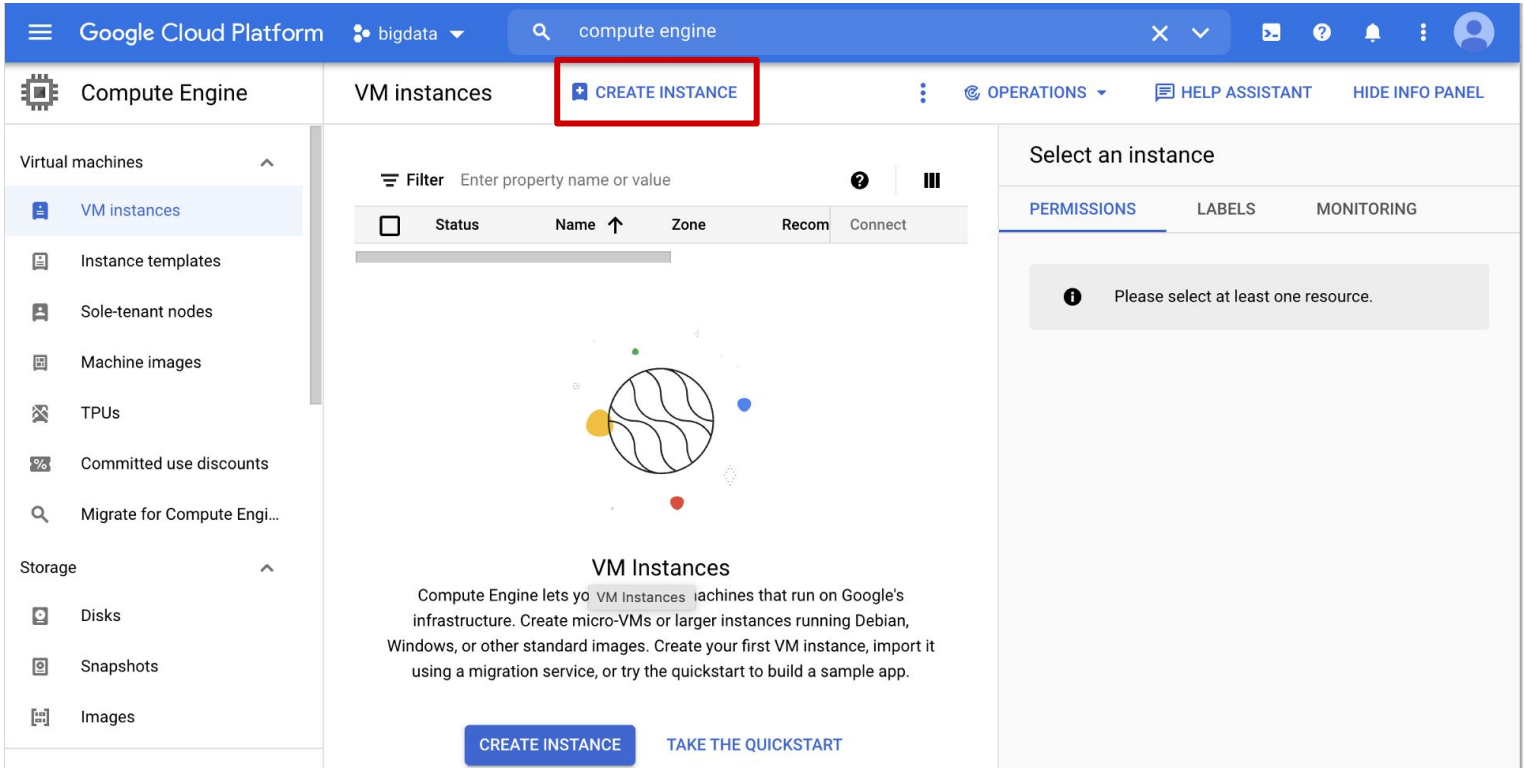
Set up the firewall

- VPC network → Firewall → Create Filewall rule
- Set service account scope and protocols and ports

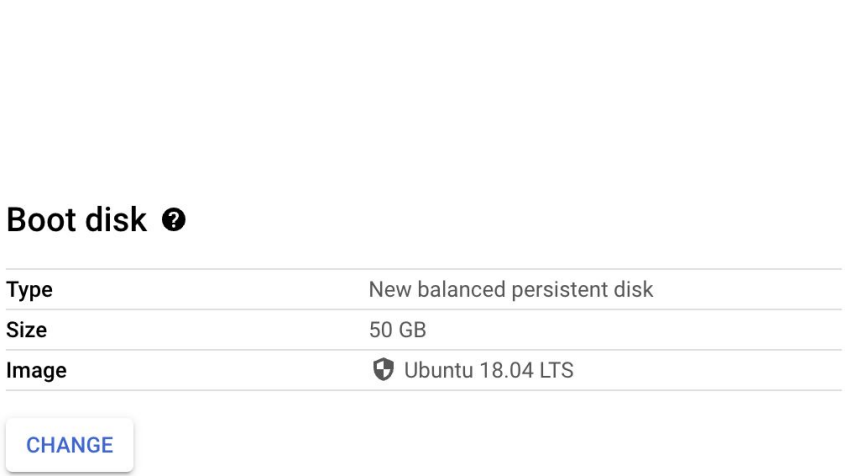


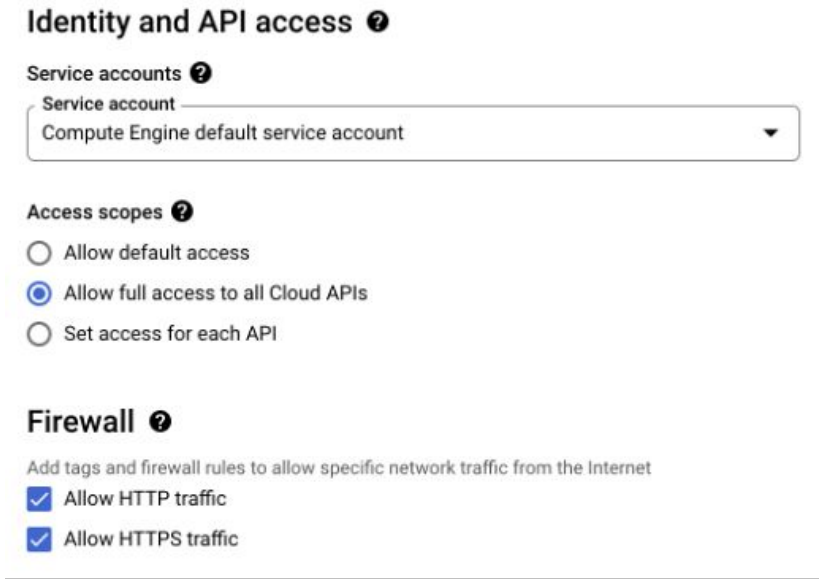


Create a VM instance

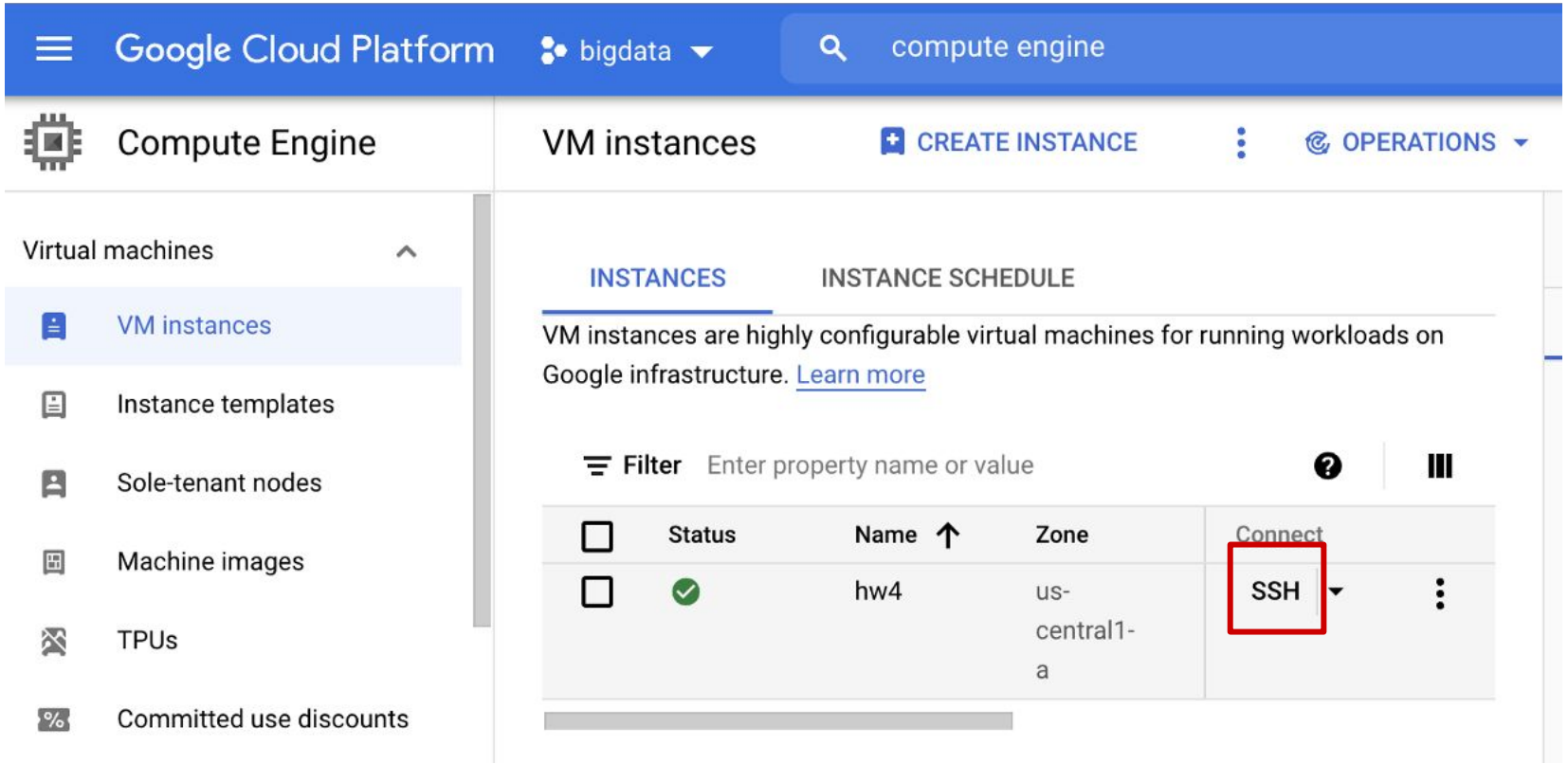


Create a VM instance





Connect to your VM using SSH



Connect to your VM using SSH

```
The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

ch3212@hw4:~$
```

Install and update packages

1. sudo apt update
2. sudo apt -y upgrade
3. sudo apt-get install wget
4. sudo apt install -y python3-pip

Download miniconda and create a virtual environment

1. mkdir -p ~/miniconda3
2. wget https://repo.anaconda.com/miniconda/Miniconda3-latest-Linux-x86_64.sh -O ~/miniconda3/miniconda.sh
3. bash ~/miniconda3/miniconda.sh -b -u -p ~/miniconda3
4. rm -rf ~/miniconda3/miniconda.sh
5. ~/miniconda3/bin/conda init bash
6. ~/miniconda3/bin/conda init zsh

reopen (or we say reconnect) your terminal and create a new environment

7. conda create --name airflow python=3.8

activate the environment (everytime you open a new terminal, you should run this)

8. conda activate airflow

optional but in case you don't like warnings

9. (optional) pip install virtualenv
10. (optional) pip install kubernetes

```
(base) ch3212@hw4:~$ conda activate airflow
(airflow) ch3212@hw4:~$
```

Install Airflow

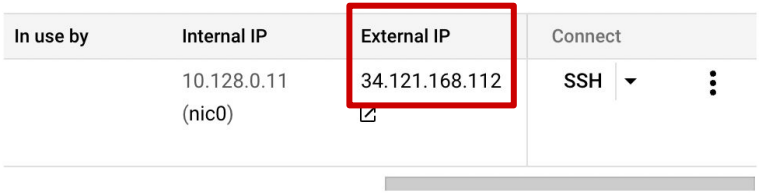
```
# Airflow needs a home. `~/airflow` is the default, but you can put it
# somewhere else if you prefer (optional)
export AIRFLOW_HOME=~/airflow
# Install Airflow using the constraints file
AIRFLOW_VERSION=2.2.1
PYTHON_VERSION=3.8
# For example: 3.8
CONSTRAINT_URL="https://raw.githubusercontent.com/apache/airflow/constraints-${AIRFLOW_VERSION}/constraints-${PYTHON_VERSION}.txt"
# For example: https://raw.githubusercontent.com/apache/airflow/constraints2.2.1/constraints-3.6.txt
pip install "apache-airflow==${AIRFLOW_VERSION}" --constraint "${CONSTRAINT_URL}"
# run airflow version to check if you install it successfully
airflow version
# The Standalone command will initialise the database, make a user,
# and start all components for you.
# airflow standalone
# Visit localhost:8080 in the browser and use the admin account details
# shown on the terminal to login.
# Enable the example_bash_operator dag in the home page
```

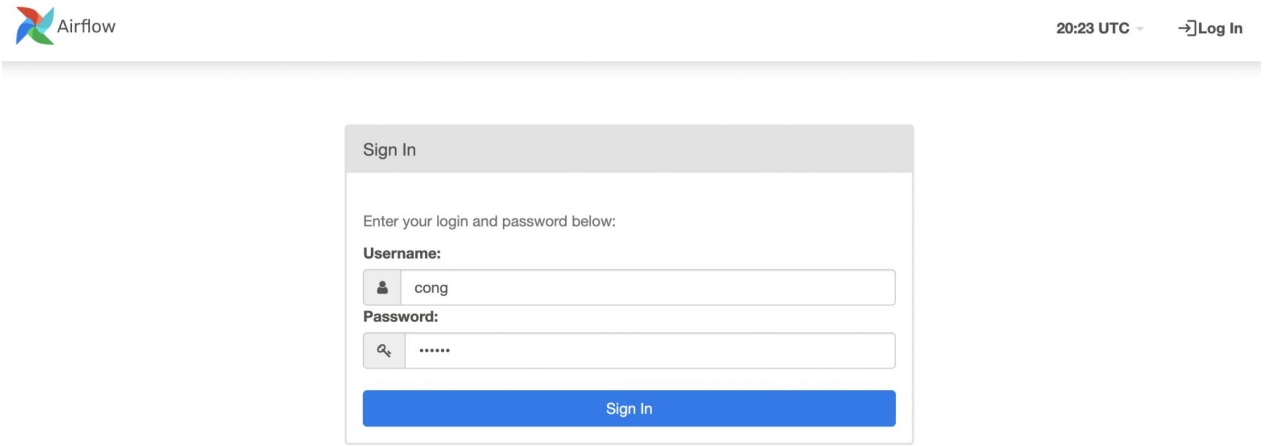
Initialize the database, make a user, and start webserver

```
# Initialize the database, after this you will see a new folder airflow in your
# $AIRFLOW_HOME which contains configuration file airflow.cfg
1.airflow db init
2.airflow users create \
      --username cong \
      --password 123456 \
      --firstname cong \
      --lastname han \
      --role Admin \
      --email ch3212@columbia.edu
3.airflow webserver --port 8080
```

Airflow UI on your web browser

- Open your browser
- Visit “**http**://<External IP>:8080”
- login





Start scheduler

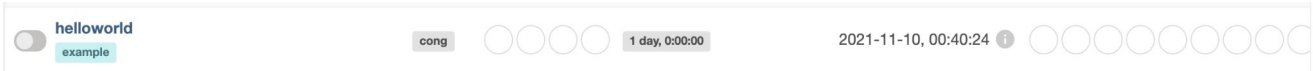
Open a new terminal (you can use screen if you prefer to open only one
terminal)

1. conda activate airflow
2. airflow db init
3. airflow scheduler

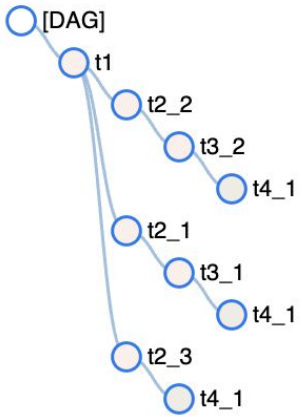
Airflow examples

Helloworld

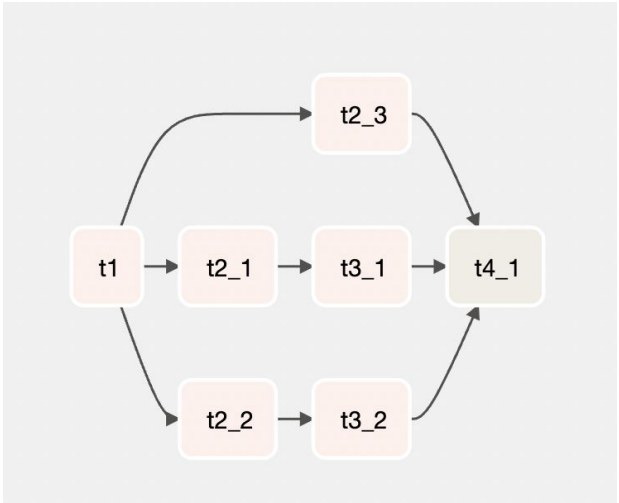
```
# Download helloworld.py from Coursework/Files
# Open a new terminal
conda activate airflow
# Create dags folders
cd airflow
mkdir dags
cd dags
# Upload helloworld.py here
# Check if the script is correct, no errors if it's correct
python helloworld.py
# Initialize db again and you will see "hello" on the website
airflow db init
```



Helloworld



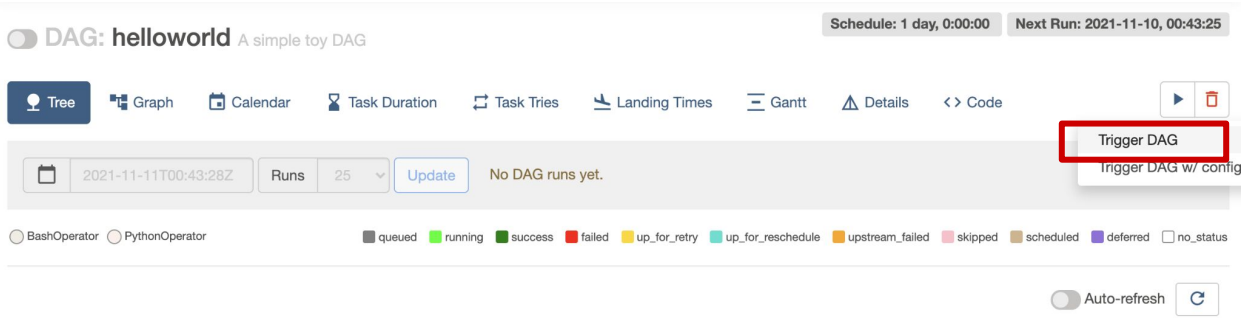
Tree



Graph

Two ways to trigger a DAG

1. Trigger manually
2. Trigger on a schedule



Trigger manually

Scheduler

- The scheduler won't trigger your tasks until the period it covers has ended.
- The scheduler runs your job one schedule_interval after the start date, at the end of the interval.

```python
from datetime import datetime, timedelta
from textwrap import dedent
import time

# The DAG object; we'll need this to instantiate a DAG
from airflow import DAG

# Operators; we need this to operate!
from airflow.operators.bash import BashOperator
from airflow.operators.python import PythonOperator
# These args will get passed on to each operator
# You can override them on a per-task basis during operator initialization
default_args = {
    'owner': 'cong',
    'depends_on_past': False,
    'email': ['ch3212@columbia.edu'],
    'email_on_failure': False,
    'email_on_retry': False,
    'retries': 1,
    'retry_delay': timedelta(seconds=30),
    # 'queue': 'bash_queue',
    # 'pool': 'backfill',
    # 'priority_weight': 10,
    # 'end_date': datetime(2016, 1, 1),
    # 'wait_for_downstream': False,
    # 'dag': dag,
    # 'sla': timedelta(hours=2),
    # 'execution_timeout': timedelta(seconds=300),
    # 'on_failure_callback': some_function,
    # 'on_success_callback': some_other_function,
    # 'on_retry_callback': another_function,
    # 'sla_miss_callback': yet_another_function,
    # 'trigger_rule': 'all_success'
}
```

References

https://airflow.apache.org/docs/apache-airflow/stable/concepts/scheduler.html

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

https://cloud.google.com/composer/docs/triggering-dags


```python
with DAG(
    'helloworld',
    default_args=default_args,
    description='A simple toy DAG',
    schedule_interval=timedelta(days=1),
    start_date=datetime(2021, 1, 1),
    catchup=False,
    tags=['example'],
) as dag:
```

Tasks

```
with DAG(
    'helloworld',
    default_args=default_args,
    description='A simple toy DAG',
    schedule_interval=timedelta(days=1),
    start_date=datetime(2021, 1, 1),
    catchup=False,
    tags=['example'],
) as dag:

    # t* examples of tasks created by instantiating operators
    t1 = PythonOperator(
        task_id='t1',
        python_callable=correct_sleeping_function,
    )

    t2_1 = PythonOperator(
        task_id='t2_1',
        python_callable=correct_sleeping_function,
    )

    t2_2 = PythonOperator(
        task_id='t2_2',
        python_callable=correct_sleeping_function,
        retries=3,
    )

    t2_3 = PythonOperator(
        task_id='t2_3',
        python_callable=correct_sleeping_function,
    )

    t3_1 = PythonOperator(
        task_id='t3_1',
        python_callable=correct_sleeping_function,
    )

    t3_2 = PythonOperator(
        task_id='t3_2',
        python_callable=correct_sleeping_function,
    )

    t4_1 = BashOperator(
        task_id='t4_1',
        bash_command='sleep 2',
        retries=3,
    )
```

```
def correct_sleeping_function():
    """This is a function that will run within the DAG execution"""
    time.sleep(2)
```

Operators

1. **PythonOperator**
2. **BashOperator**
3. branch_operator
4. email_operator
5. mysql_operator
6. DataprocOperator

…

...

PythonOperator:

```
def function():
    print(123)

task = PythonOperator(
    task_id='task_id',
    python_callable=function,
  )
```

BashOperator:

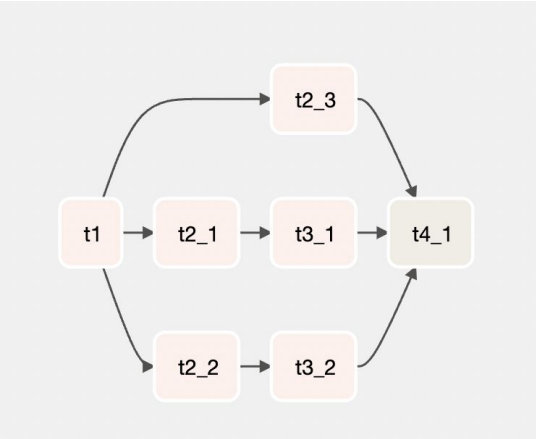
```
task = BashOperator(
    task_id='task_id',
    bash_command='sleep 2',
  )
# other examples
bash_command='python python_code.py'
bash_command='bash bash_code.sh '
```

(must have a space to satisfy Jinja template !!)

Dependencies

```
# task dependencies

t1 >> [t2_1, t2_2, t2_3]
t2_1 >> t3_1
t2_2 >> t3_2
[t2_3, t3_1, t3_2] >> t4_1
```



t2_1 will depend on t1 running
successfully to run. The following ways
are equivalent:

t1 >> t2_1

t1 << t2_1

t1.set_downstream(t2_1)

t2_1.set_upstream(t1)

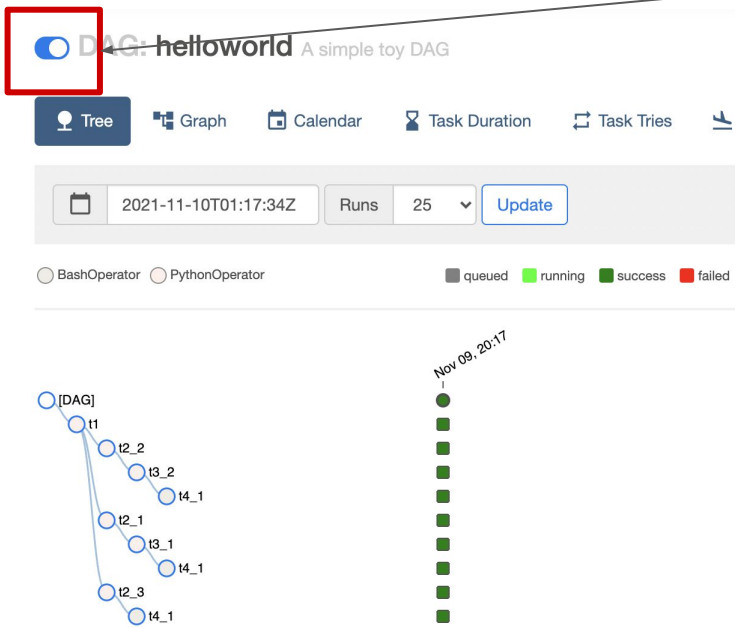
you can write in a chain

t1 >> t2_1 >> t3_1 >> t4_1

Trigger the dag

```
schedule_interval=timedelta(days=1),
start_date=datetime(2021, 1, 1),
```

Start scheduling the DAG



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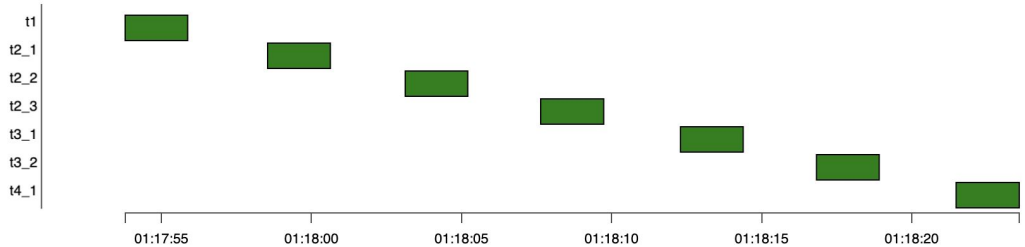
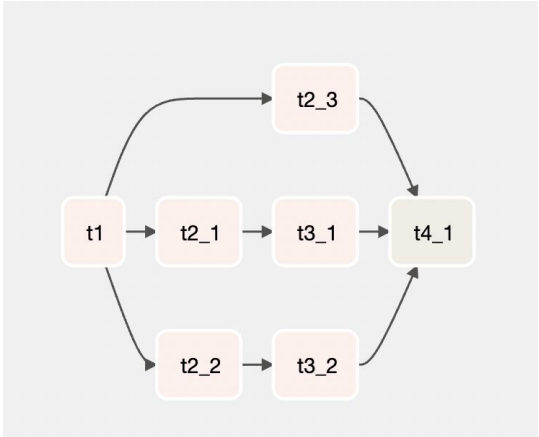


Gantt

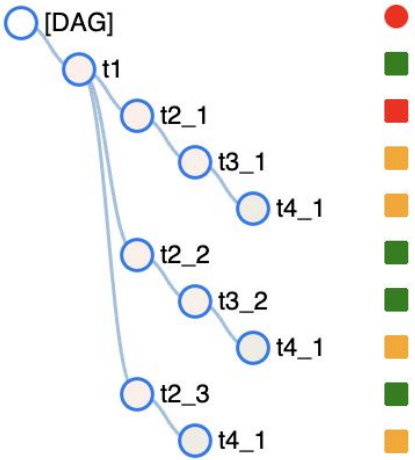
Example 2

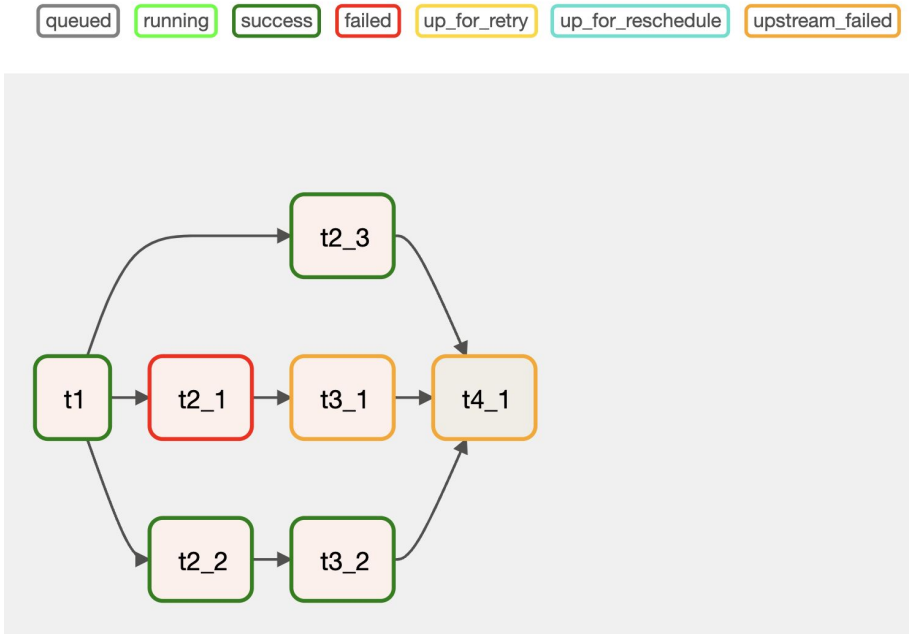
```python
t1 = PythonOperator(
    task_id='t1',
    python_callable=count_function,
)

t2_1 = PythonOperator(
    task_id='t2_1',
    python_callable=wrong_sleeping_function,
    retries=3,
)
```

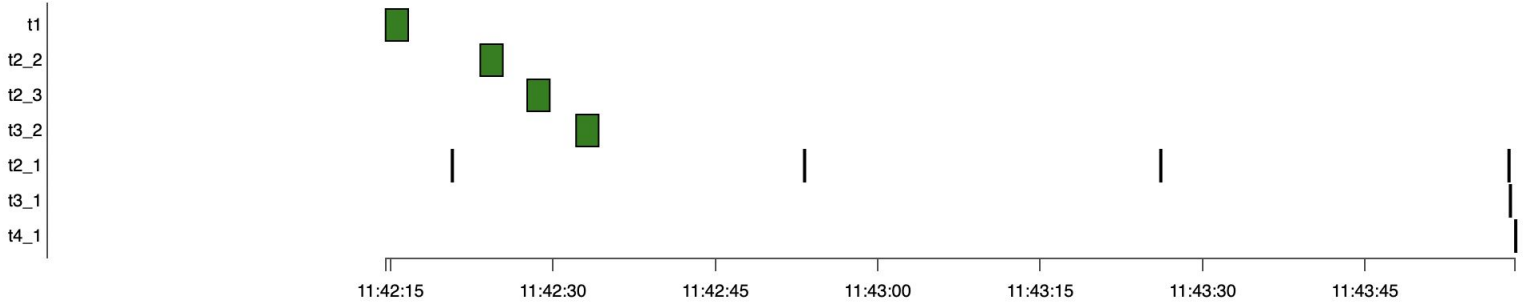
```python
count = 0

def count_function():
    # this task is t1
    global count
    count += 1
    print('count_increase output: {}'.format(count))
    time.sleep(2)

def wrong_sleeping_function():
    # this task is t2_1, t1 >> t2_1
    global count
    print('wrong sleeping function output: {}'.format(count))
    assert count == 1
    time.sleep(2)
```



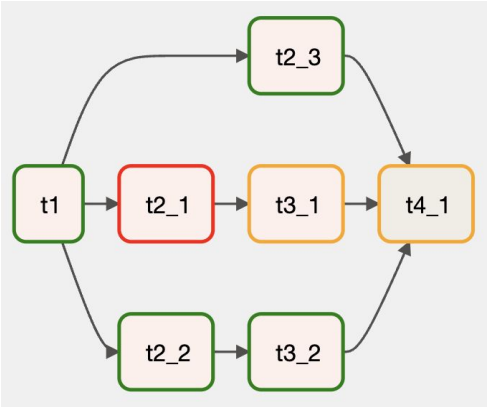
Example 2


[DAG]
t1
t2_1
t3_1
t4_1
t2_2
t3_2
t4_1
t2_3
t4_1


queued
running
success
failed
up_for_retry
up_for_reschedule
upstream_failed
t2_3
t1
t2_1
t3_1
t4_1
t2_2
t3_2


t1
t2_2
t2_3
t3_2
t2_1
t3_1
t4_1
11:42:15
11:42:30
11:42:45
11:43:00
11:43:15
11:43:30
11:43:45

Example 2



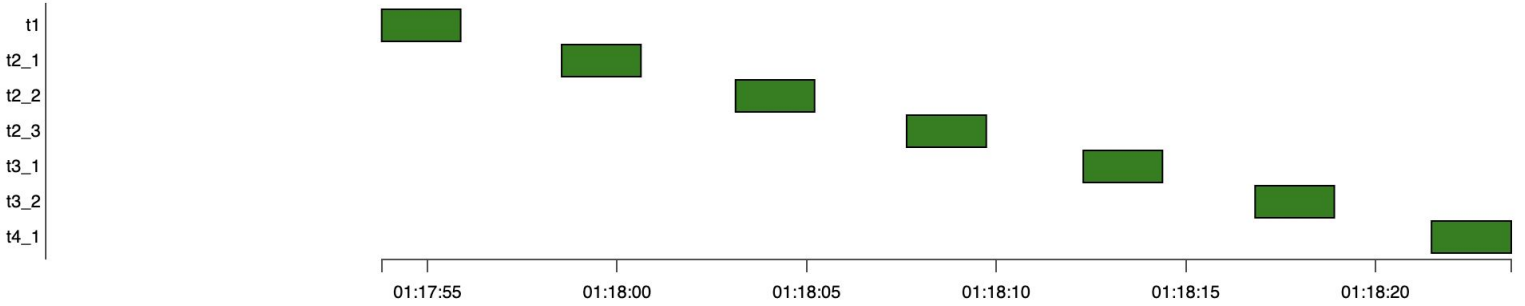

```python
count = 0

def count_function():
    # this task is t1
    global count
    count += 1
    print('count_increase output: {}'.format(count))
    time.sleep(2)

def wrong_sleeping_function():
    # this task is t2_1, t1 >> t2_1
    global count
    print('wrong sleeping function output: {}'.format(count))
    assert count == 1
    time.sleep(2)
```

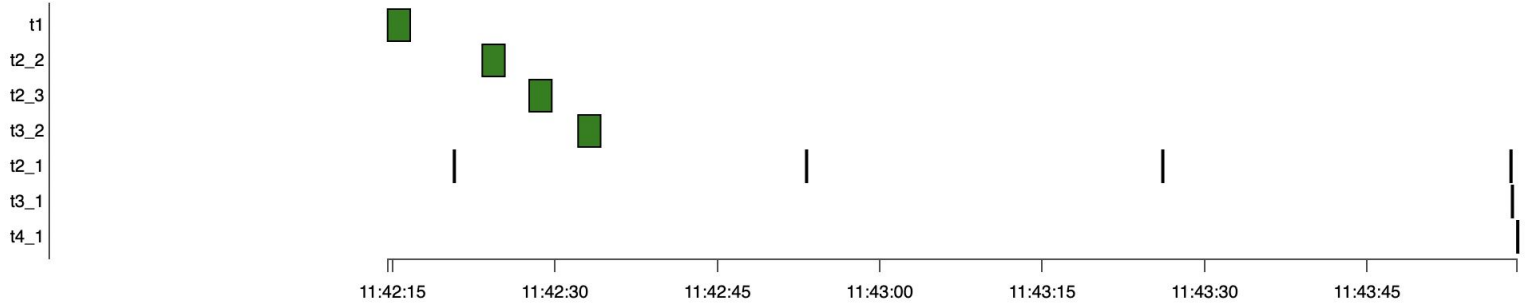
```
{logging_mixin.py:109} INFO - count_function output: 1

...

{logging_mixin.py:109} INFO - wrong_sleeping_function output: 0

...

    assert count == 1

AssertionError
```

Why?

- Airflow Python script is just a configuration file specifying the DAG's structure as code.
- Different tasks run on different workers at different points in time
- Script cannot be used to cross communicate between tasks (Xcoms can)

Why sequential?





Executors

- **SequencialExecutor**
- **LocalExecutor**
- CeleryExecutor
- KubernetesExecutor

Change SequentialExecutor to LocalExecutor

- Postgresql
- Modify the configuration in ~/airflow/airflow.cfg

```
# Default timezone in case supplied date times are naive
# can be utc (default), system, or any IANA timezone string (e.g. Europe/Amsterdam)
default_timezone = utc

# The executor class that airflow should use. Choices include
# ``SequentialExecutor``, ``LocalExecutor``, ``CeleryExecutor``, ``DaskExecutor``,
# ``KubernetesExecutor``, ``CeleryKubernetesExecutor`` or the
# full import path to the class when using a custom executor.
executor = SequentialExecutor

# The SqlAlchemy connection string to the metadata database.
# SqlAlchemy supports many different database engines.
# More information here:
# http://airflow.apache.org/docs/apache-airflow/stable/howto/set-up-database.html#database-uri
sql_alchemy_conn = sqlite:////home/ch3212/airflow/airflow.db
```

LocalExecutor

1. Install Postgres and Configure your Postgres user:

```
# In your terminal
sudo apt-get install postgresql postgresql-contrib
sudo -u postgres psql
# Next enter:
ALTER USER postgres PASSWORD 'postgres';
\q
# In your terminal
pip install 'apache-airflow[postgres]
```

LocalExecutor

2. Change your SQL Alchemy Conn inside airflow.cfg:

```
# In your terminal
vim ~/airflow/airflow.cfg
# you will see this line
sql_alchemy_conn = sqlite:///.../airflow.db
# change it to :
sql_alchemy_conn = postgresql+psycopg2://postgres:postgres@localhost/postgres
# Also change
Executor = SequentialExecutor
# To
Executor = LocalExecutor
```

LocalExecutor

3. Check for DB connection:

In your terminal

airflow db check

If Airflow could successfully connect to yours Postgres DB, you will see an INFO # containing a “Connection Successful” message in it, so now we are good to go.

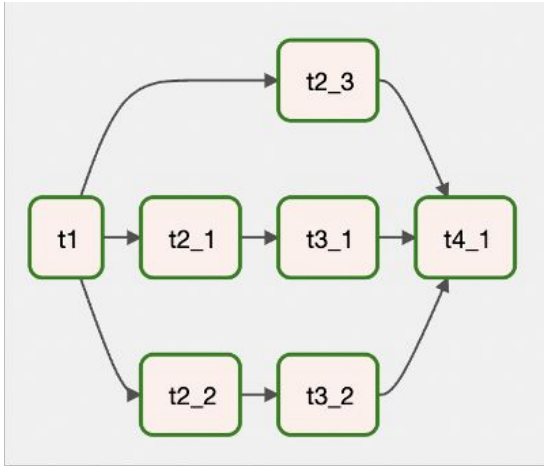
4. Close the webserver and scheduler; Init your Airflow DB:

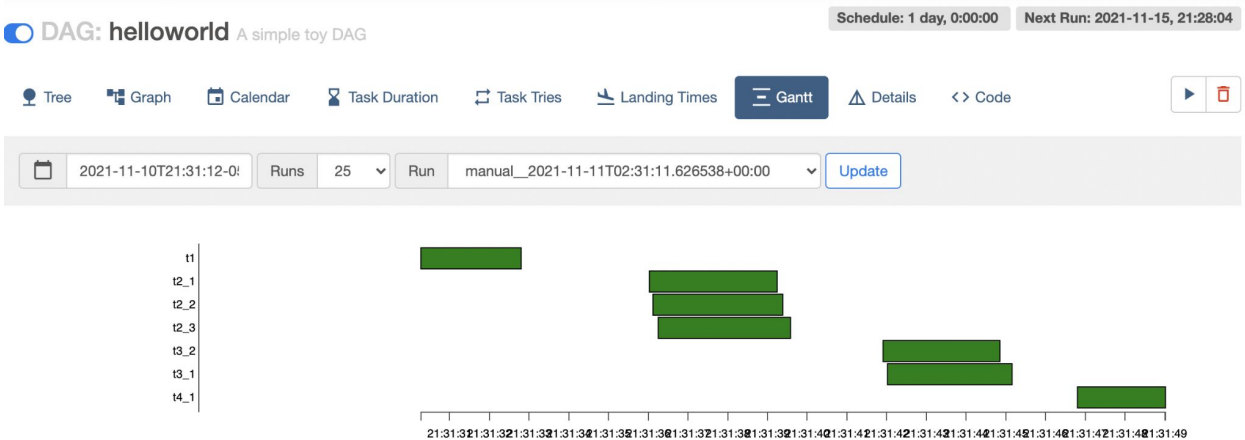
In your terminal

airflow db init

5. Create new user and restart the webserver and scheduler as shown in page 18 and 19; and login on the web browser

LocalExecutor





Take home

- DAG
- Scheduler
- Executor
- Database
- Operator

- Cross communication between tasks
- Schedule a job !! start data and schedule interval

Homework

Three tasks

- Helloworld
- Build workflows
- Written parts

Task 1 Helloworld

Q1.1 Install Airflow (20 pts)

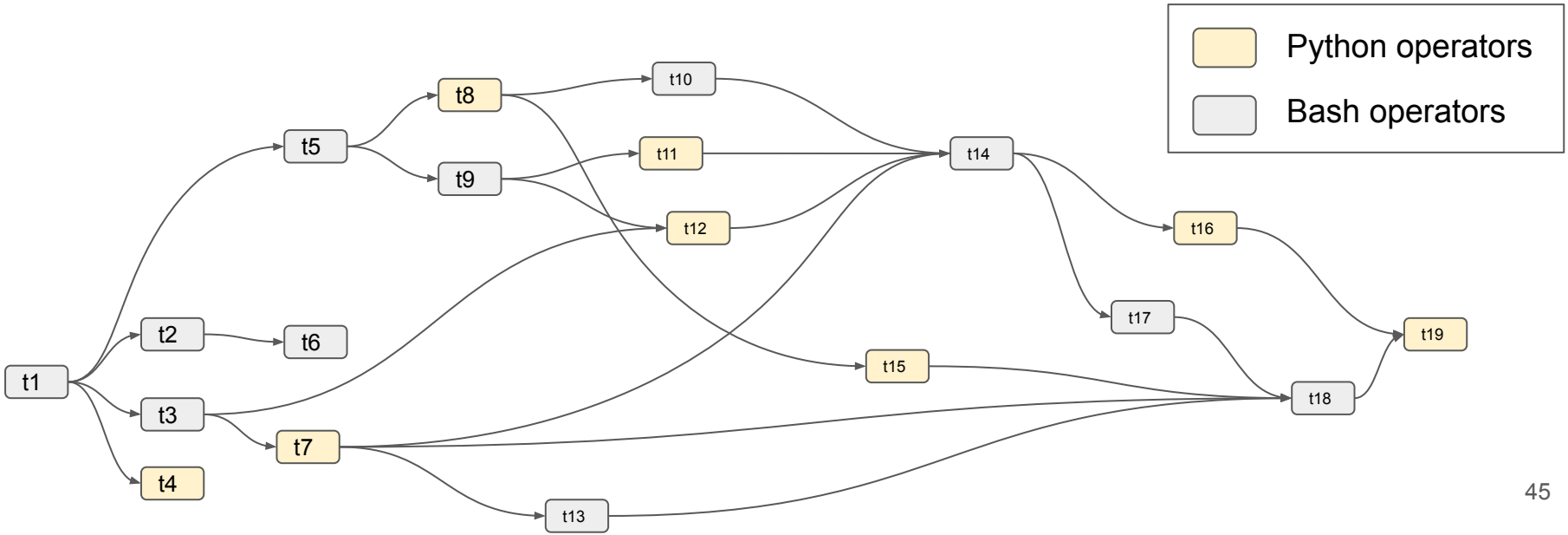
Q1.2 Run helloworld (15 pts)

- SequentialExecutor (5 pts)
- LocalExecutor (5 pts)
- Explore other features and visualizations you can find in the Airflow UI. Choose two features/visualizations to explain their functions and how they help monitor and troubleshoot the pipeline, use helloworld as an example. (5 pts)

Task 2 Build workflows

Q2.1 Implement this DAG (25 pts)

- Tasks and dependencies (10 pts)
- Manually trigger it (10 pts)
- Schedule the first run immediately and running the program every 30 minutes (5 pts)



Task 2 Build workflows

Q2.2 Stock price fetching, prediction, and storage every day (25 pts)

- Schedule fetching the stock price of [AAPL, GOOGL, FB, MSFT, AMZN] at 7:00 AM everyday.
- Preprocess data if you think necessary
- Train/update 5 linear regression models for stock price prediction for these 5 corporates. Each linear model takes the “open price”, “high price”, “low price”, “close price”, “volume” of the corporate in the past ten days as the features and predicts the “high price” for the next day.
- Everyday if you get new data, calculate the relative errors, i.e., (prediction yesterday - actual price today) / actual price today, and update the date today and 5 errors into a table, e.g., a csv file.

```python
import yfinance as yf

ticker = 'AAPL'
aapl = yf.Ticker(ticker)
hist = aapl.history(period='max')
print(type(hist))
print(hist.shape)
print(hist)
```

```
<class 'pandas.core.frame.DataFrame'>
(10317, 7)
                Open        High         Low       Close     Volume  \
Date
1980-12-12    0.100453    0.100890    0.100453    0.100453  469033600
1980-12-15    0.095649    0.095649    0.095213    0.095213  175884800
1980-12-16    0.088661    0.088661    0.088224    0.088224  105728000
1980-12-17    0.090408    0.090845    0.090408    0.090408   86441600
1980-12-18    0.093029    0.093466    0.093029    0.093029   73449600
...                ...         ...         ...         ...        ...
2021-11-04  151.359097  152.207849  150.420465  150.740005   60394600
2021-11-05  151.889999  152.199997  150.059998  151.279999   65414600
2021-11-08  151.410004  151.570007  150.160004  150.440002   55020900
2021-11-09  150.199997  151.429993  150.059998  150.809998   56787900
2021-11-10  150.020004  150.130005  147.850006  147.919998   65076700
```

Task 3 Written parts

Q3.1 Answer the question (5 pts)

- What are the pros and cons of SequentialExecutor, LocalExecutor, CeleryExecutor, KubernetesExecutor?

Q3.2 Draw the DAG of your group project (10 pts)

- Formulate it into at least 5 tasks
- Task names (functions) and their dependencies
- How do you schedule your tasks?

References

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

https://cloud.google.com/composer/docs