
BBC
Clearing Airflow obstructions
@tati_alchueyr
Principal Data Engineer @ BBC Datalab
Airflow Summit 2021
Online
15 July 2021

Heads up!

- During this **session** there will be some **quizzes**

- Be prepared to either:
  - **Scan** the **QR code**
  - **Access** using the **URL**

@tati_alchueyr.__doc__

- **Brazilian** living in London since 2014
- Principal Data **Engineer** at the **BBC Datalab** team
- Graduated in **Computer Engineering** at Unicamp
- **Passionate** software developer for **18 years**
- Experience in the **private** and **public** sectors
- Developed software for **Medicine**, **Media** and **Education**

- Loves **Open Source**
- Loves **Brazilian Jiu Jitsu**
- Proud mother of **Amanda** (v4.0)

I ❤ Airflow **Community** & **Summit**

Tomek Urbaszek

Jarek Potiuk

Kaxil Naik

Ash Berlin-Taylor

Leah Cole

BBC.Datalab.Hummingbirds

The work presented here is the result of lots of **teamwork** within **one squad** of a much **larger team** and **organisation**

Darren Mundy

David Hollands

Richard Bownes

Tatiana Al-Chueyr

active squad team members

directly contributed in the past

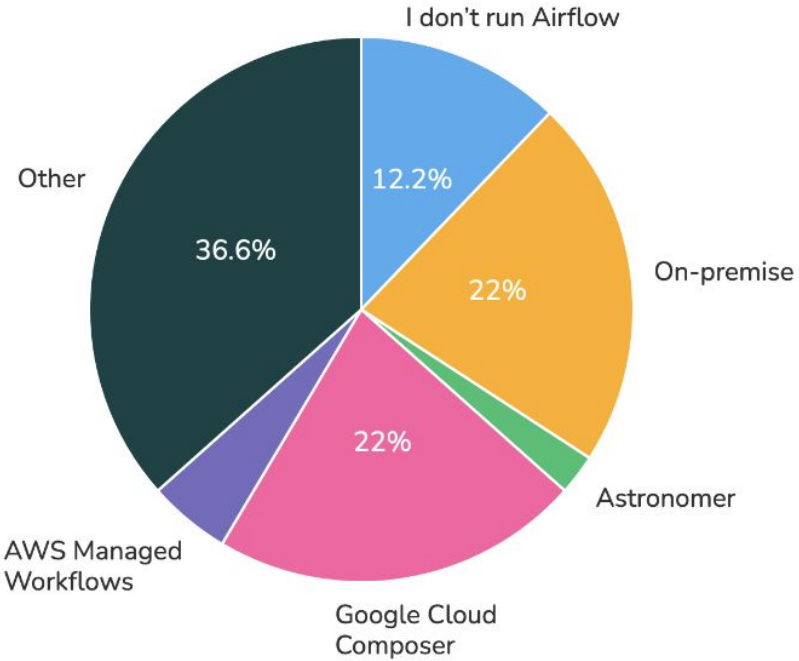
Bettina Hermant

Marc Oppenheimer

Quiz time how do you run Airflow?

A. I don’t run Airflow
B. On-premise
C. Astronomer.io
D. Google Cloud Composer
E. AWS Managed Workflows
F. Other

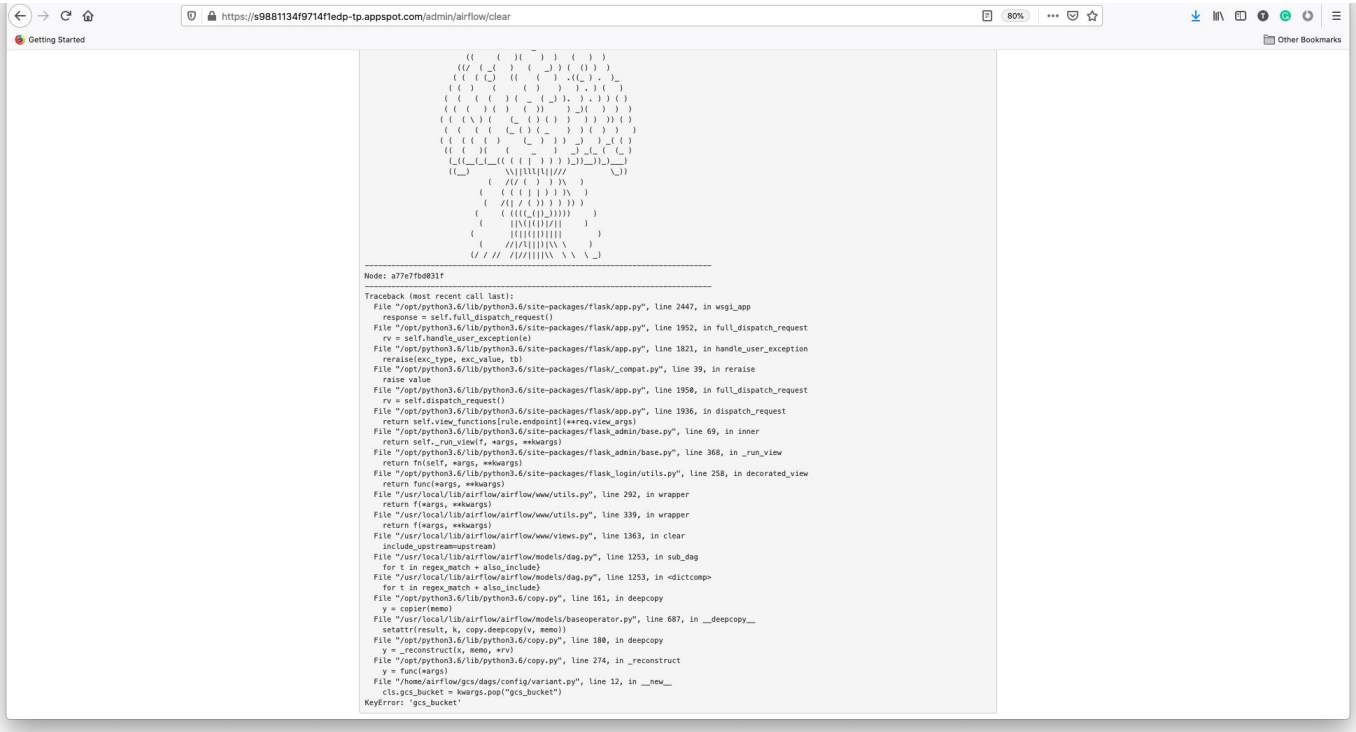
Quiz time how do you run Airflow?



* responses from Airflow Summit 2021 participants, during the presentation

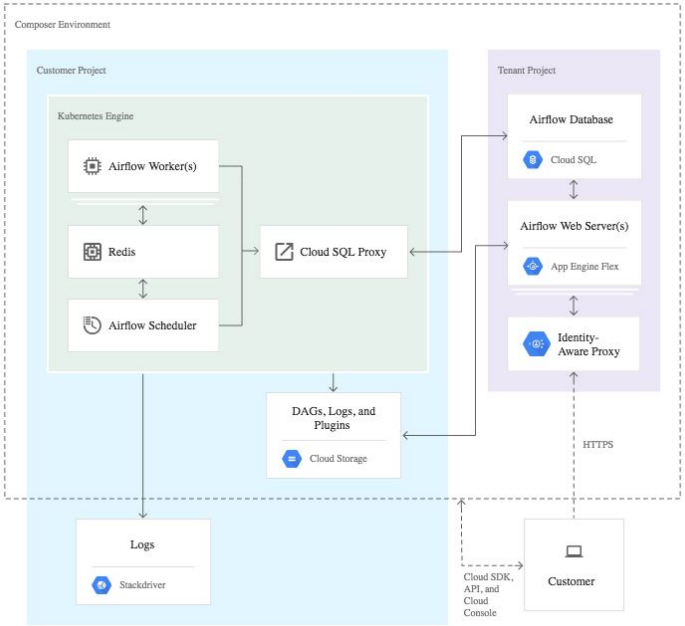

How we use Airflow
when things went wrong

How we use Airflow when things go wrong



How we use Airflow **infrastructure**

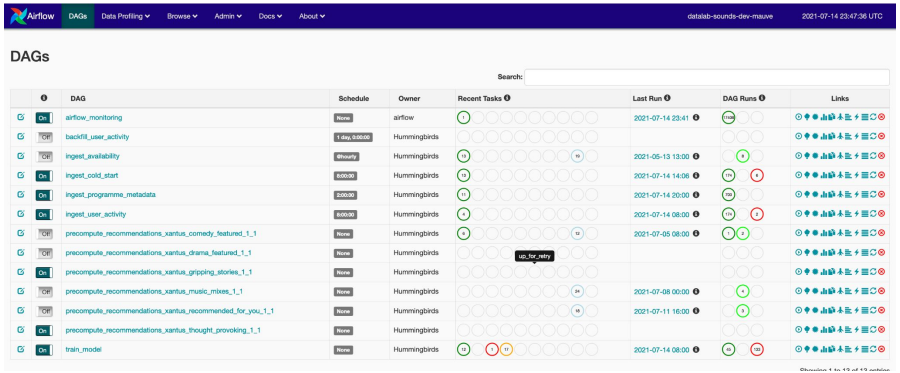
- **Managed** Airflow
  - Cloud Composer (GCP)
  - Terraform
- **Celery Executors** GCP constraint
  - Running within Kubernetes (GKE)
- **Outdated** version **1.10.12**
  - Upgrades have been time consuming
    - Last: 1.10.4 => 1.10.12 @ Dec ‘20
  - GCP supports newer releases
    - 1.10.5 since April ‘21 (March ‘21)
    - 2.0.1 since May ‘21 (Feb ‘21)

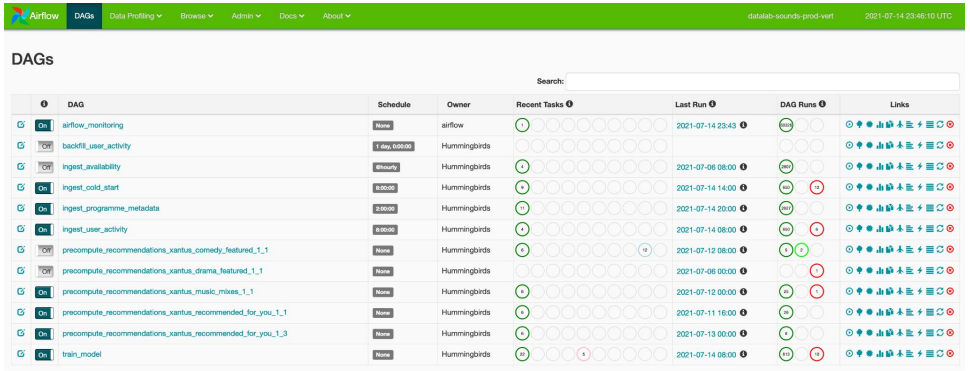


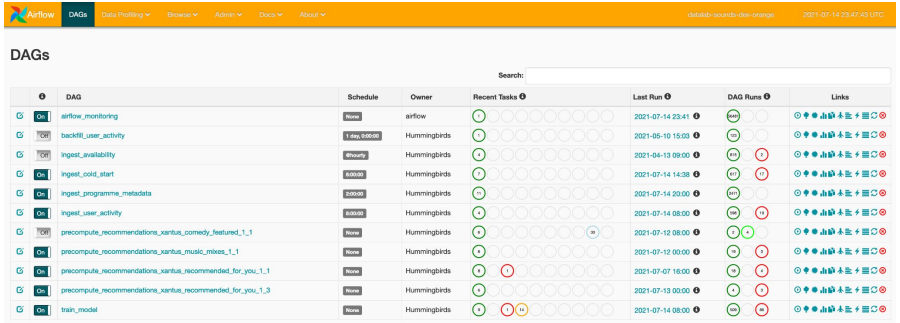
How we use Airflow **operators**

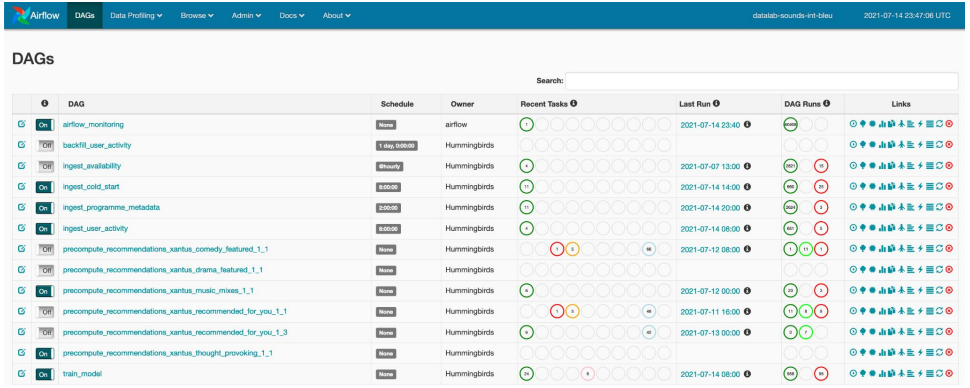
- Execute within **Airflow executors**
  - BaseOperator
  - BashOperator
  - DummyOperator
  - **PythonOperator**
  - ShortCircuitOperator
  - **TriggerDagRunOperator**
  - GCSDeleteObjectsOperator
- Delegate to **Kubernetes** in a dedicated GKE cluster
  - **GKEPodOperator**
- Delegate to **Apache Beam** (Dataflow)
  - **DataflowPythonOperator**
  - DataflowCreatePythonJobOperator

How we use Airflow local, dev, int, prod



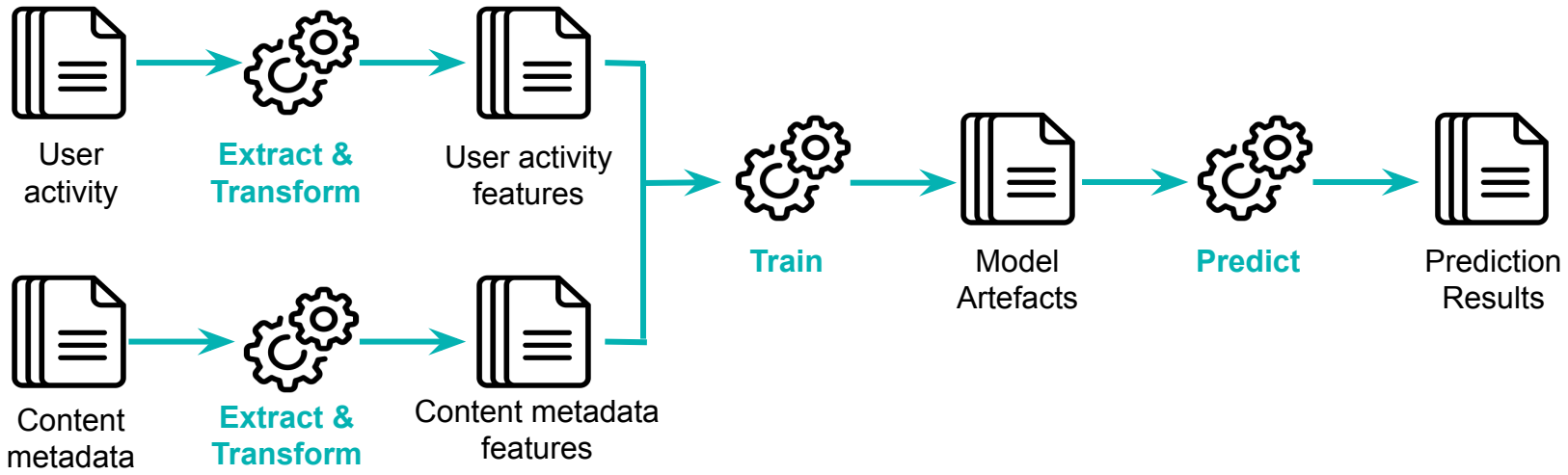




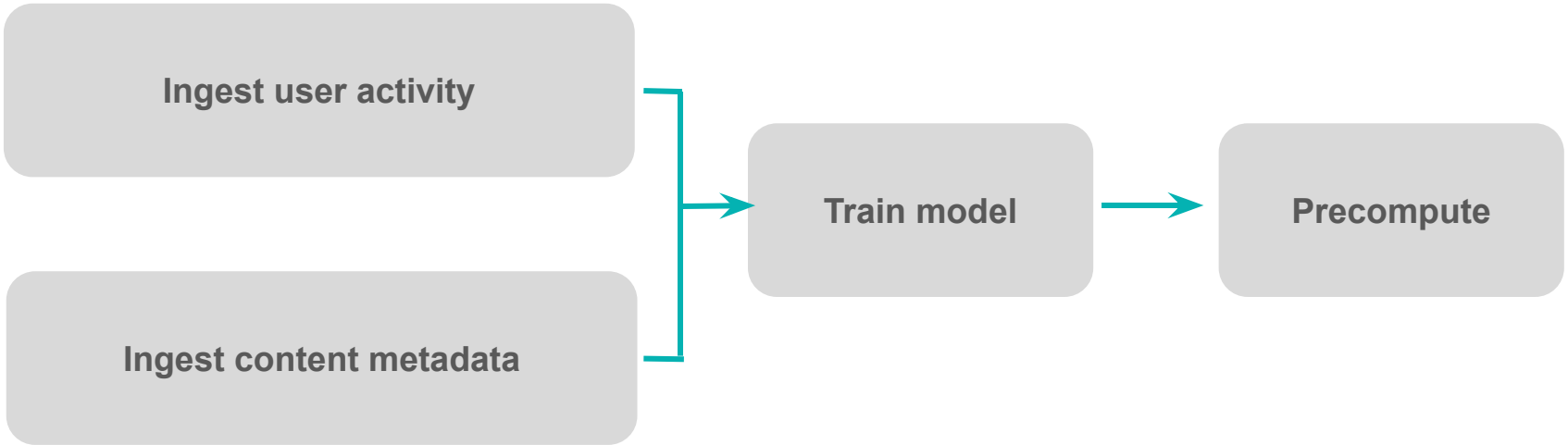


How we use Airflow **application**

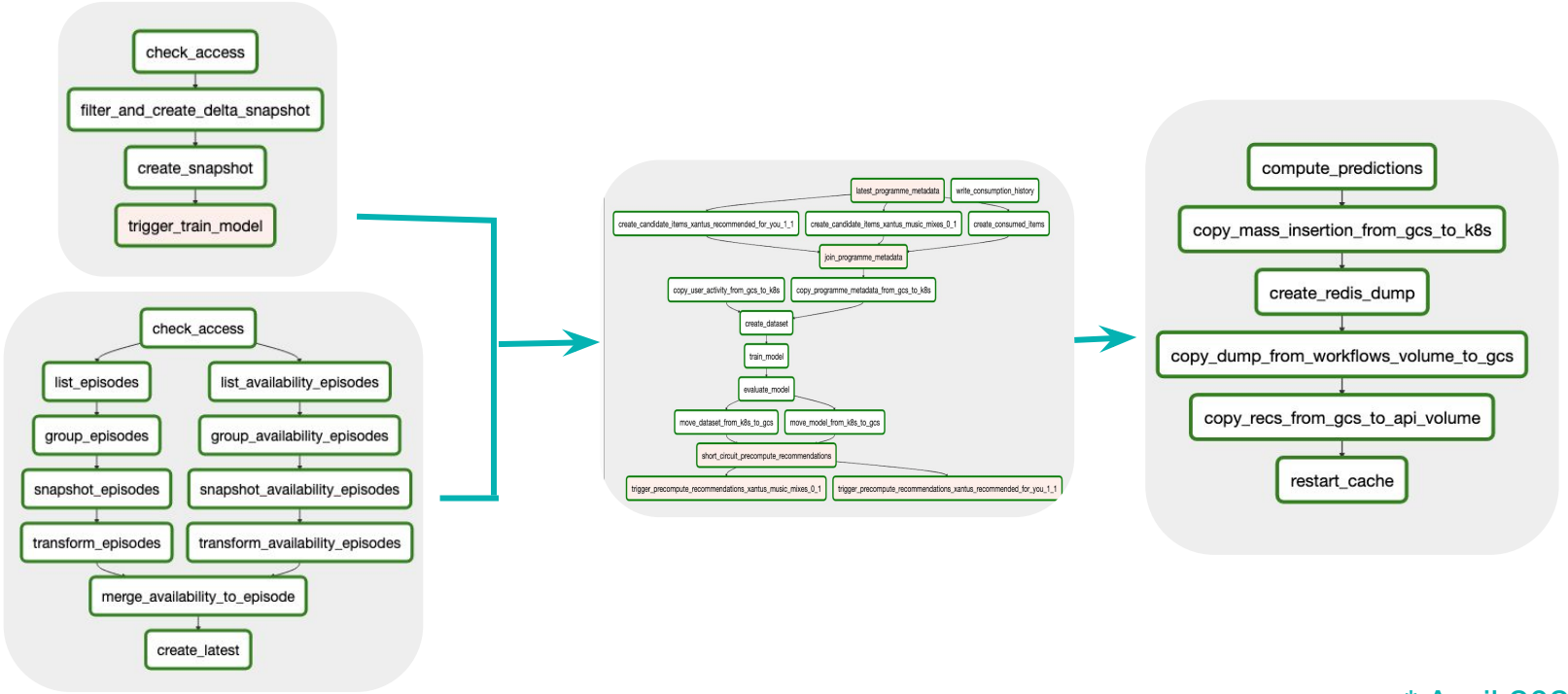
- Data integration: **ETL** (extract, transform, load)
- **Machine learning**: training and precomputation



How we use Airflow application



How we use Airflow **application**



* April 2021

Quiz time which is our most stable **DAG**?

A. Ingest & transform Content Metadata

B. Ingest & transform User Activity

C. Train model

D. Precompute recommendations

Quiz time which is our most stable **DAG**? tips

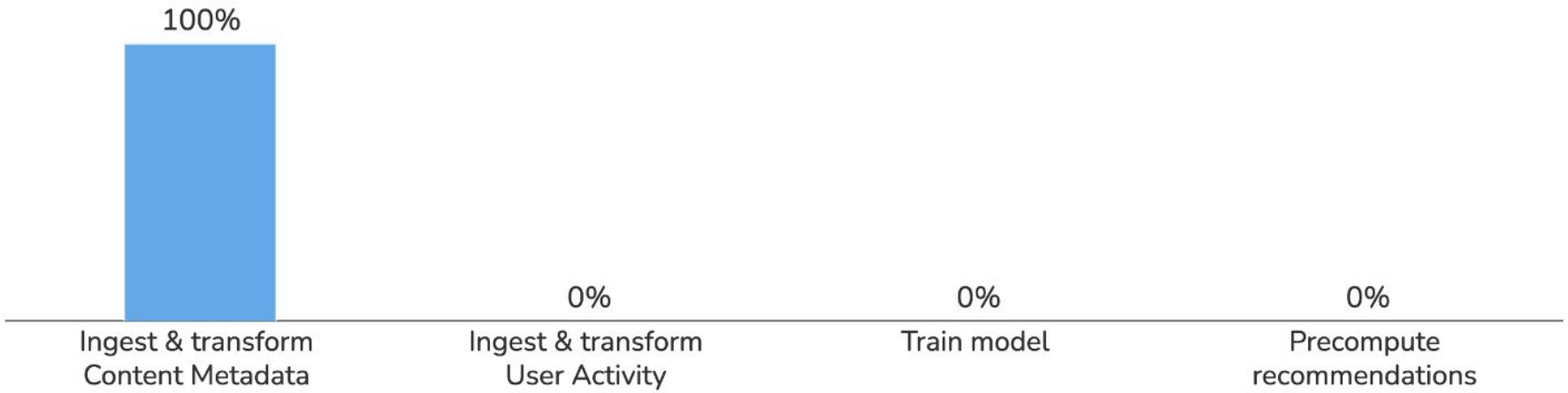
A. Ingest & transform Content Metadata **Python Operator**
   - ~ 225k records
   - Transforms ~12 GB => 57 MB

B. Ingest & transform User Activity **Dataflow Operator**
   - ~ 3.5 million records
   - Output: ~ 2 GB

C. Train model **Kubernetes Operator**
   - Output: ~ 8 GB model & artefacts

D. Precompute recommendations **Dataflow Operator**
   - ~ 3.5 million records
   - Output: ~ 2.5 GB

Quiz time which is our most stable **DAG**? attendees



* responses from Airflow Summit 2021 participants, during the presentation

Quiz time which is our most stable DAG? answer

A. Ingest & transform Content Metadata
   - 2 live incidents

B. Ingest & transform User Activity
   - **1 live incident**

C. Train model
   - 2 live incidents

D. Precompute recommendations
   - 2 live incidents

* from October 2020 until April 2021

Quiz time which is our most stable **DAG**? details

A. Ingest & transform Content Metadata
   - Insufficient CPU
   - Spikes -> Timeouts (during higher volumes) / Continuing from where it stopped

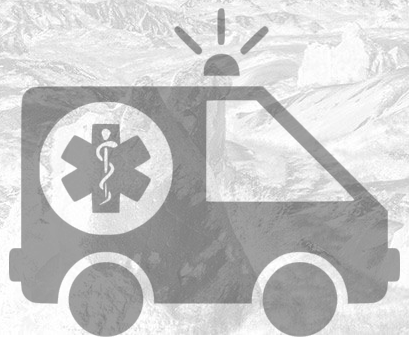
B. Ingest & transform User Activity
   - Idempotency issue

C. Train model
   - K8s Pod reattach
   - Scheduling leading to two tasks running concurrently

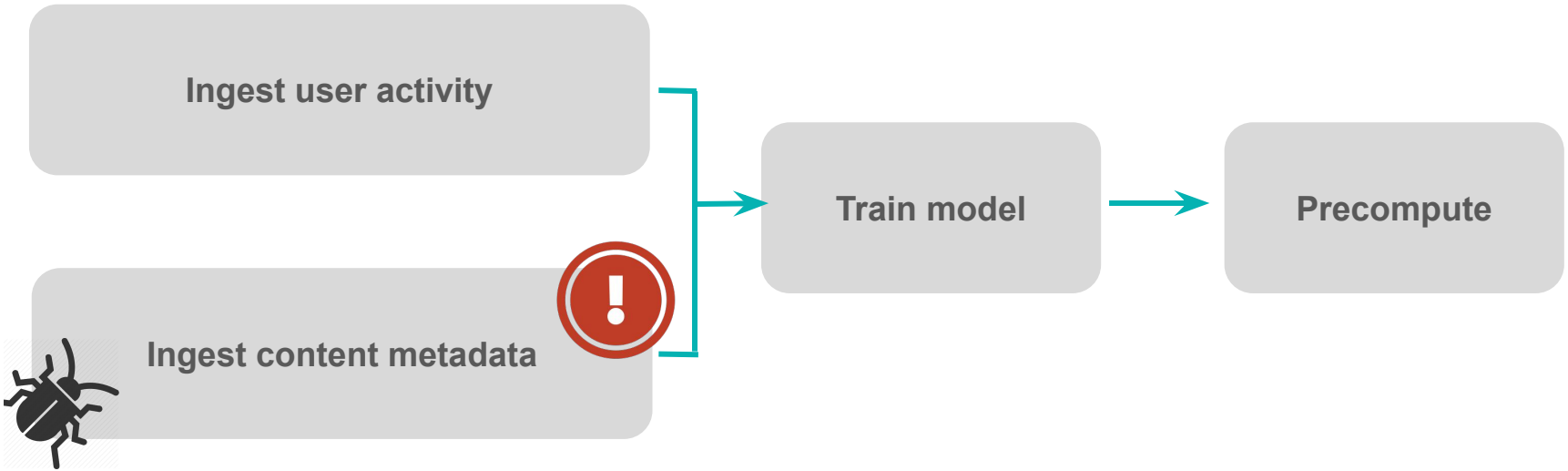
D. Precompute recommendations
   - Change to default job settings in Dataflow
   - GCS access limit
   - Non-stop Dataflow job

Removal of workflows obstructions

when things went wrong



Obstruction 1 The programme metadata chronic issue



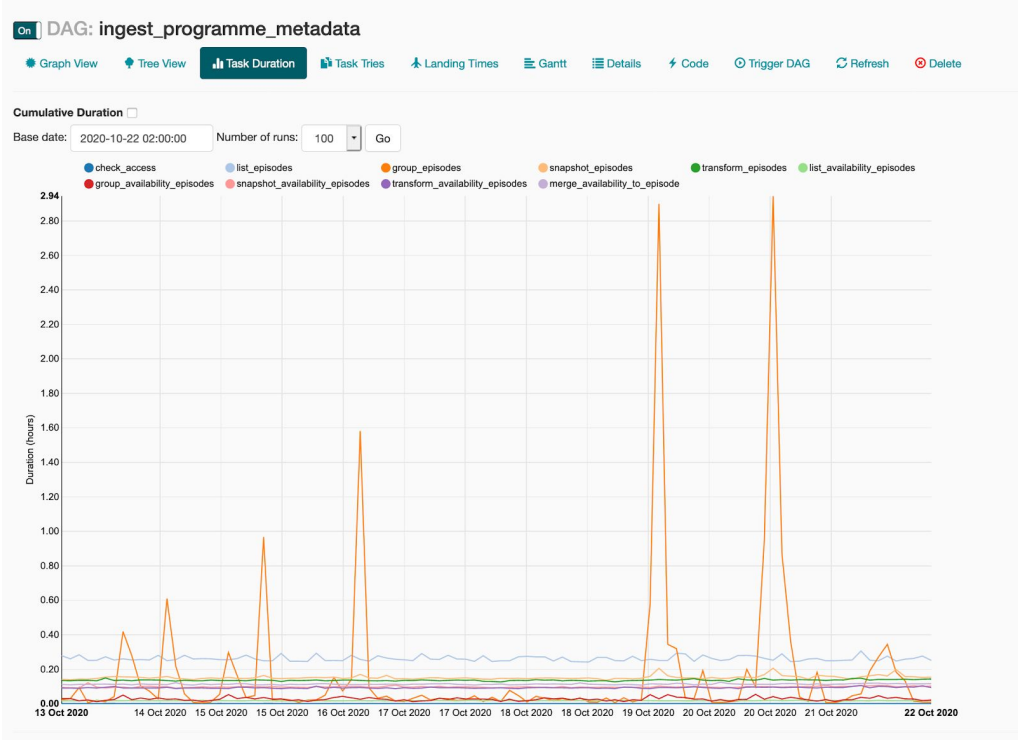
Obstruction 1 The programme metadata chronic issue

DAG's goals

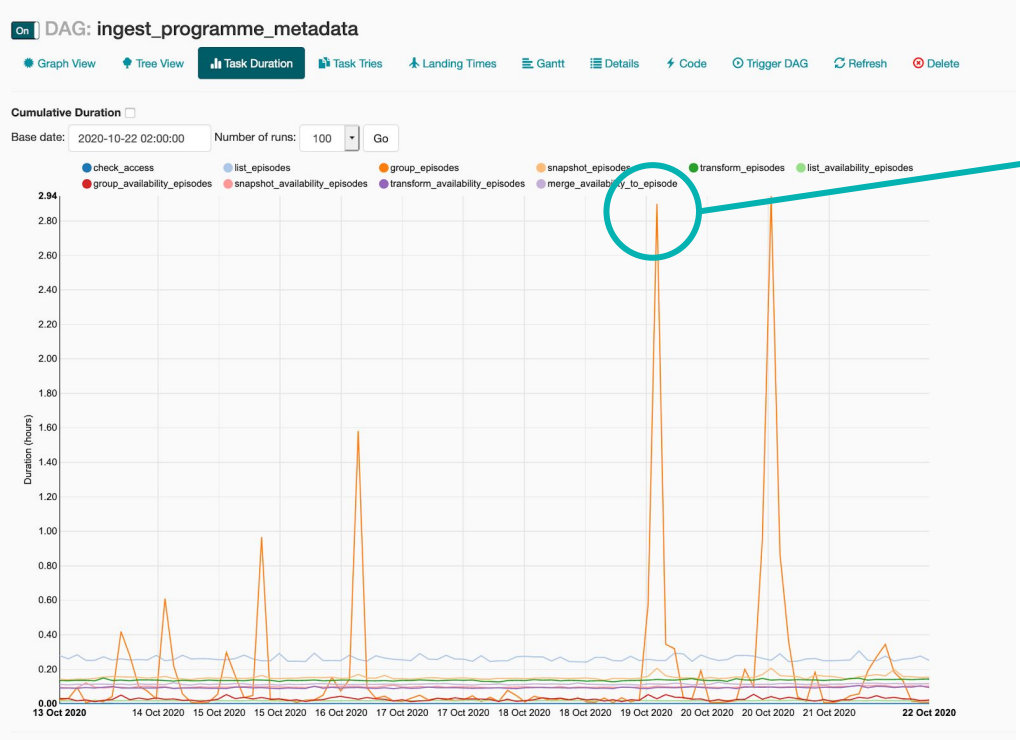
- Import objects from AWS S3 (protected by STS) into Google Cloud Storage
- Requirements: between dozens and thousands KB-sized objects
- Filter and enrich the metadata
- Merge multiple streams of data and create an up-to-date snapshot

Mostly implemented using subclasses of the Python Operator class

Obstruction 1 The programme metadata chronic issue



Obstruction 1 The programme metadata chronic issue



Issue

Depending on the volumes of data, a single **PythonOperator** task which usually takes **10 min** could take almost **3h**!

Consequences

Delay

Blocked Airflow executor

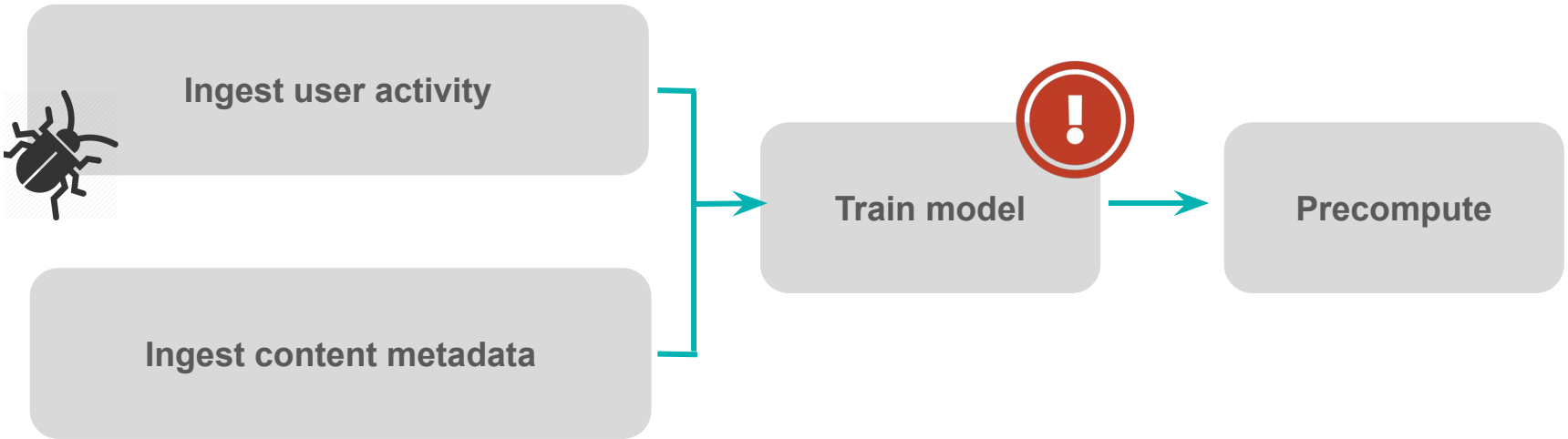
Solutions

Increase timeouts

Improve machine type

Delegate processing to another service

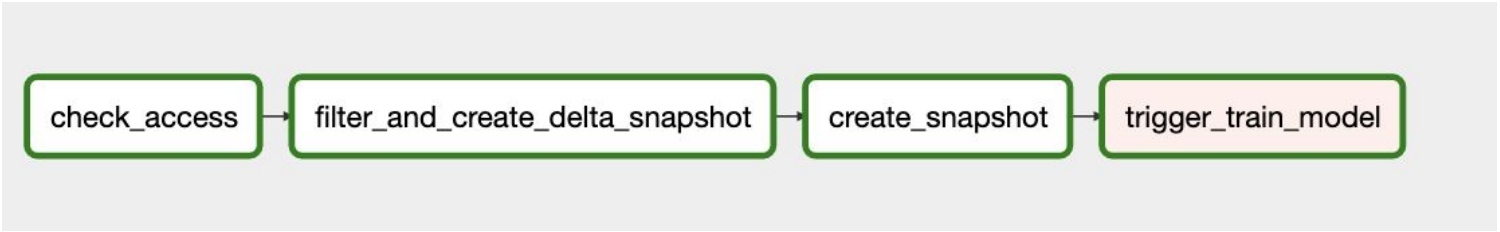
Obstruction 2 When the user activity workflow failed



Obstruction 2 When the user activity workflow failed

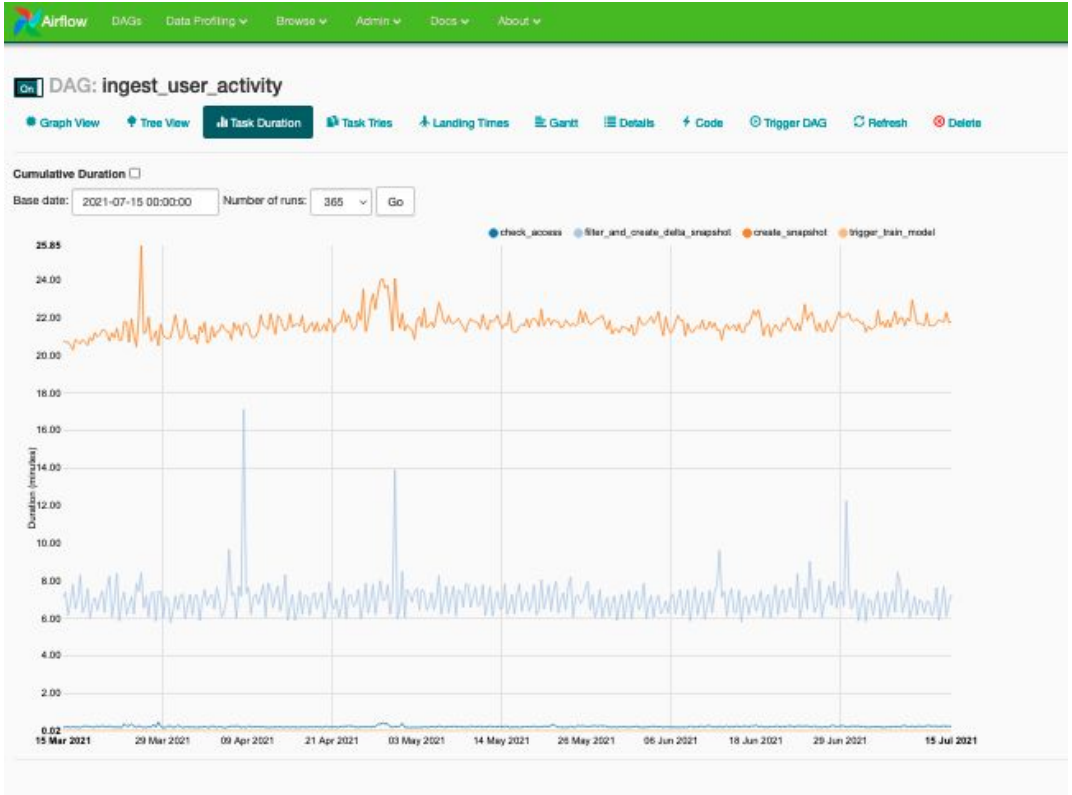
DAG's goals

- Read from user activity Parquet files in Google Cloud Storage
- Filter relevant activity and metadata
- Export a snapshot for the relevant interval of time
- Requirements: millions of records in MB-sized files



Mostly implemented using subclasses of the Dataflow Operator class

Obstruction 2 When the user activity workflow failed



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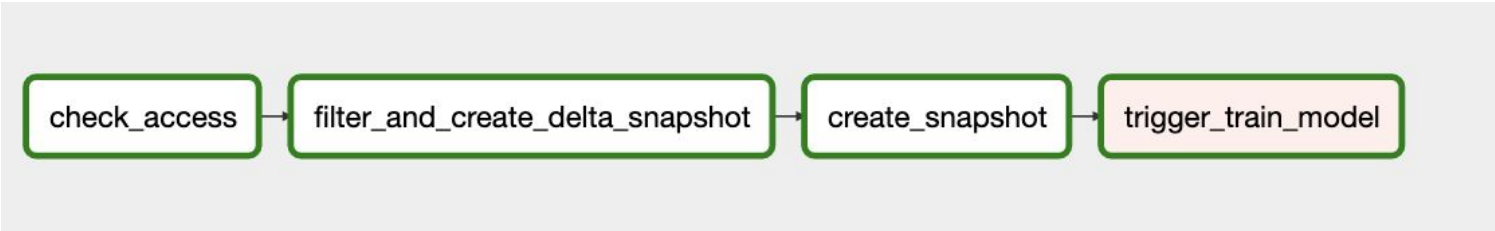
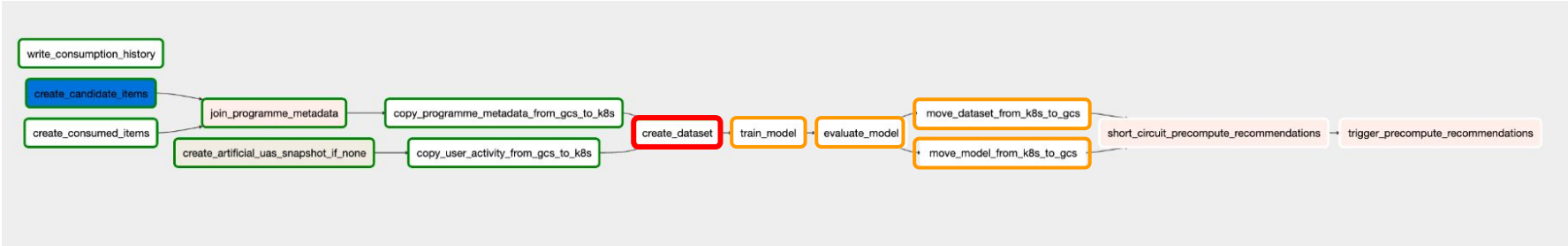
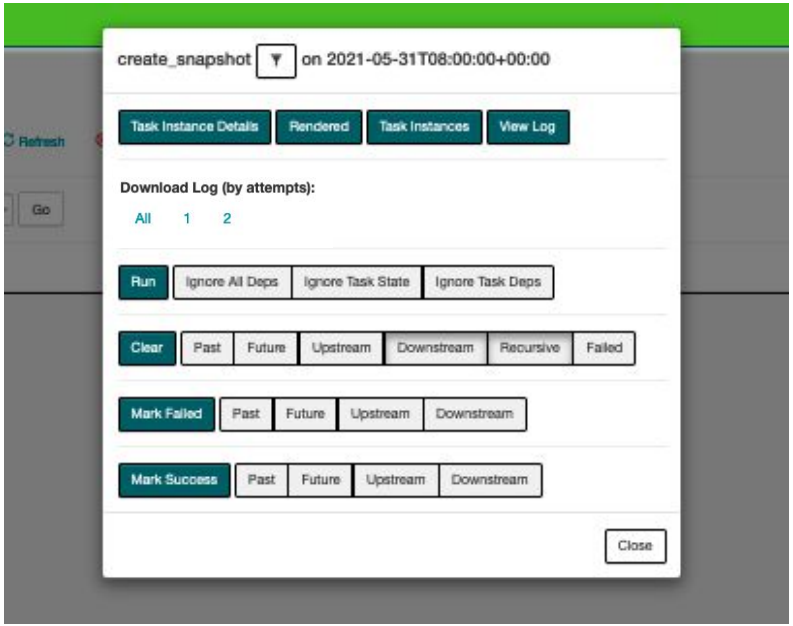




Obstruction 2 When the user activity workflow failed

Troubleshooting

- The volume of user activity meant to train the model had **doubled**!



Obstruction 2 When the user activity workflow failed

What happened

- Dataflow took longer than expected to run a job triggered by Airflow
- Airflow retried
- Both jobs completed successfully - and output the data in the same directory!
- The setup to train the model didn’t expect to handle such spike it the volume of data and failed

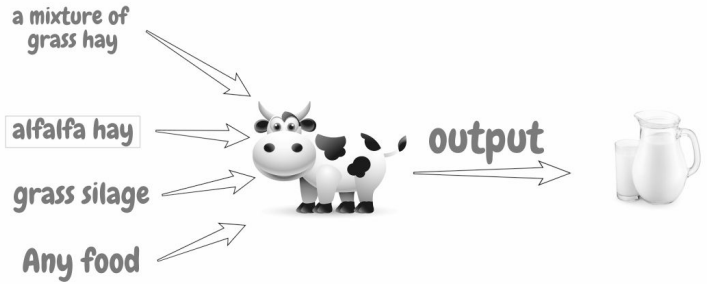
Obstruction 2 When the user activity workflow failed

What happened

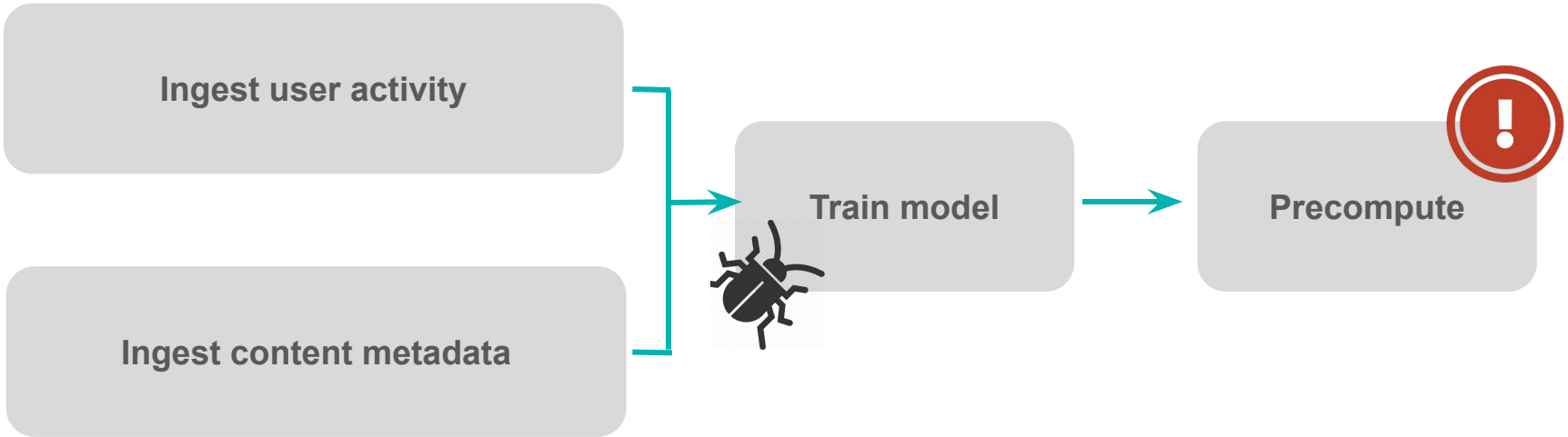
- Dataflow took longer than expected to run a job triggered by Airflow
- Airflow retried
- Both jobs completed successfully - and output the data in the same directory!
- The setup to train the model didn’t expect to handle such spike it he volume of data and failed

Solution

- Have idempotent tasks
- Clear the target path before processing a task



Obstruction 3 When precompute failed due to training



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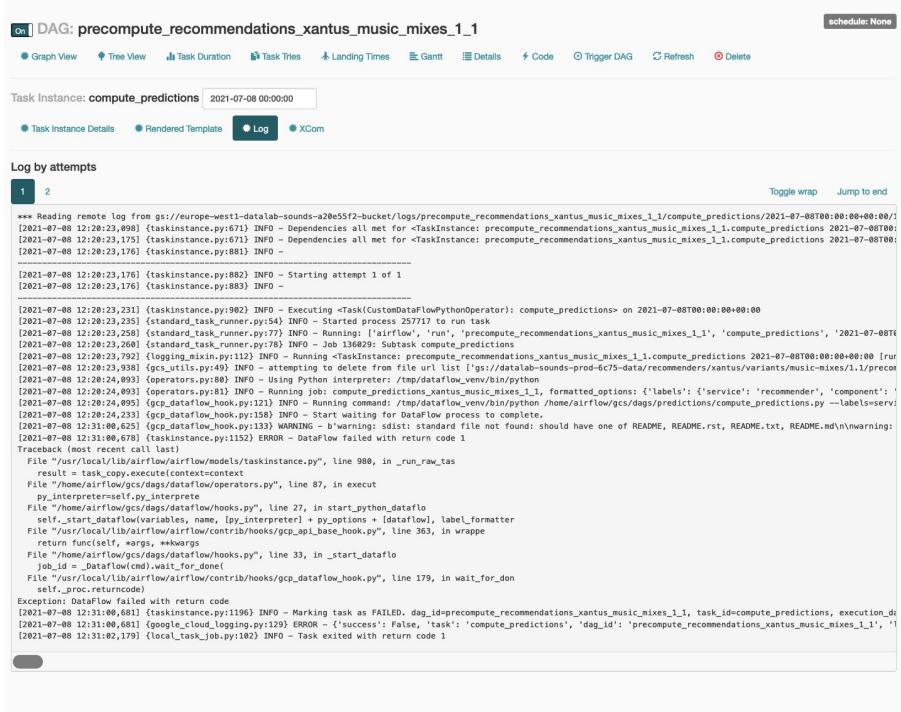
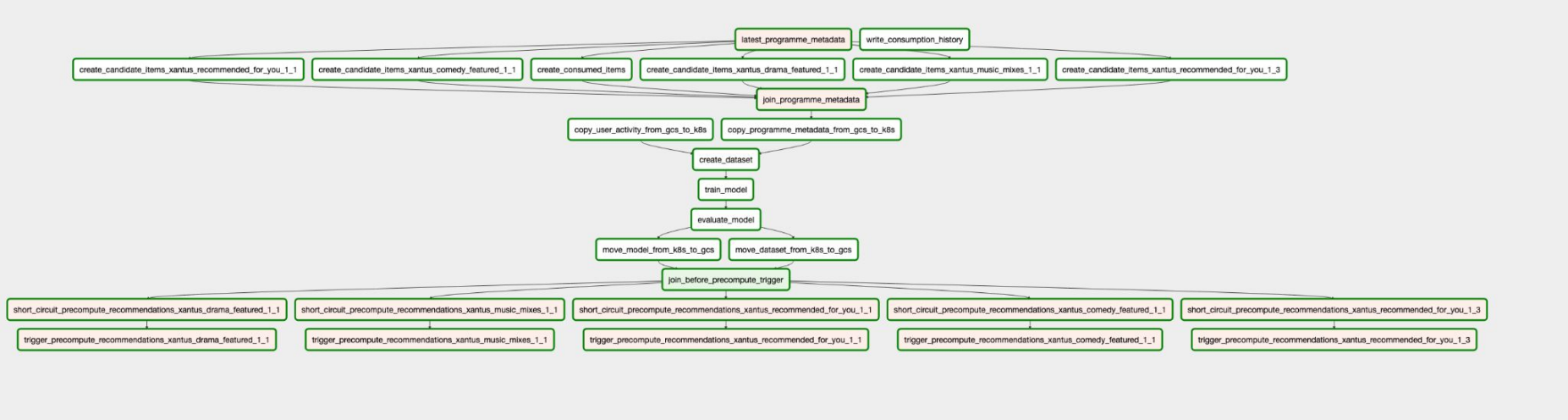
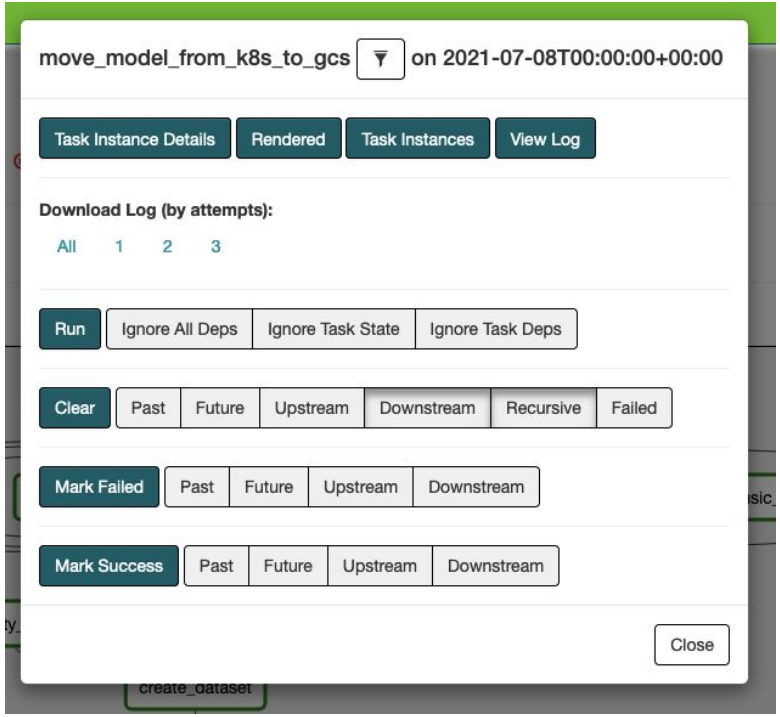



```
"message": "No such object:
datalab-sounds-prod-6c75-data/recommenders/xa
ntus/model/2021-07-08T00:00:00+00:00/xantus.p
kl"
```

Obstruction 3 When precompute failed due to training



Obstruction 3 When precompute failed due to training



Obstruction 3 When precompute failed due to training

[2021-07-08 12:15:55,278] {logging_mixin.py:112} INFO - Running <TaskInstance: train_model.move_model_from_k8s_to_gcs 2021-07-08T00:00:00+00:00 [running]> on host airflow-worker-867b96c854-jzqw7

[2021-07-08 12:15:55,422] {gcp_container_operator.py:299} INFO - Using gcloud with application default credentials.
[2021-07-08 12:15:57,286] {pod_launcher.py:173} INFO - Event: move-model-to-gcs-3deac821b57047619c1c9505ddc5db18 had an event of type Pending

[2021-07-08 12:15:57,286] {pod_launcher.py:139} WARNING - Pod not yet started: move-model-to-gcs-3deac821b57047619c1c9505ddc5db18

[2021-07-08 12:17:57,499] {taskinstance.py:1152} ERROR - Pod Launching failed: Pod Launching failed: Pod took too long to start

[2021-07-08 12:18:59,584] {pod_launcher.py:156} INFO - b'gsutil -m rm gs://datalab-sounds-prod-6c75-data/recommenders/xantus/model/2021-07-08T00:00:00+00:00/xantus.pkl || true\n'

[2021-07-08 12:18:59,911] {pod_launcher.py:156} INFO - b'gsutil -m mv /data/recommenders/xantus/model/2021-07-08T00:00:00+00:00/xantus.pkl (...)

[2021-07-08 12:19:35,295] {pod_launcher.py:156} INFO - b'Operation completed over 1 objects/4.7 GiB.
\n'

[2021-07-08 12:19:35,536] {pod_launcher.py:156} INFO - b'rm -rf /data/recommenders/xantus/model/2021-07-08T00:00:00+00:00/xantus.pkl\n'

[2021-07-08 12:19:36,687] {taskinstance.py:1071} INFO - Marking task as SUCCESS.dag_id=train_model,

Obstruction 3 When precompute failed due to training

```
$ kubectl logs move-model-to-gcs-a0b5193a42e040aaa37b3ad82953ee29 -n xantus-training
 gsutil -m rm gs://datalab-sounds-prod-6c75-data/recommenders/xantus/model/2021-07-08T00:00:00+00:00/xantus.pkl || true
 CommandException: 1 files/objects could not be removed.
 gsutil -m mv /data/recommenders/xantus/model/2021-07-08T00:00:00+00:00/xantus.pkl
 gs://datalab-sounds-prod-6c75-data/recommenders/xantus/model/2021-07-08T00:00:00+00:00/xantus.pkl
 Copying file:///data/recommenders/xantus/model/2021-07-08T00:00:00+00:00/xantus.pkl [Content-Type=application/octet-stream]...



 Removing file:///data/recommenders/xantus/model/2021-07-08T00:00:00+00:00/xantus.pkl...
 | [1/1 files][  4.7 GiB/  4.7 GiB] 100% Done 111.3 MiB/s ETA 00:00:00
 Operation completed over 1 objects/4.7 GiB.
 rm -rf /data/recommenders/xantus/model/2021-07-08T00:00:00+00:00/xantus.pkl
```

Obstruction 3 When precompute failed due to training

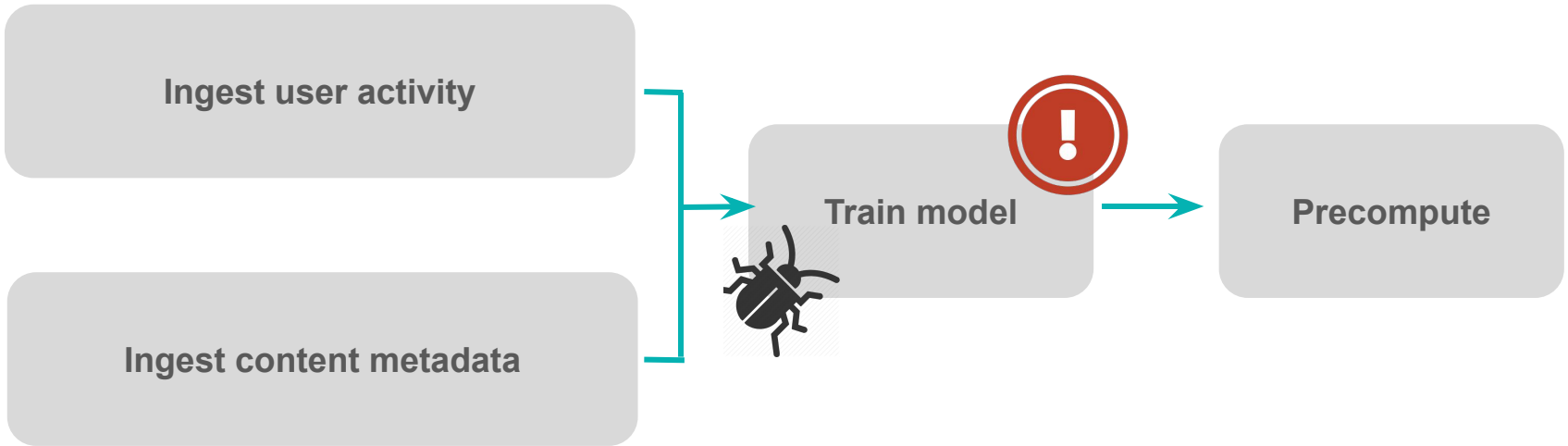
What happened

- The GKE node pool, where jobs were executed, was struggling
- Airflow Kubernetes Operator timed out after a long time waiting (Kubernetes didn’t know)
- A new task retry was triggered
- Both pods run concurrently and due to how we implemented idempotency, the data was deleted - but the last task retry was successful

Solution

- Use newer version of the KubernetesPodOperator
- Confirm by the end of the task that the desired artefact exists

Obstruction 4 Intermittent DAG after an Airflow upgrade

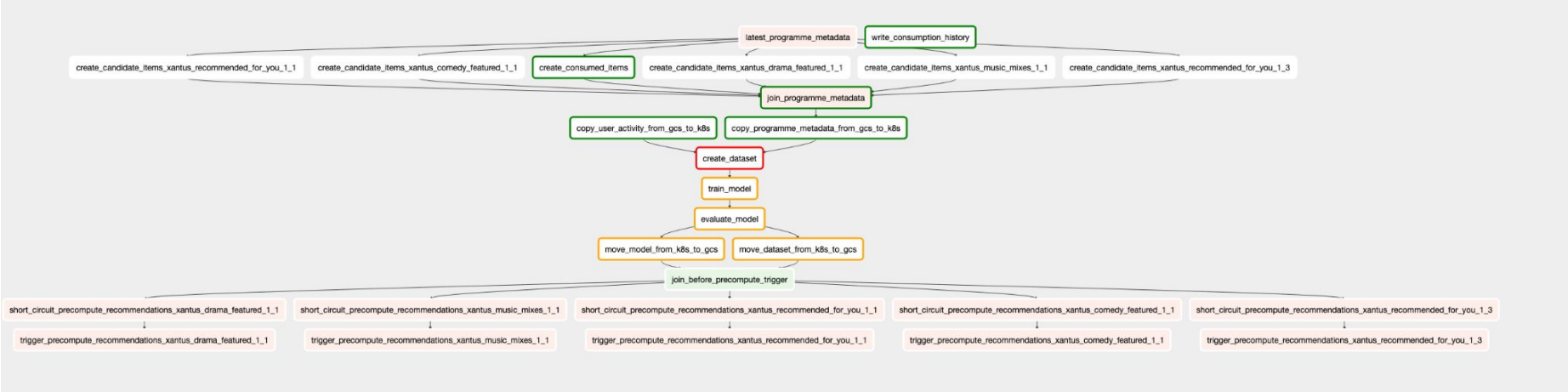


Obstruction 4 Intermittent DAG after an Airflow upgrade

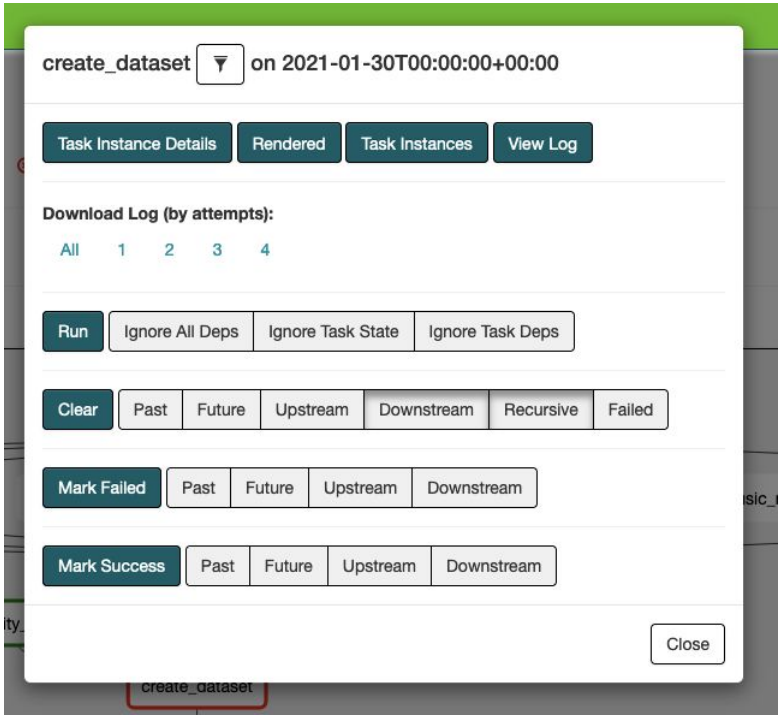
What happened

- After upgrading from Airflow 1.10.4 to 1.10.12 some KubenetesPodOperator tasks became intermittent
- Legit running pods failed
- The logs seemed to show that new jobs were trying to reattach to previously existing Pods and failed

Obstruction 4 Intermittent DAG after an Airflow upgrade



Obstruction 4 Intermittent DAG after an Airflow upgrade




```
HTTP response headers: HTTPHeaderDict({'Audit-Id':
'133bc1f2-388b-490c-bdc6-34053685d5ee', 'Content-Type':
'application/json', 'Date': 'Sat, 30 Jan 2021 09:11:33 GMT',
'Content-Length': '231'}
HTTP response body:
b'{"kind":"Status","apiVersion":"v1","metadata":{},"status":"Fail
ure","message":"container \\"base\\" in pod
\\"create-dataset-17a3b6f132e44544a836550be367c670\\" is
waiting to start:
ContainerCreating","reason":"BadRequest","code":400}\n

(...)
"/opt/python3.6/lib/python3.6/site-packages/kubernetes/client/
rest.py", line 231, in reques
    raise ApiException(http_resp=r
kubernetes.client.rest.ApiException: (400
Reason: Bad Request
```

Obstruction 4 Intermittent DAG after an Airflow upgrade

Solution

airflow.contrib.operators.kubernetes_pod_operator

Executes task in a Kubernetes POD

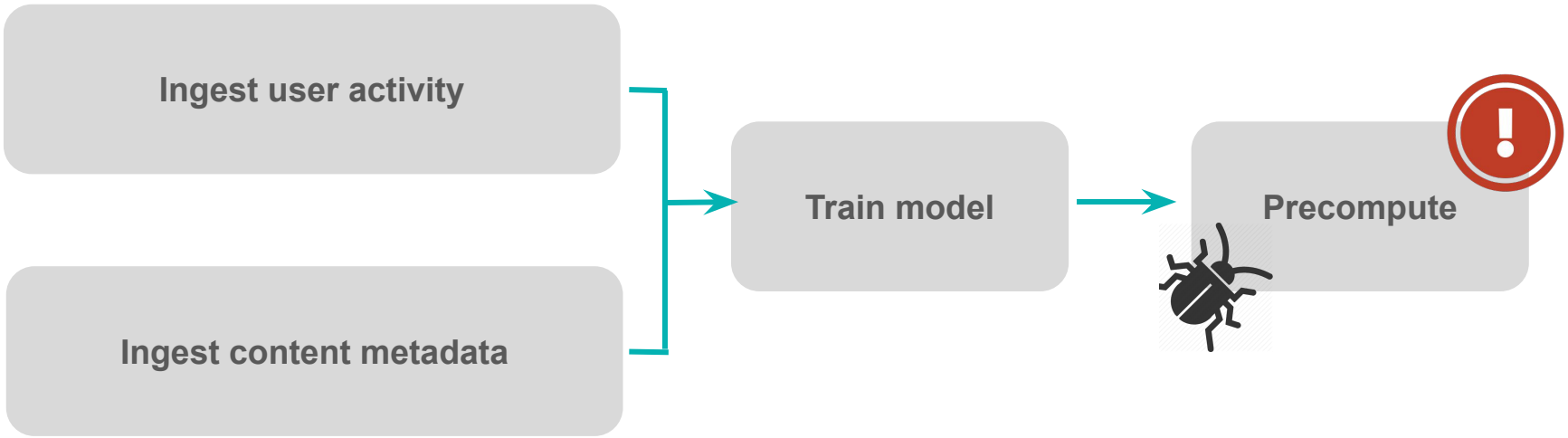
Module Contents

```
class airflow.contrib.operators.kubernetes_pod_operator.KubernetesPodOperator(namespace=None, image=None, name=None,
cmds=None, arguments=None, ports=None, volume_mounts=None, volumes=None, env_vars=None, secrets=None, in_cluster=None,
cluster_context=None, labels=None, reattach_on_restart=True, startup_timeout_seconds=120, get_logs=True,
image_pull_policy='IfNotPresent', annotations=None, resources=None, affinity=None, config_file=None, node_selectors=None,
image_pull_secrets=None, service_account_name='default', is_delete_operator_pod=False, hostnetwork=False,
tolerations=None, configmaps=None, security_context=None, pod_runtime_info_envs=None, dnspolicy=None, schedulername=None,
full_pod_spec=None, init_containers=None, log_events_on_failure=False, do_xcom_push=False, pod_template_file=None,
priority_class_name=None, *args, **kwargs)[source]
```

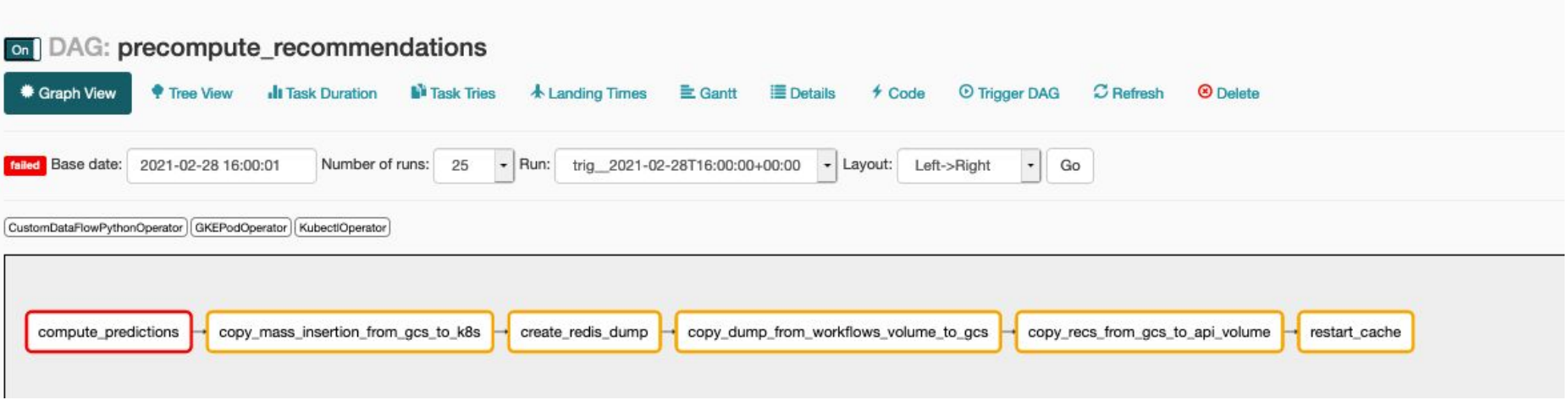
Bases: airflow.models.BaseOperator

https://airflow.apache.org/docs/apache-airflow/1.10.12/_api/airflow/contrib/operators/kubernetes_pod_operator/index.html

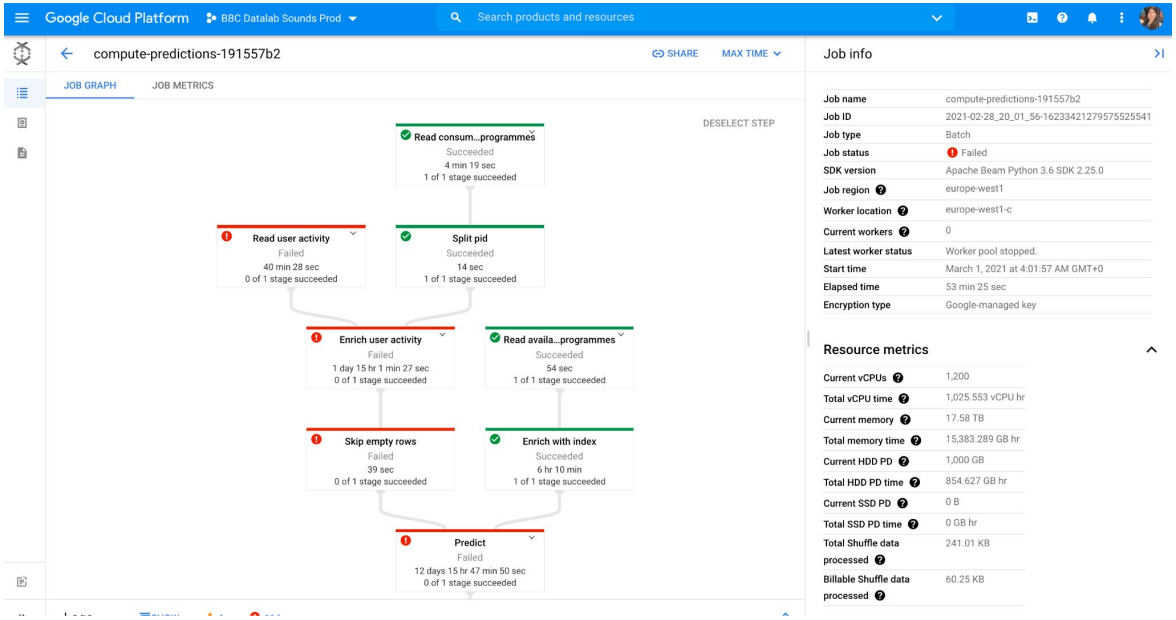
Obstruction 5 When the Dataflow job said no



Obstruction 5 When the Dataflow job said no



Obstruction 5 When the Dataflow job said no



OSError: [Errno 28] No space left on device During handling

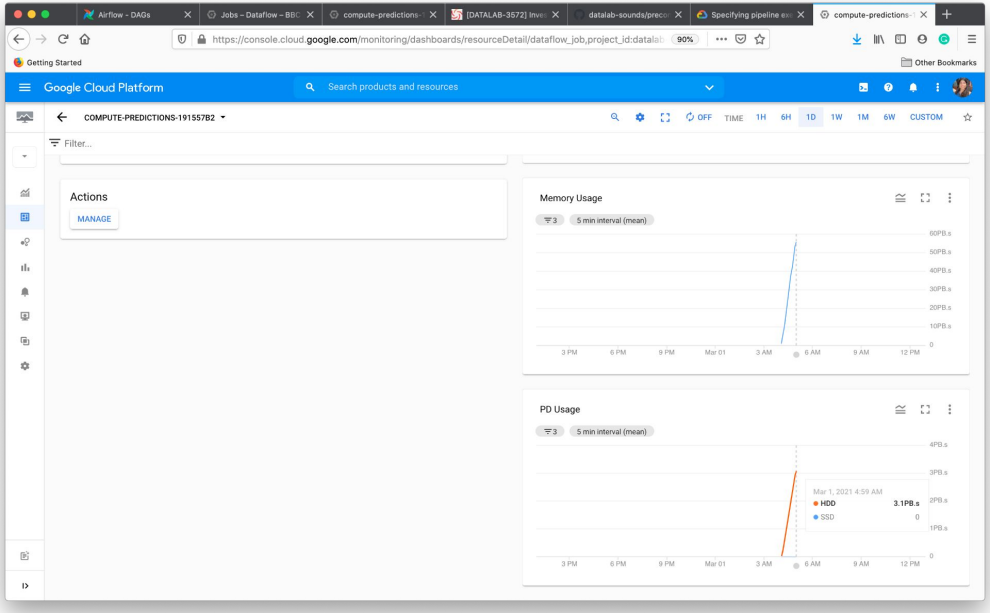
Obstruction 5 When the Dataflow job said no

	successful compute-predictions-21628eba 2021-02-24_20_06_12-17726452853028084617 25 February 2021	unsuccessful compute-predictions-191557b2 2021-02-28_20_01_56-16233421279575525541 1st March 2021
consumption-history/	1.87 GiB	1.88 GiB
consumed-items/	55.63 MiB	55.68 MiB
candidate-items/rfy/	25.06 MiB	25.09 MiB
xantus.pkl	4.67 GiB	4.69 GiB
item_features.npz	1.73 MiB	1.73 MiB
mapping.json	473.84 MiB	476.01 MiB

If a batch job uses Dataflow Shuffle, then the default is 25 GB; otherwise, the default is 250 GB.

https://cloud.google.com/dataflow/docs/guides/specifying-exec-params#python

Obstruction 5 When the Dataflow job said no



Job info

Job name	compute-predictions-21628eba
Job ID	2021-02-24_20_06_12-17726452853028084617
Job type	Batch
Job status	Succeeded
SDK version	Apache Beam Python 3.6 SDK 2.25.0
Job region	europe-west1
Worker location	europe-west1-b
Current workers	0
Latest worker status	Worker pool stopped.
Start time	February 25, 2021 at 4:06:14 AM GMT+0
Elapsed time	2 hr 13 min
Encryption type	Google-managed key

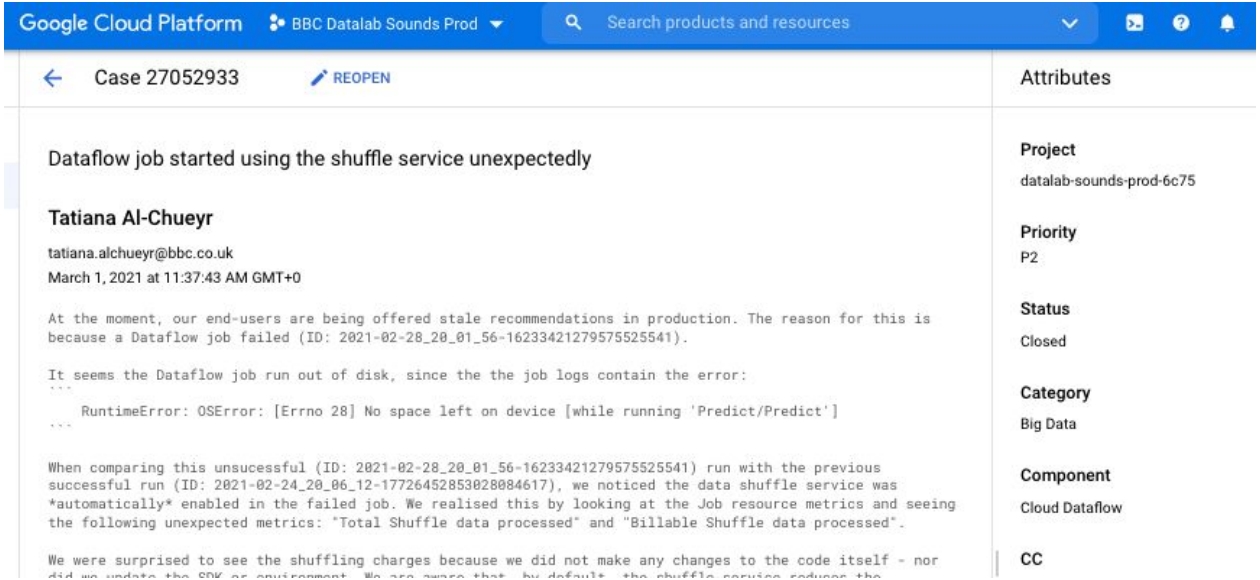
Resource metrics

Current vCPUs	1,200
Total vCPU time	2,633.094 vCPU hr
Current memory	17.58 TB
Total memory time	39,496.416 GB hr
Current HDD PD	9.77 TB
Total HDD PD time	21,942.453 GB hr
Current SSD PD	0 B
Total SSD PD time	0 GB hr

Labels

airflow-version	v1-10-12-composer

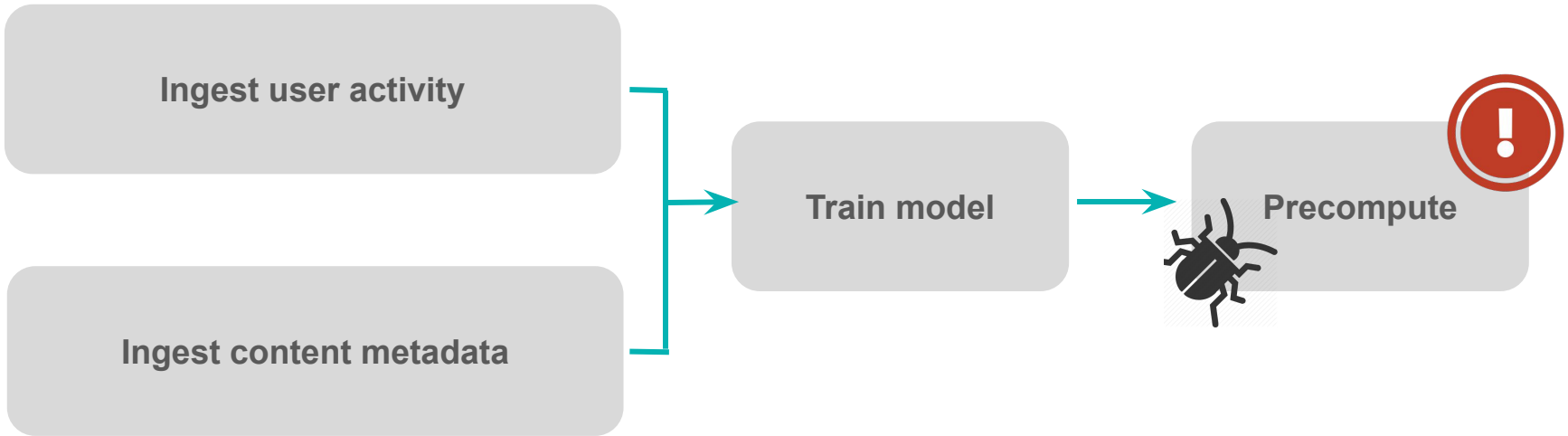
Obstruction 5 When the Dataflow job said no



Solution

```
--experiments=shuffle_mode=appliance
```

Obstruction 6 The never ending Dataflow job



Obstruction 6 The never ending Dataflow job

datalab_devops_int – Jun 14th

google cloud monitoring APP 6:46 PM

Incident #0.m3oacbpboewe is ongoing

> [Composer - datalab-sounds-int-bleu] Workflow failure
> Workflow Runs for datalab-monitoring-int-f09d Cloud Composer Workflow labels {project_id=datalab-monitoring-int-f09d, workflow_name=datalab-sounds-int-bleu.precompute_recommendations_xantus_recommended_for_you_1_1} is above the threshold of 0.000 ...

Obstruction 6 The never ending Dataflow job

[2021-05-13 11:52:34,884] {gcp_dataflow_hook.py:1 (...) Traceback (most recent call last):\n File "/home/airflow/gcs/dags/predictions/compute_predictions.py", line 337, in run\n   return pipeline\n File "/tmp/dataflow_venv/lib/python3.6/site-packages/apache_beam/pipeline.py", line 569, in __exit__\n self.result.wait_until_finish()\n File "/tmp/dataflow_venv/lib/python3.6/site-packages/apache_beam/runners/dataflow/dataflow_runner.py", line 1650, in wait_until_finish\n self)\napache_beam.runners.dataflow.dataflow_runner.DataflowRuntimeException: Dataflow pipeline failed. State: FAILED,
(..)
The job failed because a work item has failed 4 times. Look in previous log entries for the cause of each one of the 4 failures. For more information, see https://cloud.google.com/dataflow/docs/guides/common-errors. The work item was attempted on these workers: \n compute-predictions-xantu-05130255-opno-harness-mtj1\n   Root cause: The worker lost contact with the service.,\n compute-predictions-xantu-05130255-opno-harness-2x4v\n   Root cause: The worker lost contact with the service.,\n compute-predictions-xantu-05130255-opno-harness-5gkd\n   Root cause: The worker lost contact with the service.,\n compute-predictions-xantu-05130255-opno-harness-2t1n\n   Root cause: The worker lost contact with the service.'

Obstruction 6 The never ending Dataflow job

Name	Type	End time	Elapsed time	Start time
compute-predictions-xantus-music-mixes-1-1-87d98f40	Batch	May 13, 2021, 10:44:25 AM	3 days 5 hr	May 10, 2021, 5:21:29 AM
compute-predictions-xantus-music-mixes-1-1-	Batch	May 13, 2021,	5 hr 12 min	May 13, 2021,

Obstruction 6 The never ending Dataflow job

Solution

- Backport the latest Google Cloud operators in Apache Airflow
- Particularly:
  - DataflowCreatePythonJobOperator
  - DataflowJobStatusSensor

https://medium.com/google-cloud/backporting-google-cloud-operators-in-apache-airflow-34b6c9efffc8

Quiz time which do you reckon was the most costly **issue?**

A. Processing programme metadata within Airflow executors
B. Non-idempotent tasks
C. Breaking change after Airflow upgrade
D. Breaking change in upstream service
E. Not monitoring efficiently pre-production environments

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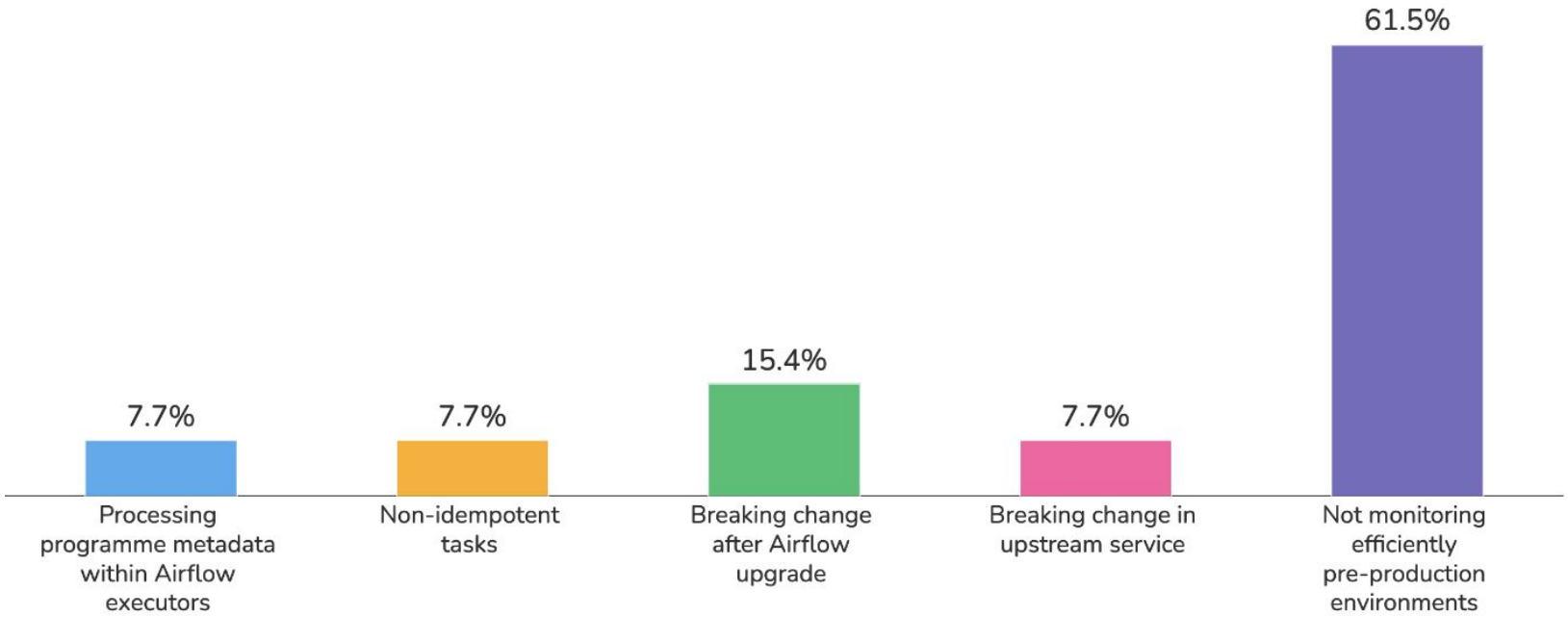

* responses from Airflow Summit 2021 participants, during the presentation

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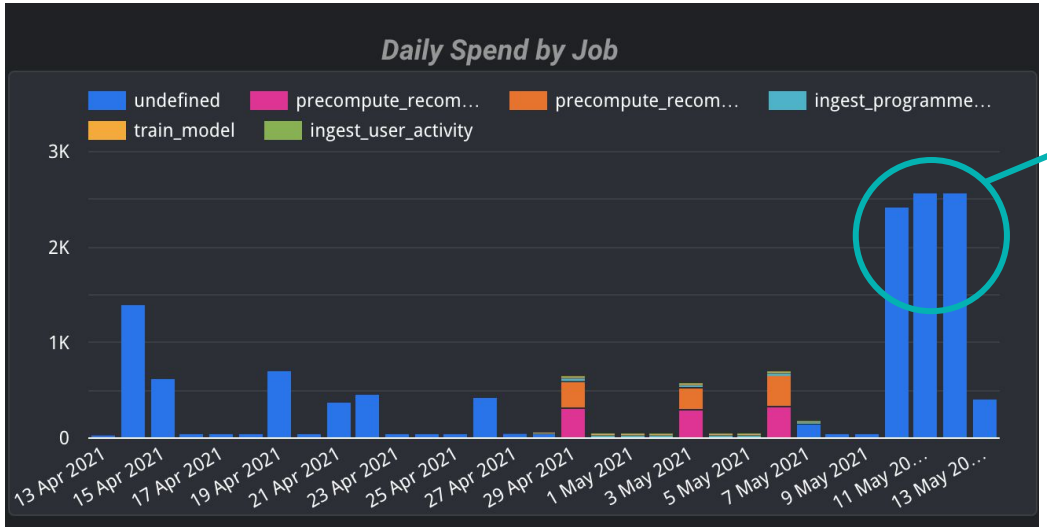


The never ending Dataflow Job, triggered with **DataflowOperator** in our int environment, run for over 3 days and costed over £12k

Hygienic workflows throughout development

Hygienic pipelines

Smell 1 To plugin or not to plugin

- **Requirement**:
  - Have common packages across multiple DAGs without using PyPI or similar
- **Attempt**:
  - Use plugins to expose those
  - Deploy using
    - `gcloud composer environments storage dags import .`
    - `gcloud composer environments storage dags import .`
- **Problems**
  - Lots of broken deployments
  - Unsynchronised upload of **plugins** and **DAGs** to **Composer** web server & workers
  - Issues in enabling DAG serialisation with **plugins**

Smell 1 To plugin or not to plugin

- **Solution**:
  - Stop using plugins
  - Use standard Python packages
  - Upload them using Google Cloud to the Bucket / path
    - gsutil rm (...)
    - gsutil cp (...)

Smell 2 Configuration (mis)patterns

- **Requirement**:
  - Have a strategy for handling environment-specific and common configuration
- **Attempt**:
  - To use Environment variables to declare each env-specific variable
  - To deploy using Terraform
  - To declare common configuration in the DAGs
- **Problems**
  - Each variant updated represented a Cloud Composer deployment
  - Redundant configuration definition across DAGs and multiple utilities modules
  - Hard to identify the data sources / targets paths

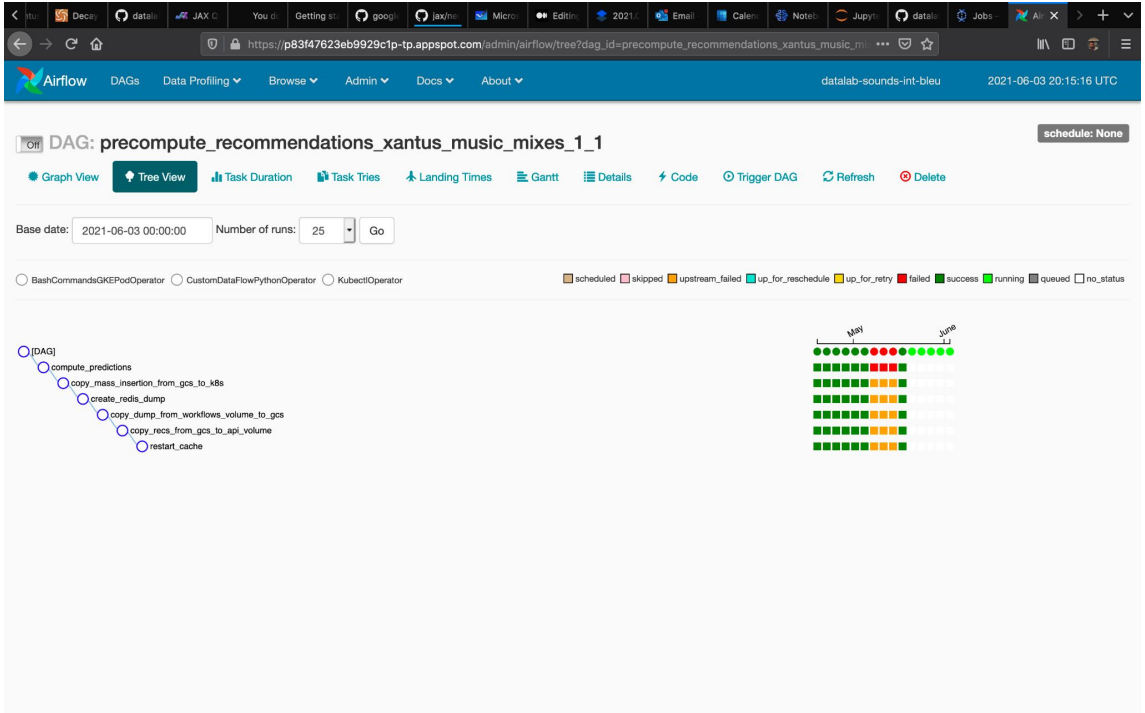
Smell 2 Configuration (mis)patterns

- **Solution**: have configuration files loaded into Airflow variables with paths and variables

```
  "precompute_recommendations_dag": {
    "start_date": "2020-12-07T06:00:00.00",
    "redis_image": "marketplace.gcr.io/google/redis5",
    "dataflow": {
      "num_workers": "40",
      "notused_comments": "30 vCPU with 15 GB RAM per vCPU",
      "machine_type": "custom-30-460800-ext"
    },
    "paths": {
        "candidate_items_gcs_prefix": "%(gcs_base_path)s/programme-metadata/candidate-items/{{ ts }}/",
        "workflows_redis_mass_path": "%(gcs_base_path)s/precomputed-recommendations/redis-mass-insertion/{{ ts }}/",
        "workflows_redis_dump_path": "%(gcs_base_path)s/precomputed-recommendations/redis-dump/{{ ts }}/",
        "api_redis_dump_path": "%(volume_base_path)s/precomputed_recommendations/",
        "precompute_recommendations_dag_id": "precompute_recommendations_%(identifier)s"
    }
  },
  "ingest_user_activity_dag": {
    "start_date": "2020-12-07T06:00:00.00",
    "ingest_interval_hours": "8",
    "snapshot_interval_days": "120",
    "max_active_dag_runs": "1",
    "ingest_catchup": "1",
    "user_activity_bucket": "datalab-sounds-data-dev-ff72_uas",
    "user_activity_prefix": "dev_test_key",
    "paths": {
        "deltas_prefix": "user-activity/uas/deltas/",
        "delta_snapshot_path": "user-activity/uas/deltas/{{ ts }}/%(formatted_ingest_interval)s/",
        "list_original_paths": "workflows/user-activity-to-process/original/{{ ts }}/%(formatted_ingest_interval)s/",
        "user_activity_snapshots_path": "user-activity/uas/snapshots/{{ ts }}/%(formatted_snapshot_interval)s/",
        "list_deltas_path": "workflows/user-activity-to-process/deltas/{{ ts }}/%(formatted_snapshot_interval)s/"
    }
  },
```

https://www.astronomer.io/guides/dynamically-generating-dags

Smell 2 Configuration (mis)patterns



Takeaways Avoiding live incidents

- ❏ Keep processing **out** of **Airflow executors**
- ❏ **Idempotency** matters - and it can be hard!
- ❏ **Backporting** is better than sticking to the past
- ❏ Reviewing **release notes** can help avoid live incidents
- ❏ **Monitoring pre-production** environments can **save money**

Takeaways Keeping the house clean

- Avoid **plugins**
- A **delete-deploy** approach can avoid problems
- Early **configuration-driven approach** saves time

Much more than **obstructions**

With the help of **Apache Airflow**, Datalab:

- Was able to end a contract of the BBC, with an **external** recommendation service, by increasing in **59% the audience engagement**
- Serves **daily millions** of **personalised recommendations** to the **BBC audiences**
- Built a **configurable** Machine Learning pipeline **agnostic of the model**
  - Constantly **adds new variants** and **extends workflows**


BBC
Thank you!
Tatiana Al-Chueyr
@tati_alchueyr
Airflow
Summit 2021