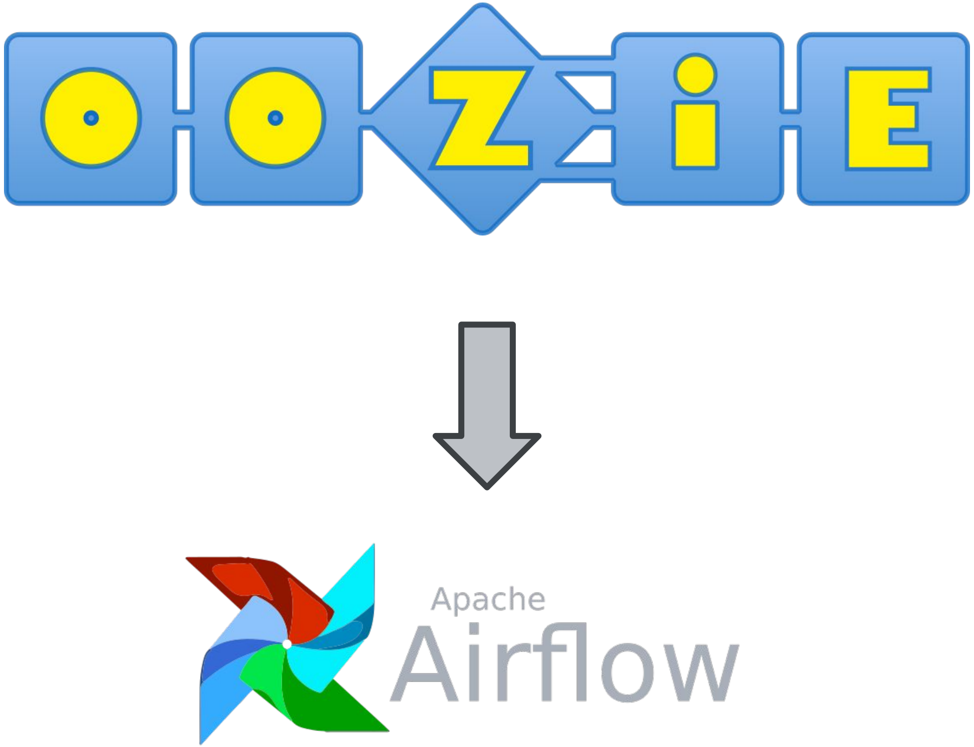
Migrating Apache Oozie Workflows to Apache Airflow



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Google Cloud

Overview

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The Need for Workflow Solutions

Cron simple tasks

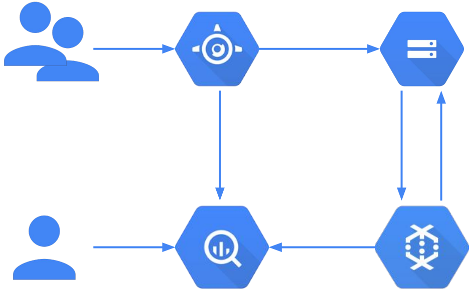
```
* * * * * command to run

       CRON Job
```

Cost: low

Friction: medium

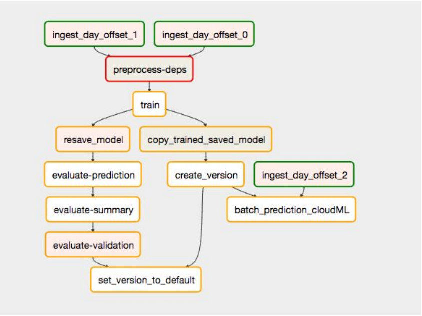
Cron + scripting



Cost: medium

Friction: high

Custom applications



Cost: high

Friction: high

The Landscape

OSS

Apache Oozie

Luigi (Spotify)

Apache Airflow

Azkaban (Linkedin)

Cadence (Uber)

Managed

AWS Glue

Google Cloud Scheduler

Google Cloud Composer

AWS DataPipeline

Azure DataFactory

Workflow Solution Lock-in

- Workflow structure mismatch (e.g., loop vs DAG)
- Workflow language spec (e.g., code vs config, XML vs YAML)
- No standard set of supported tasks
- Workflow expressiveness (e.g., dependency relationship)
- Coupling between workflow language and its underlying implementation

It’s hard to migrate workflows from one system to another.

Oozie to Airflow Converter

- Understand the pain of workflow migration
- Figure out a viable migration path (hopefully it’s generic enough)
- Incorporate lessons learned towards future workflow spec design
- Why Apache Oozie and Apache Airflow?
    - Widely used
    - OSS
    - Sufficiently different (e.g., XML vs Python)

Apache Oozie

- Apache Oozie is a workflow management system to manage Hadoop jobs.
- It is deeply integrated with the rest of Hadoop stack supporting a number of Hadoop jobs out-of-the-box.
- Workflow is expressed as XML and consists of two types of nodes: control and action.
- Scalable, reliable and extensible system.

Hello world Oozie workflow

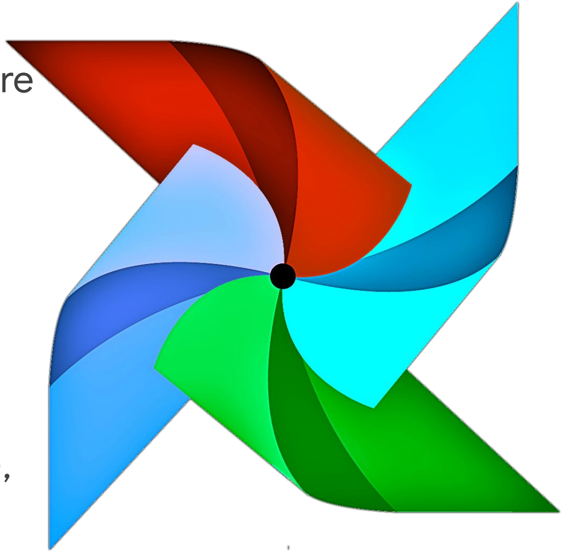
This is a very simple Oozie workflow that performs a shell action. Pay attention to the following XML elements:

1. start
2. action
3. kill
4. end

```
<workflow-app xmlns="uri:oozie:workflow:1.0" name="shell-wf">
    <start to="shell-node"/>
    <action name="shell-node">
        <shell xmlns="uri:oozie:shell-action:1.0"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
               xsi:schemaLocation="uri:oozie:shell-action:1.0 ">
            <resource-manager>${resourceManager}</resource-manager>
            <name-node>${nameNode}</name-node>
            <prepare>
                <delete path="${nameNode}/user/${userName}/${examplesRoot}/apps/shell/test"/>
                <mkdir path="${nameNode}/user/${userName}/${examplesRoot}/apps/shell/test"/>
            </prepare>
            <configuration>
                <property>
                    <name>mapred.job.queue.name</name>
                    <value>${queueName}</value>
                </property>
            </configuration>
            <exec>java</exec>
            <argument>-version</argument>
            <capture-output/>
        </shell>
        <ok to="end"/>
        <error to="fail"/>
    </action>
    <kill name="fail">
        <message>Shell action failed, error
message[${wf:errorMessage(wf:lastErrorNode())}]</message>
    </kill>
    <end name="end"/>
</workflow-app>
```

Apache Airflow

- Apache Airflow is a top-level project at the Apache Software Foundation (ASF).
- Airflow has become very popular within the open-source community.
- It's designed to enable users to programmatically author, schedule and monitor workflows.
- Workflows are authored as directed acyclic graphs (DAGs), and can be configured as code - using Python 2.x or 3.x.



Hello world DAG code

This is a very simple Airflow DAG that does three things in order:

1. Echo “hi”
2. Run the date command
3. Sleep for 5 seconds

As you can see, the workflow is written entirely in Python.

```
from airflow import DAG
from airflow.operators.bash_operator import BashOperator
from datetime import datetime, timedelta

YESTERDAY = datetime.combine(
    datetime.today() - timedelta(days=1), datetime.min.time())

default_args = {
  'owner': 'airflow',
  'depends_on_past': False,
  'start_date': YESTERDAY,
  'email_on_failure': False,
  'email_on_retry': False,
  'retries': 1,
  'retry_delay': timedelta(minutes=5),
}

with DAG('hello_world', default_args=default_args) as dag:
  t0 = BashOperator(task_id='p_hi', bash_command='echo "hi"', dag=dag)
  t1 = BashOperator(task_id='p_date', bash_command='date', dag=dag)
  t2 = BashOperator(task_id='sleep', bash_command='sleep 5', dag=dag)
  t0 >> t1 >> t2
```

Converter Design

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Design Goals

Correctness

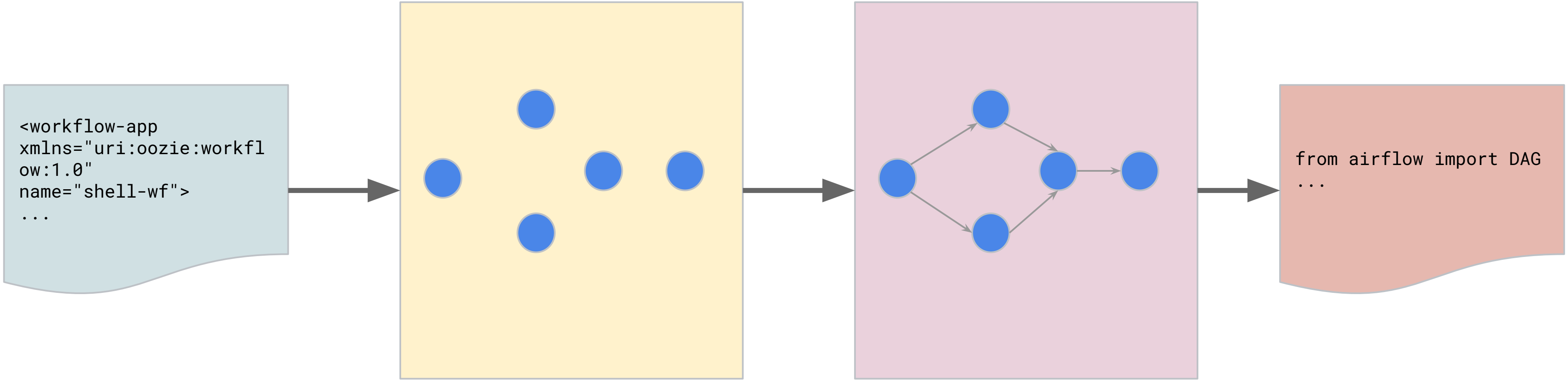
1. Identical actions
2. Respect dependencies
3. Side effects are captured
4. Same workflow outcome

Flexibility

1. Support 1:M action mappings
2. Swappable mapper
3. Allow scheduling info overrides

We focus on workflow-app migration initially.

High-level Design Overview



```
<workflow-app
xmlns="uri:oozie:workfl
ow:1.0"
name="shell-wf">
...
```

```
from airflow import DAG
...
```

workflow XML ⟶ [nodes] where node: name, attributes, child elements, etc.

[nodes] -> workflow object:

- dependencies
- relationship
- airflow-nodes

workflow object ⟶ dag.py

The Workflow Class

- Container object to hold metadata regarding an oozie workflow
- Intermediate representation of Oozie workflows
- Notable properties:
    - nodes: list of control/action nodes
    - relationships: task dependencies (e.g., “ok”, “error”)
    - dependencies: airflow “import” statements

The Mapper Class

- Two types of mapper classes
  - Control mapper: maps a control node in Oozie
  - Action mapper: maps an action node in Oozie
- Control mapper: update task relationship
- Action mapper: in addition to updating task relationship, also transform oozie action properties to Airflow operator arguments
- These arguments are then fed into per-operator Jinja templates

Operator Jinja Templates

```
{{ task_id }}_prepare = bash_operator.BashOperator(
   task_id='{{ task_id }}_prepare',
   bash_command='{{ prepare_command }}'
)

{{ task_id }} = dataproc_operator.DataProcPigOperator(
   query_uri='{}/{}'.format(PARAMS['gcp_uri_prefix'], '{{ script_file_name }}'),
   task_id='{{ task_id }}',
   trigger_rule='{{ trigger_rule }}',
   variables={{ params_dict }},
   dataproc_pig_properties={{ properties }},
   cluster_name=PARAMS['dataproc_cluster'],
   gcp_conn_id=PARAMS['gcp_conn_id'],
   region=PARAMS['gcp_region'],
   dataproc_job_id='{{ task_id }}'
)

{% with relation=relations %}
{% include "relations.tpl" %}
{% endwith %}
```

Pig action template

```
{{ task_id }}_prepare = bash_operator.BashOperator(
   task_id='{{ task_id }}_prepare',
   bash_command='{{ prepare_command }}'
)

{{ task_id }} = bash_operator.BashOperator(
   task_id='{{ task_id }}',
   bash_command="gcloud dataproc jobs submit pig --cluster={0} --region={1}
--execute 'sh {{ bash_command }}'"
         .format(PARAMS['dataproc_cluster'], PARAMS['gcp_region'])
)

{{ task_id }}_prepare.set_downstream({{ task_id }})
```

Shell action template

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Oozie Control Node Mapping

Oozie Node	Airflow Operator/Representation
START	None (Airflow doesn’t need an explicit start node)
DECISION	PythonBranchOperator
FORK	None (Airflow runs concurrent tasks whenever it can)
JOIN	None (TriggerRule.ALL)
END	DummyOperator if DECISION in upstream.nodes None otherwise
KILL	None (Task failure leads to DAG failure by default)

Oozie Action Node Mapping (Implemented)

Oozie Node	Airflow Operator/Representation
PIG	DataProcPigOperator
MapReduce	DataprocHadoopOperator
Shell	BashOperator where a pig job is submitted to run a shell script
SubWorkflow	SubDagOperator
HDFS	BashOperator where a pig job is submitted to run a shell script
SPARK	DataprocSparkOperator
SSH	SSHOperator

Prepare statement in a Oozie action is mapped to a BashOperator.

Putting It All Together

1. Load and parse the workflow XML file with the Python XML ElementTree API → workflow

   Output: workflow

2. Syntax clean-up and map Oozie node to Airflow node

   Output: workflow + airflow nodes

3. Set up task relationship by following the “to” links and create trigger rules for each Airflow node

   Output: workflow + airflow nodes + relationship + trigger rules

4. Convert transformed workflow to Airflow Dags with Jinja template rendering

   Output: raw DAG file

5. Prettify the DAG to improve readability and facilitate future changes

   Output: formatted DAG file

Demo

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Demo Recap

- Oozie to Airflow converter repo: https://github.com/GoogleCloudPlatform/cloud-composer
- Successfully converted a representative Oozie workflow to Airflow DAG
    - Includes all control nodes
    - Embeds a sub-workflow
    - Contains common actions such as MapReduce, Shell, Pig
- No post-conversion modification and runs well out of the box

Roadmap

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Next Step

- Implement the rest of Oozie actions
- Support coordinator app for scheduling and pre-condition check
- Complete the development of EL functions
- Improve user experience of the converter tool (e.g., better error messaging, debugging support, etc)
- How to solve the general workflow migration problem?
  - A config-based workflow language spec (e.g., YAML spec)
  - Opinionated on control and data flow
  - Open to any task

Call for Contribution

- We collaborated with Polidea to design and implement the conversation tool.
- To scale the development and make it useful for the community, we welcome all contributions:
    - Try out the tool
    - Share your Oozie workflow
    - Help with the tool development
    - Improve documentation, testing coverage, etc

github.com/GoogleCloudPlatform/cloud-composer/tree/master/oozie-to-airflow

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Polidea

Thank you!