A Workflow Management Engine in CORD

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A Workflow?

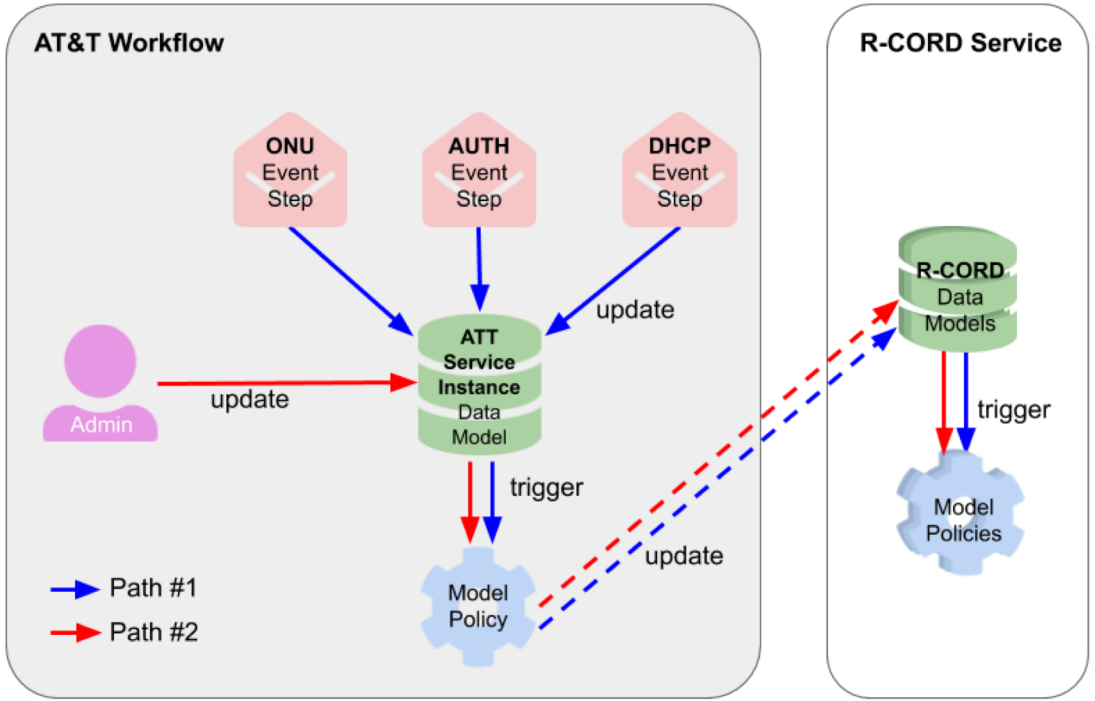
This differentiates a **workflow** from a general **program**

Is a **series of tasks** in order to accomplish a **repeatable** business objective with details on **when**, **how** and **what** work is to be done.

Task = (When ⇒ How ⇒ What)
= (Event ⇒ Action ⇒ Result)

Current Workflows in CORD

- Implemented as a **XOS Synchronizer**
  - **Data-models** (data)
  - **Model-policies** (model-event handlers)
  - **Event-steps** (external-event handlers)
- Event handlers define **when**, **how**, and **what**
- A container per workflow
  - Scalability & Isolation



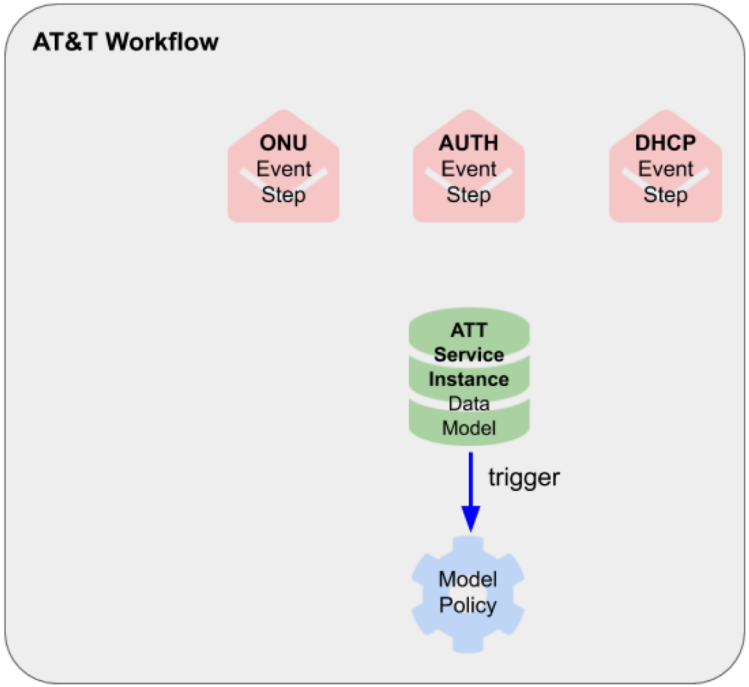
Execution Flow of **AT&T Workflow**

- Two execution paths
- inter-workflow calls (dot arrows)

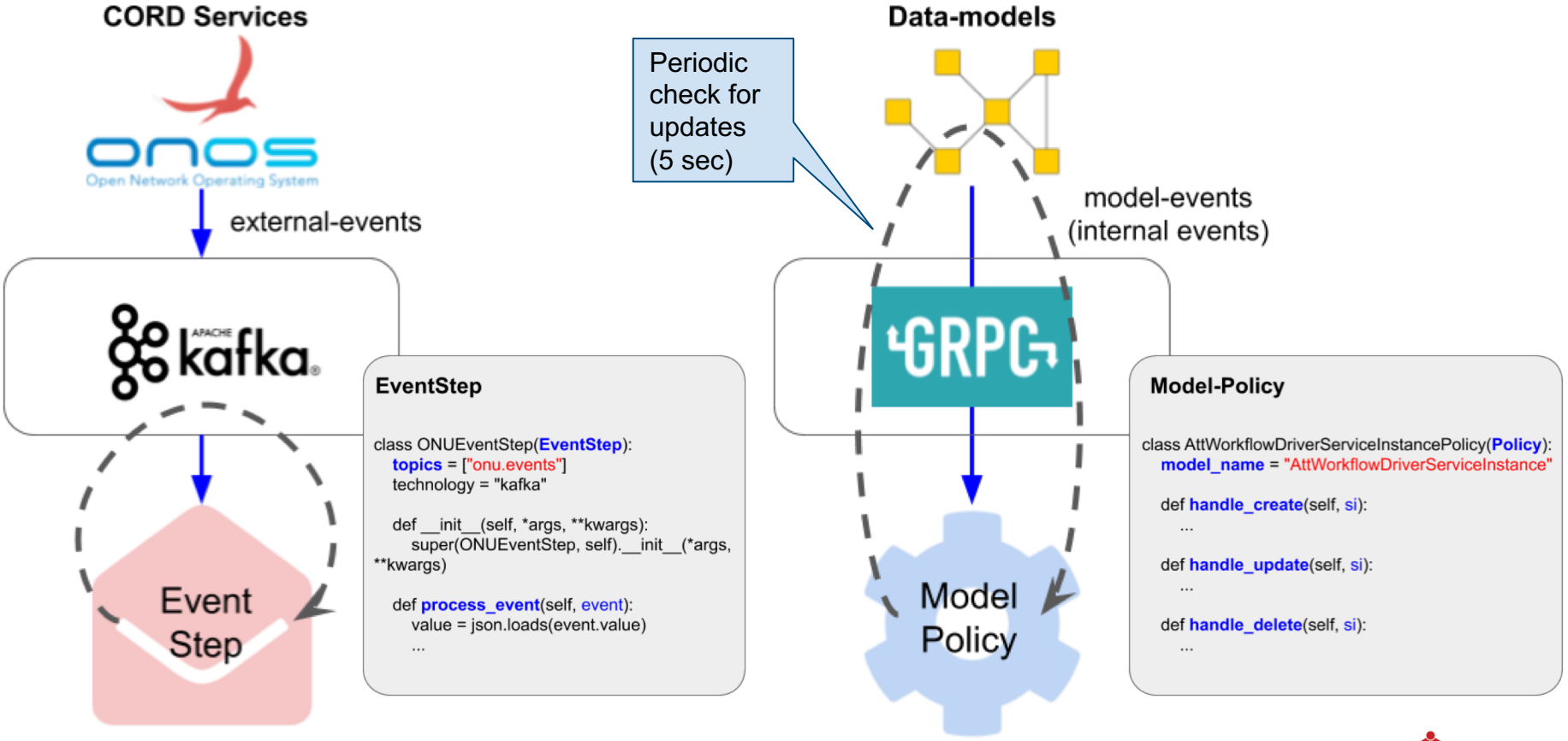
Difficulties & Limitations

- Development
  - Inconsistent technologies & interfaces for event-handling
  - Seemingly fragmented codes
  - Manual workflow state management
  - Possible race conditions & loops
- Management
  - Difficult to understand execution flows & relations
  - Difficult to monitor workflow state

Execution Flow At First Glance

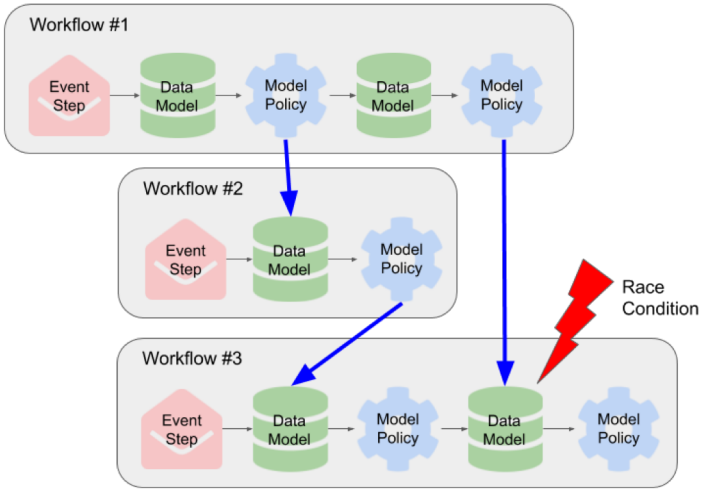


Event-steps vs. Model-policies

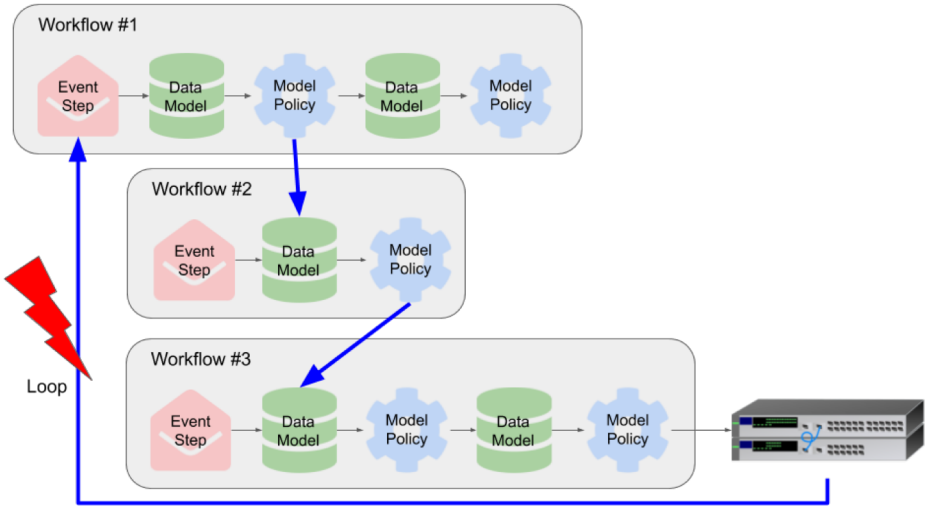


Possibly…

Race Conditions



Loops

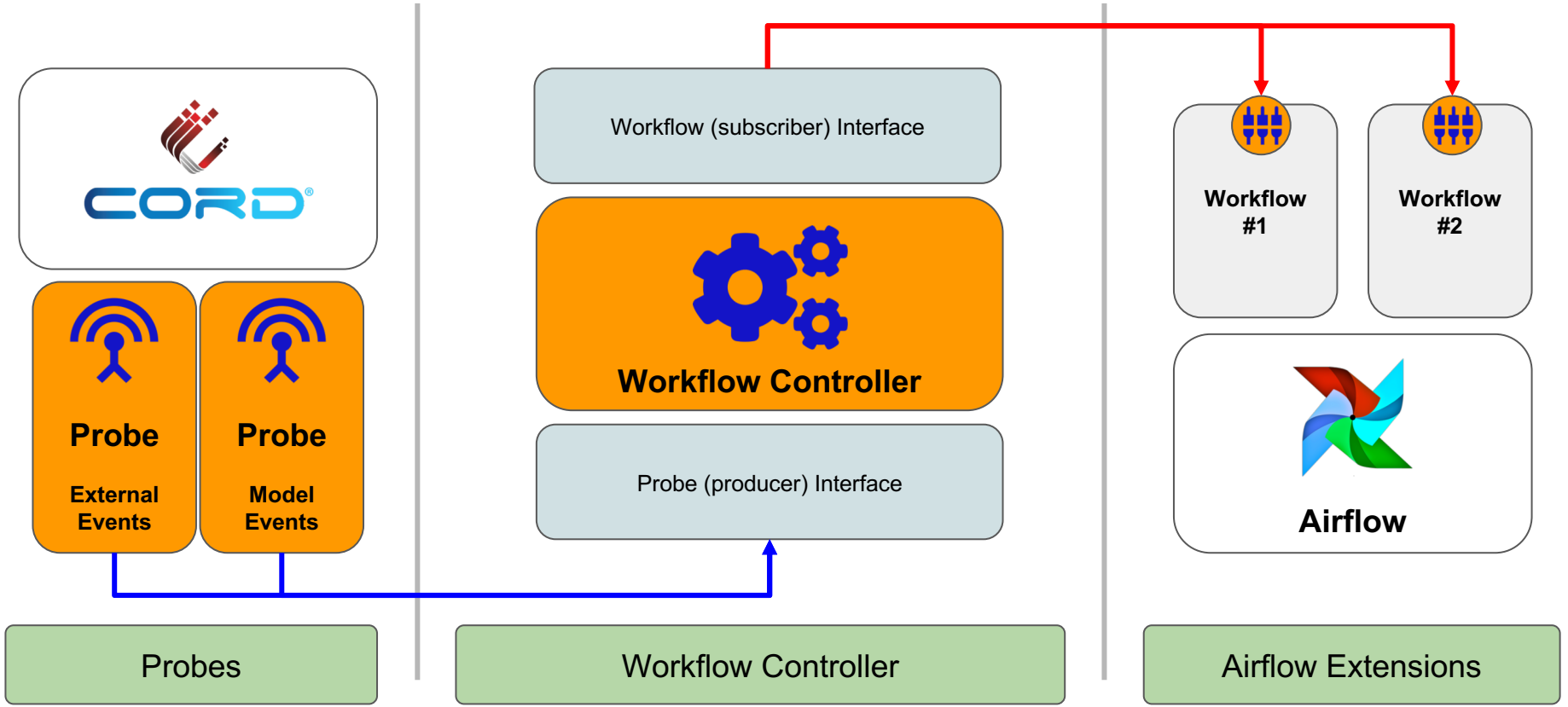


The Pilot Engine

- Based on **Apache Airflow**
  - An open-source workflow management platform by Airbnb
- Development
  - Simple & consistent event-handler interfaces
  - Execution flow is clearly described
  - State management
  - Can avoid race conditions using Pools (like mutex)
  - Can find loops via graphs
- Management
  - Visualize state, flows and relations of workflows
  - Scalable (using kubernetes/celery)

Airflow

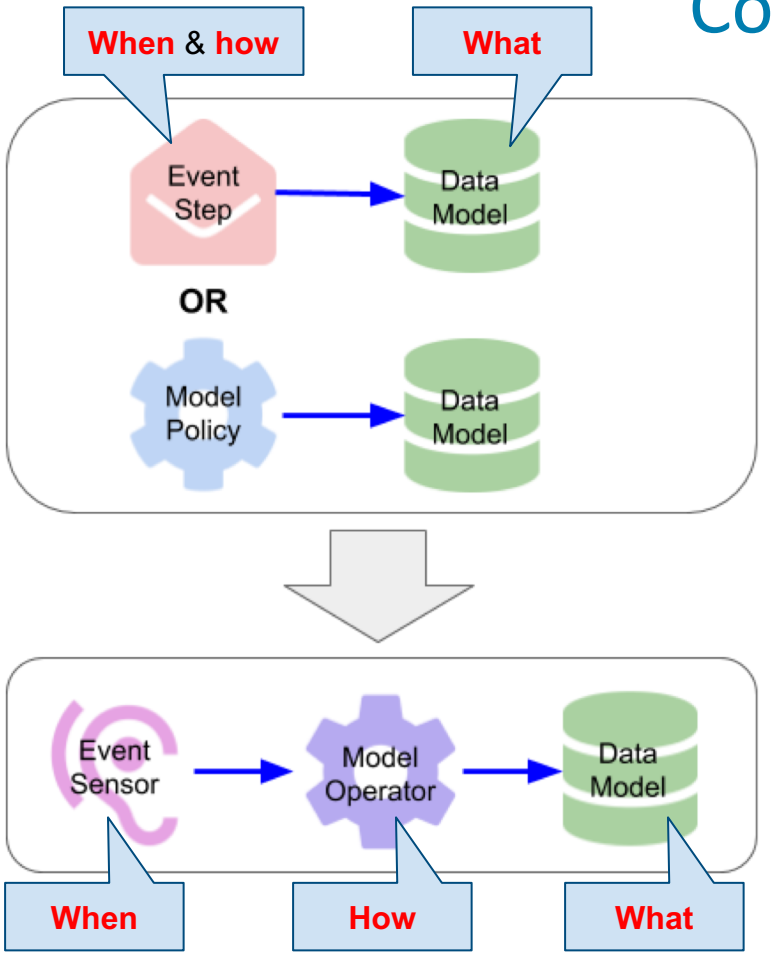
Design of the Pilot Engine



Workflow Controller

- Bridge the gap between **CORD** and **Airflow**
  - **OLTP** (Online Transactional Processing)
    vs. **OLAP** (Online Analytical Processing)
  - OLTP ⇒ Short transactions (e.g., CRUD)
  - OLAP ⇒ Periodical batch processing (e.g., Hadoop analysis)
  - **Run a transaction as a workflow instance**
- Workflow management
  - Launch new workflow instances
  - Monitor state of workflow instances
- Event routing
  - Route events to workflow instances

Code Changes




```
onu_event_sensor = CORDEventSensor(
    task_id='onu_event_sensor',
    topic='onu.events',
    key_field='serialNumber',
    controller_conn_id='local_cord_controller',
    poke_interval=5,
    dag=dag_att
)
```

When

```
onu_event_handler = CORDModelOperator(
    task_id='onu_event_handler',
    python_callable=on_onu_event,
    data_models=['ATTServiceInstanceModel'],
    cord_event_sensor_task_id='onu_event_sensor',
    dag=dag_att
)
```

How

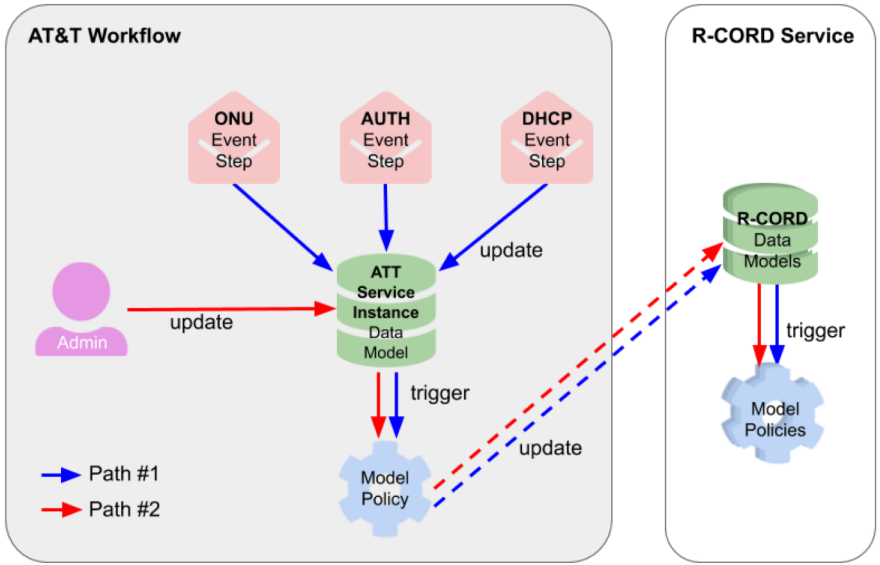
What

```
onu_event_sensor >> onu_event_handler
```

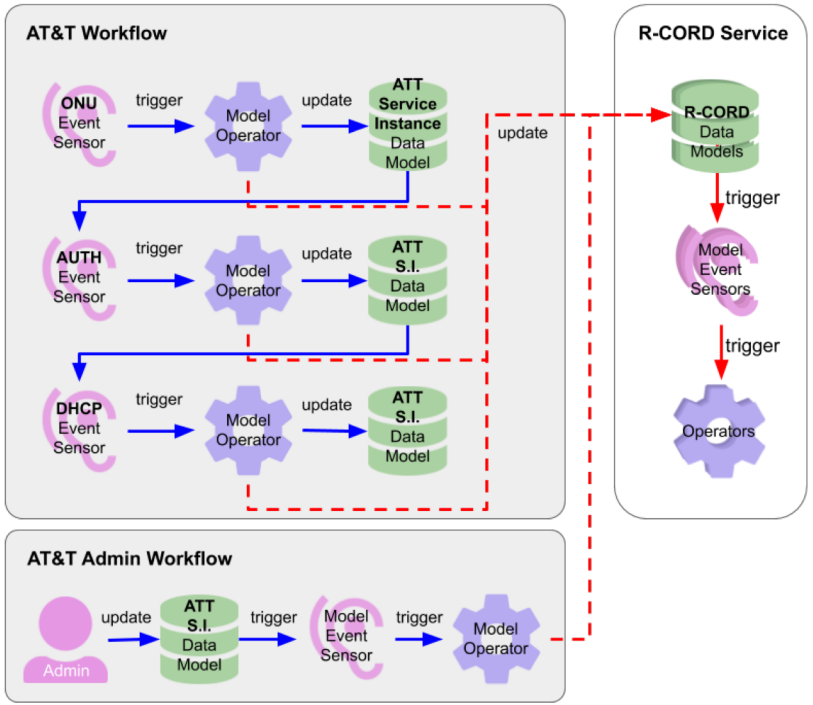
Explicit flow definition

Design Changes

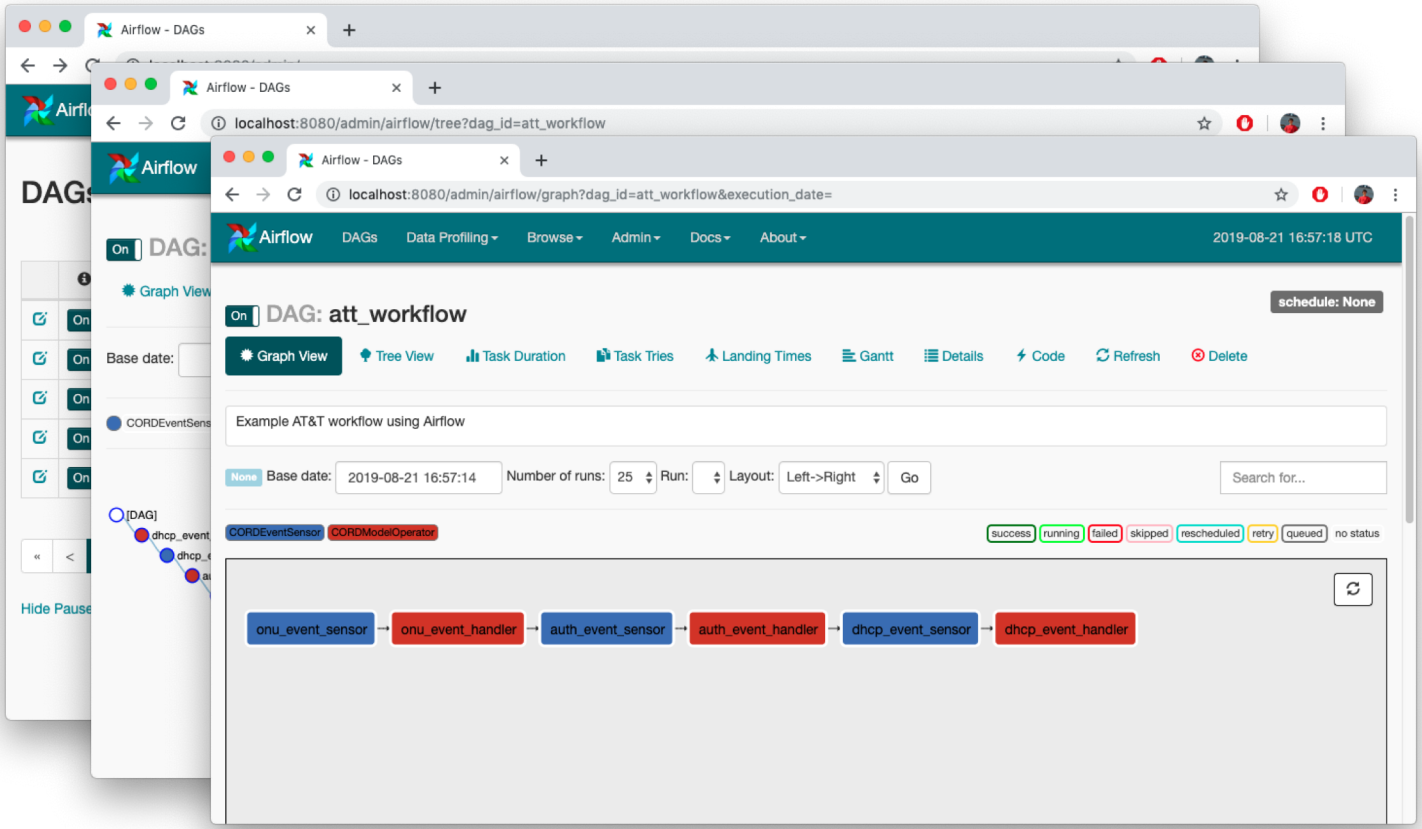
XOS Synchronizer



The Pilot Engine



Monitoring


Airflow - DAGs
localhost:8080/admin/airflow/tree?dag_id=att_workflow
localhost:8080/admin/airflow/graph?dag_id=att_workflow&execution_date=
Airflow
DAGs
Data Profiling
Browse
Admin
Docs
About
2019-08-21 16:57:18 UTC
DAG: att_workflow
schedule: None
Graph View
Tree View
Task Duration
Task Tries
Landing Times
Gantt
Details
Code
Refresh
Delete
Example AT&T workflow using Airflow
Base date: 2019-08-21 16:57:14
Number of runs: 25
Run:
Layout: Left->Right
Go
Search for...
CORDEventSensor
CORDModelOperator
success
running
failed
skipped
rescheduled
retry
queued
no status
onu_event_sensor
onu_event_handler
auth_event_sensor
auth_event_handler
dhcp_event_sensor
dhcp_event_handler

Limitations

- Performance
  - Slow polling-based event detection*
  - Slow task scheduling*
- Scalability
  - Single point of failure
  - Unscalable Airflow UI (Web admin)*
- Usability
  - Annoying workflow registration
  - Annoying restriction in programming (e.g., a single python file per a workflow)

Related to Airflow's target market, "an orchestrator for ***OLAP***"

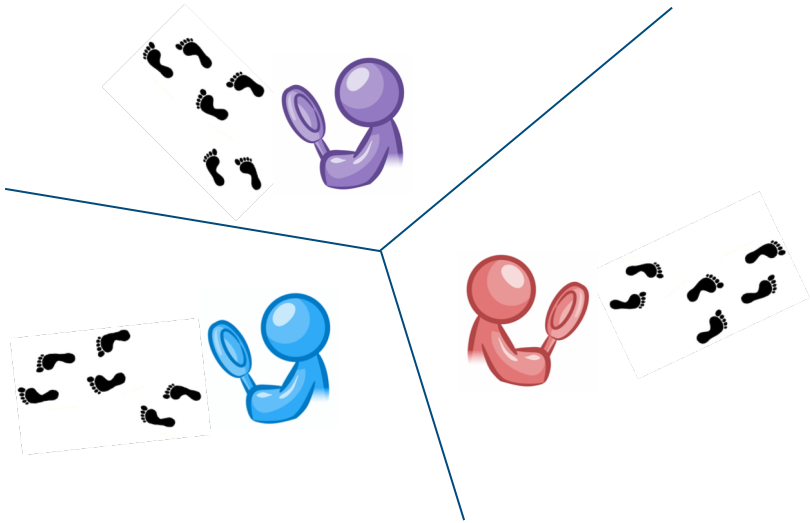
OLAP
(Online Analytical Processing): periodic, long-running batch jobs

Future Workflow Management Engine in CORD

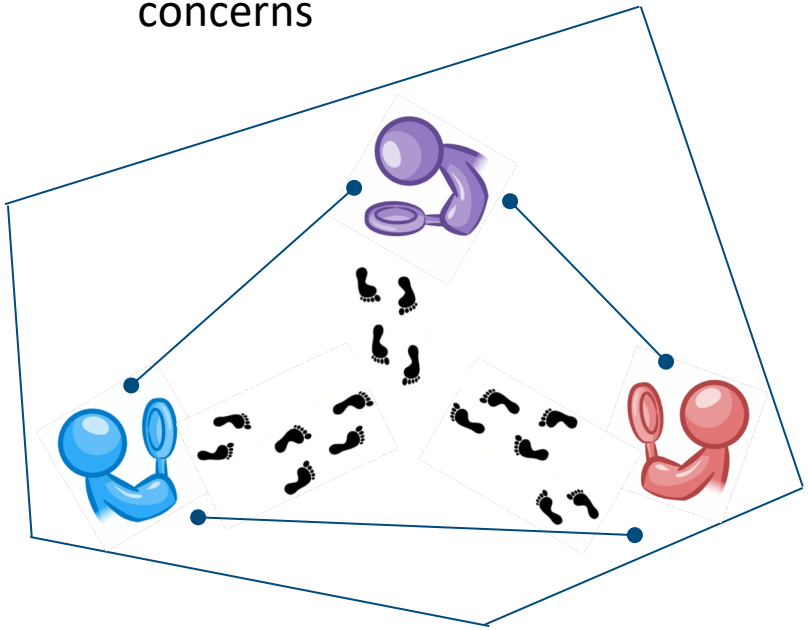
- **Best assets of the pilot engine**
  - Simple & consistent event handlers
  - Simple state management & flow control
  - Task scheduling using Pools to avoid race conditions
  - Visualizations for monitoring
- **Supplementary features to the pilot engine**
  - Automated loop detection & race condition
  - Fast event detection (event-driven or short polling period)
  - Fast task-scheduling
  - High availability & Scalability
  - A container per workflow (Like XOS Synchronizer)
  - Simple workflow registration at runtime
  - Workflow code packaging for deployment

Best of Both Worlds

- **XOS Synchronizer**
  - **Separation** of concerns



- **The Pilot Engine**
  - **Explicit** and **connected** concerns



Thank You