Reliable Airflow DAG Design when building a Time-series Data Lakehouse

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Enterprise Data Lake, Bloomberg

Airflow Summit

Let's flow together

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Toronto, Canada

Time-series Data

Disclaimer: dummy data

Date	Company ID	Price	P/E Ratio	Industry Sector
1992-09-16	Company A	15000	5	Tech
1992-09-16	Company B	5000	10	Tech
...	...	...	...	...
2023-09-18	Company A	23600	19	Tech
2023-09-18	Company B	19000	11	Tech
2023-09-19	Company A	23500	20	Tech
2023-09-19	Company B	21000	10	Tech

Human Expectations

“Daily starting Tuesday, September 19th, 2023, between 5:30 PM and 7:30 PM EDT”

Recurrence Pattern

Start Date and Time

Expected Delivery Window

Time-series Analysis

Disclaimer: dummy data

“Daily starting Tuesday, September 19th, 2023, between 5:30 PM and 7:30 PM EDT”

1992-09-16	Company B	5000	10	Tech
…	…	…	…	…
2023-09-18	Company A	23600	19	Tech
2023-09-18	Company B	19000	11	Tech

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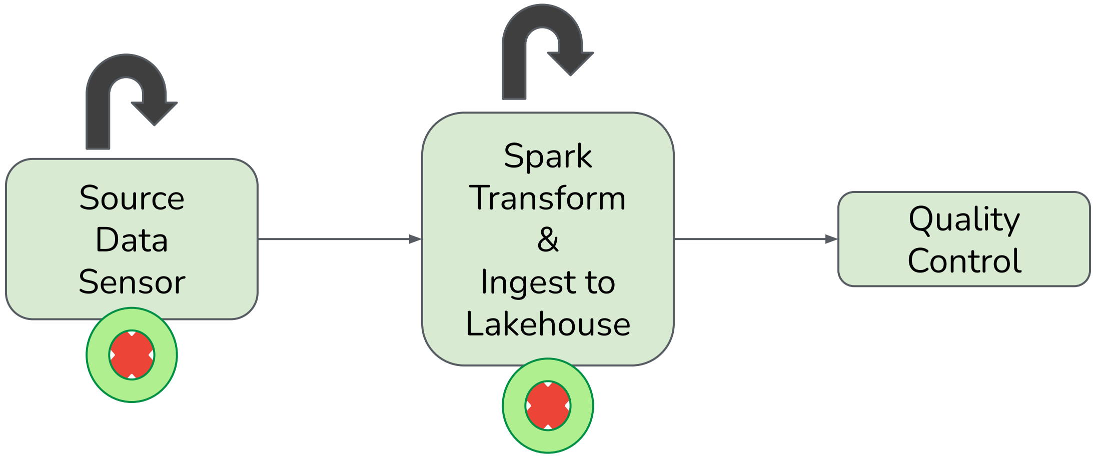
Designing for Reliability

- Recoverability
- Scalability
- Failure and Delay Detection (SLA Miss Detection)

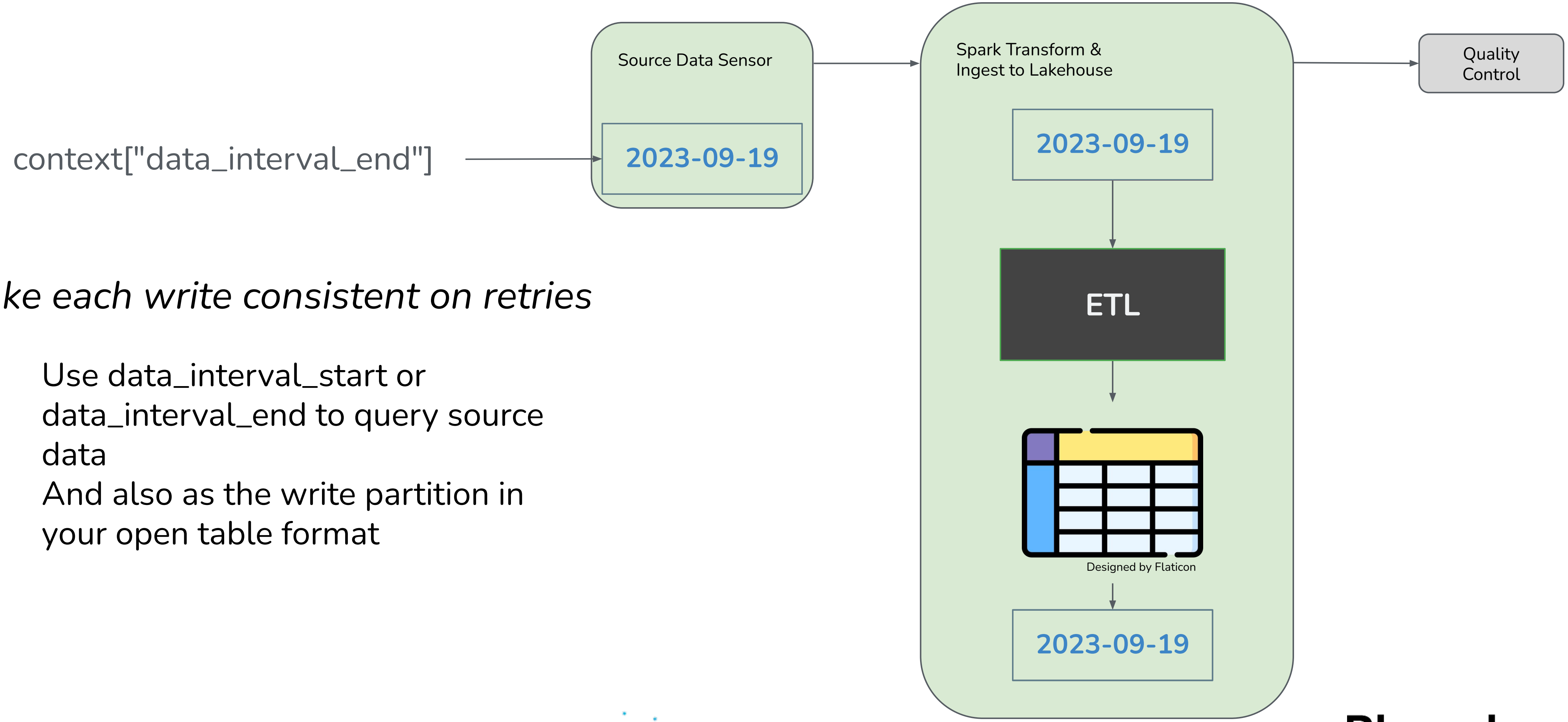
Recoverability

Making tasks safe to re run

Example DAG Run



Making Each Task Safe to Re-run



Make each write consistent on retries

1. Use data_interval_start or data_interval_end to query source data
2. And also as the write partition in your open table format

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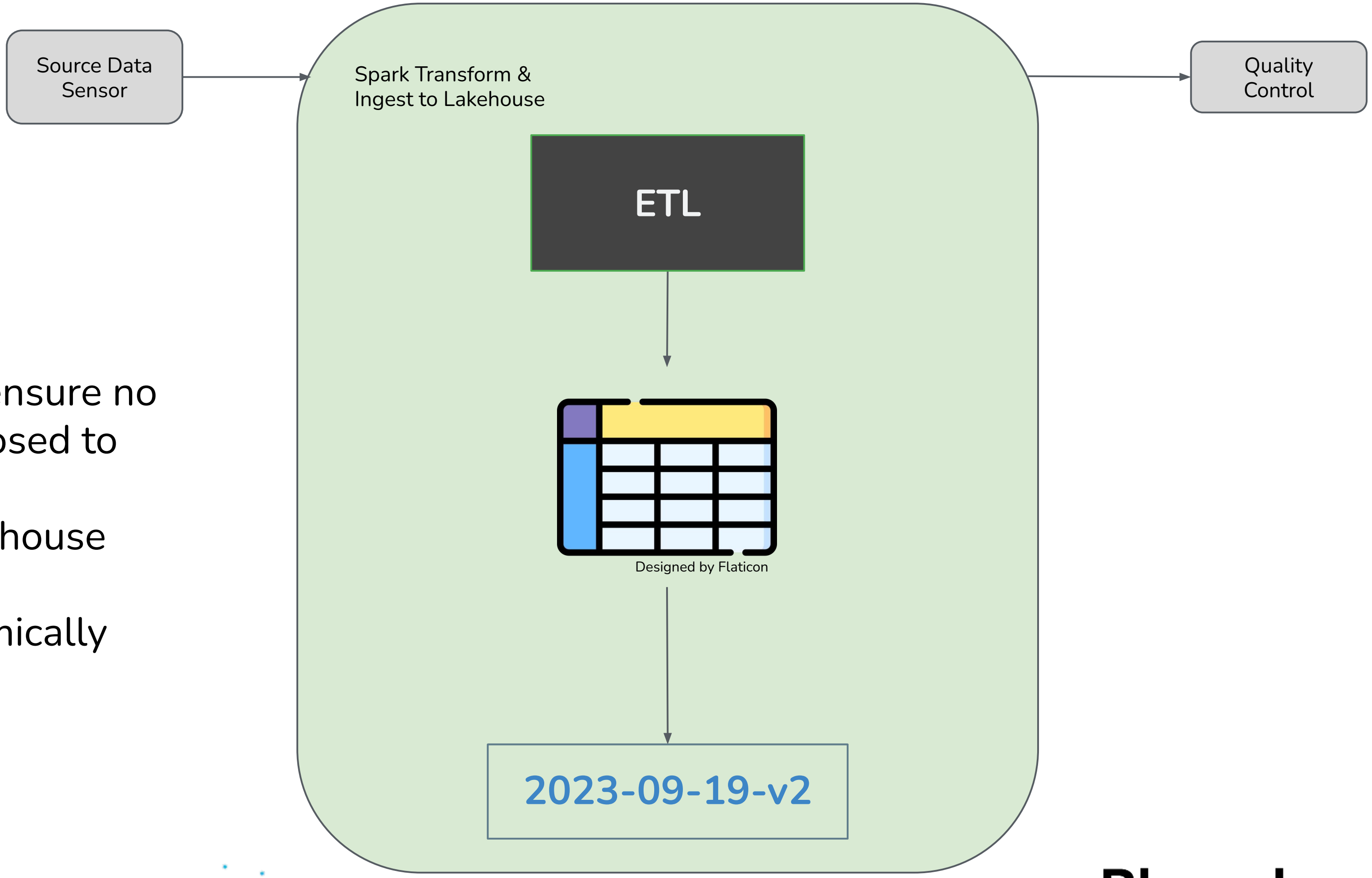
Making Each Task Safe to Re-run

Make each write atomic

1. Use snapshot isolation to ensure no in-between states are exposed to other writers or readers
2. Use a write-optimized lakehouse partition strategy
3. Utilize operations that atomically replace an entire partition



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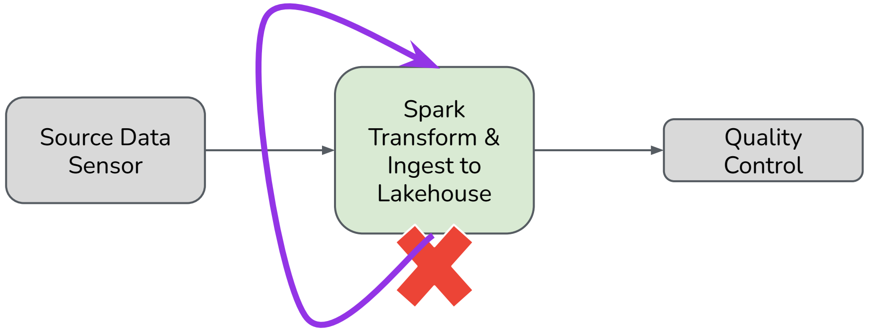
Retry on Failure



Enable Retries

1. Enable automatic task level retries with ‘retries’ parameter
2. Invoke a retry manually by ‘clearing’ a task

FAILED → *QUEUED*

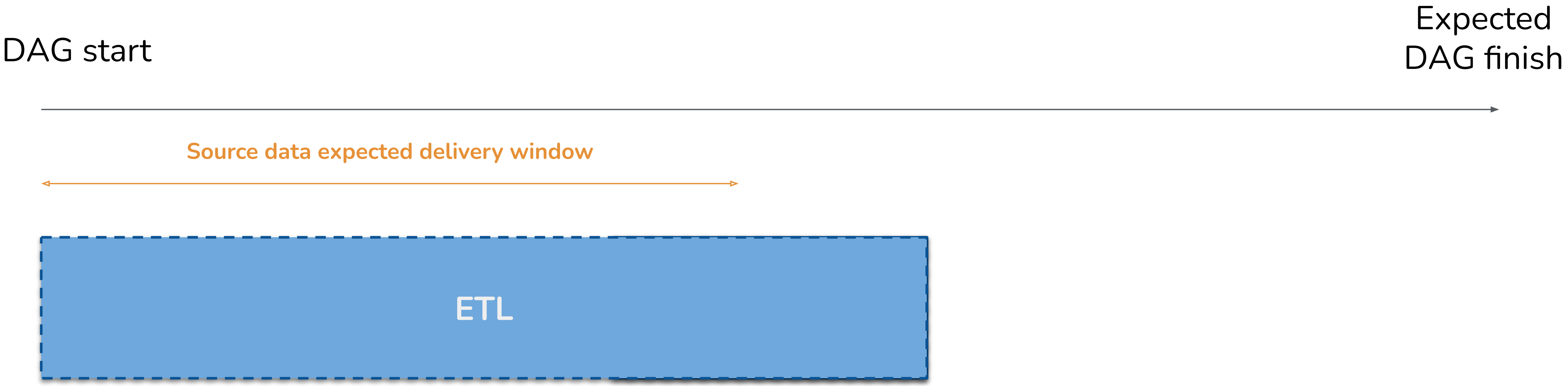
SUCCESS → *QUEUED*

```
with DAG(
    dag_id="my_dag",
    start_date=pendulum.datetime(2016, 1, 1),
    schedule="@daily",
    default_args={"retries": 2},
):
    op = BashOperator(
            task_id="hello_world",
            bash_command="Hello World!"
      )

    op2 = BashOperator(
            task_id="good_bye_cruel_world",
            bash_command="Good Bye!"
      )

    op >> op2
```

Scalability

Optimizing resource utilization

Scalability



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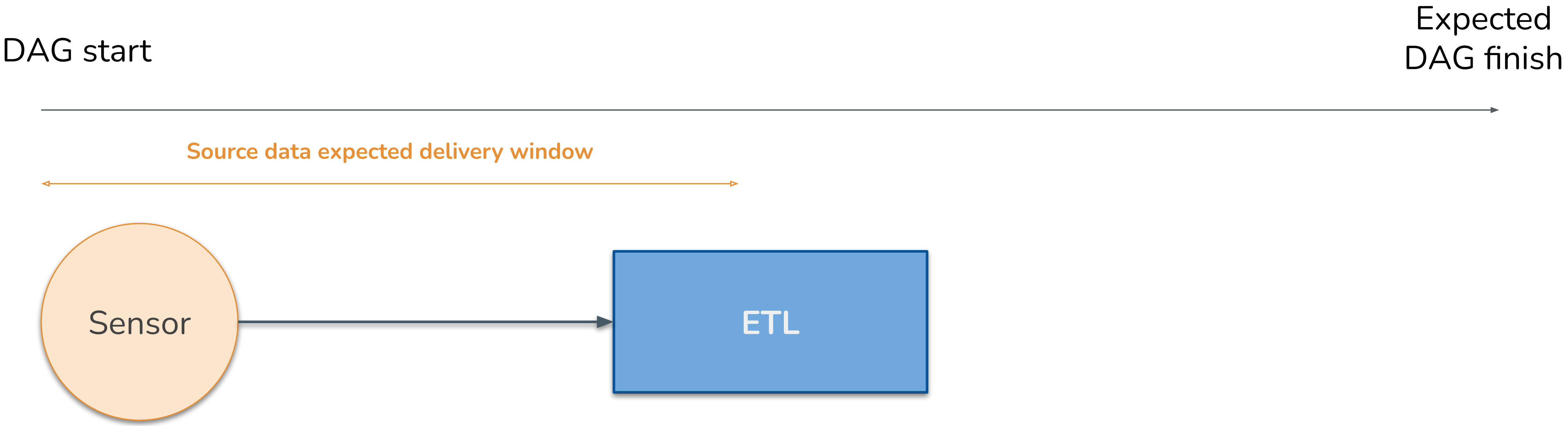
Hogging resources, only when we need them



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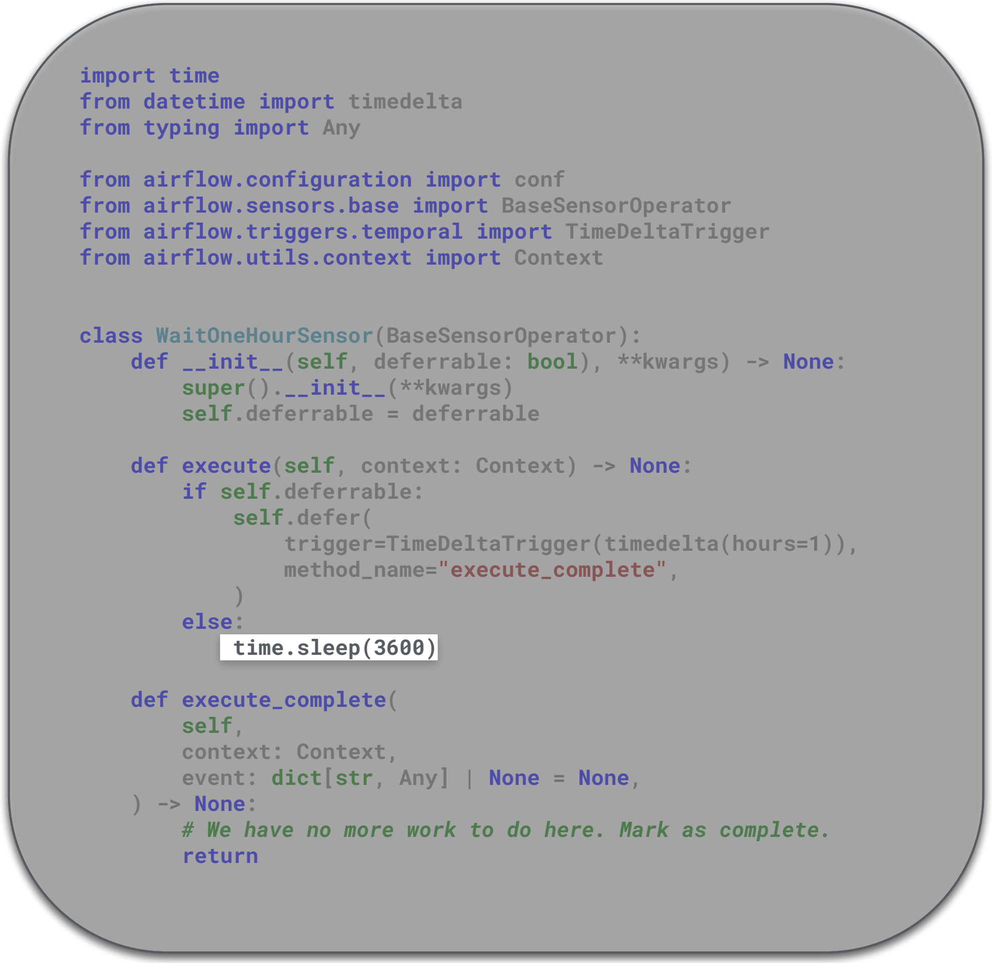
Sensors



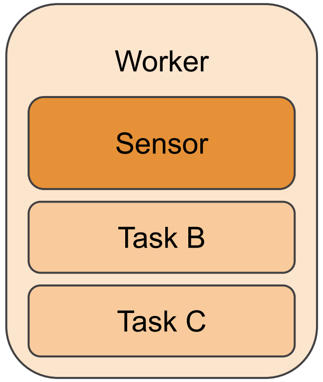
```python
import time
from datetime import timedelta
from typing import Any

from airflow.configuration import conf
from airflow.sensors.base import BaseSensorOperator
from airflow.triggers.temporal import TimeDeltaTrigger
from airflow.utils.context import Context


class WaitOneHourSensor(BaseSensorOperator):
    def __init__(self, deferrable: bool), **kwargs) -> None:
        super().__init__(**kwargs)
        self.deferrable = deferrable

    def execute(self, context: Context) -> None:
        if self.deferrable:
            self.defer(
                trigger=TimeDeltaTrigger(timedelta(hours=1)),
                method_name="execute_complete",
            )
        else:
            time.sleep(3600)

    def execute_complete(
        self,
        context: Context,
        event: dict[str, Any] | None = None,
    ) -> None:
        # We have no more work to do here. Mark as complete.
        return
```



Worker

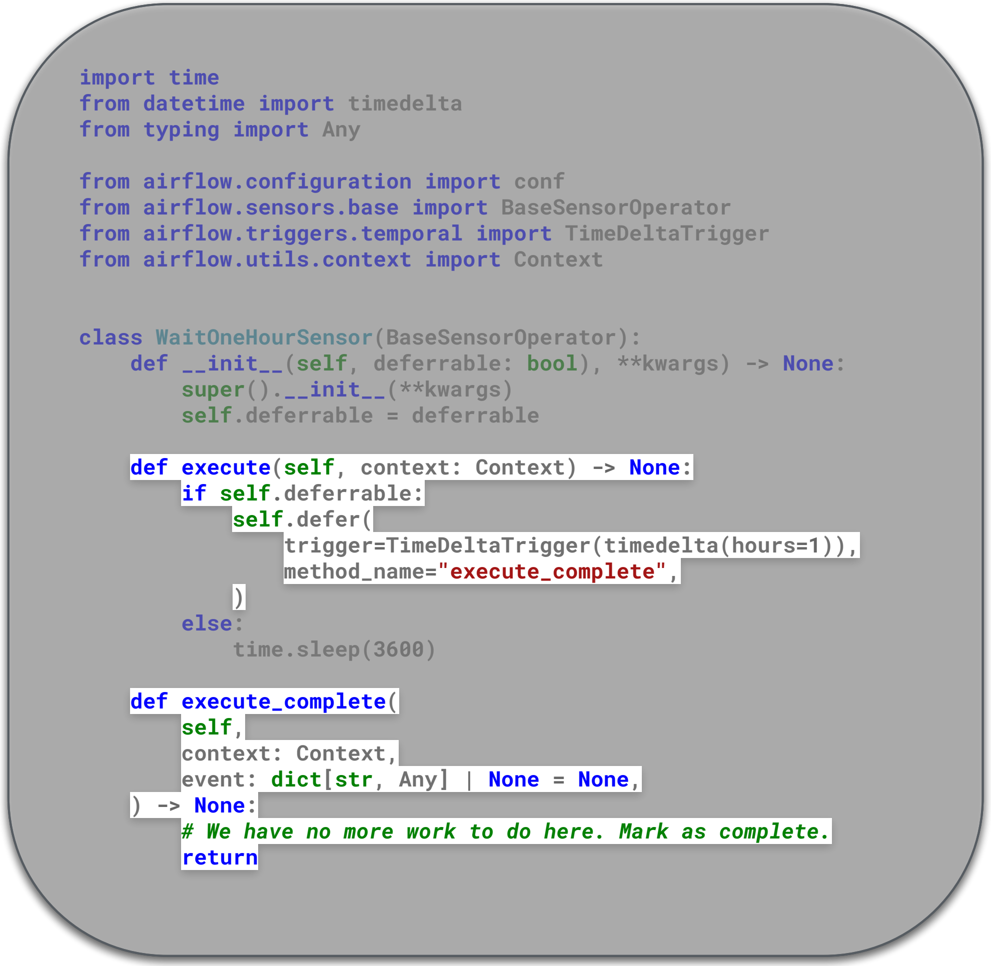
Sensor

Task B

Task C

https://airflow.apache.org/docs/apache-airflow/stable/authoring-and-scheduling/deferring.html#deferrable-operators-triggers

Asynchronous Sensors (Deferrable)



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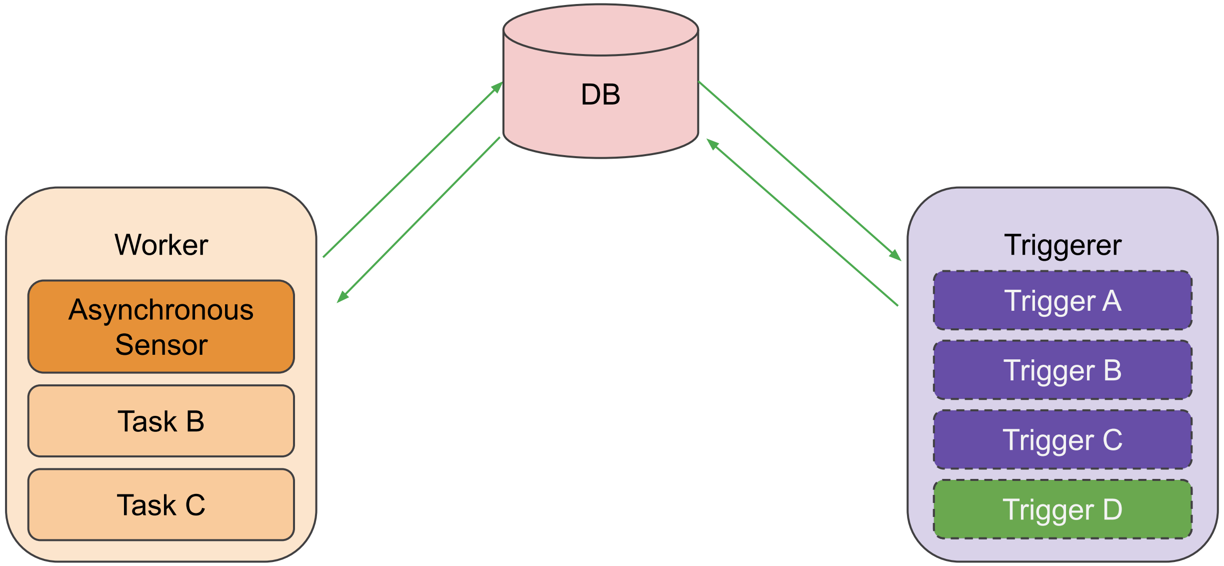

https://airflow.apache.org/docs/apache-airflow/stable/authoring-and-scheduling/deferring.html#deferrable-operators-triggers

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Failure and Delay Detection

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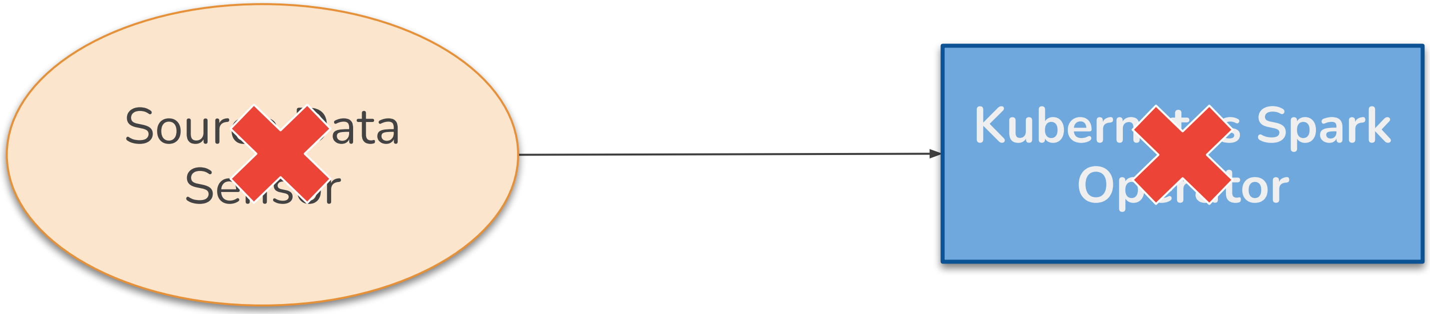
Failure Detection

```
dag.dagrun_timeout: timedelta
task.execution_timeout: timedelta
```

```
task.on_failure_callback: Callable
```



Accountable Owner

Failed:
- ➔ S3 client failure - rate limit
- ➔ Credentials issue

Delay Detection:
- ➔ Source File is not available in expected window

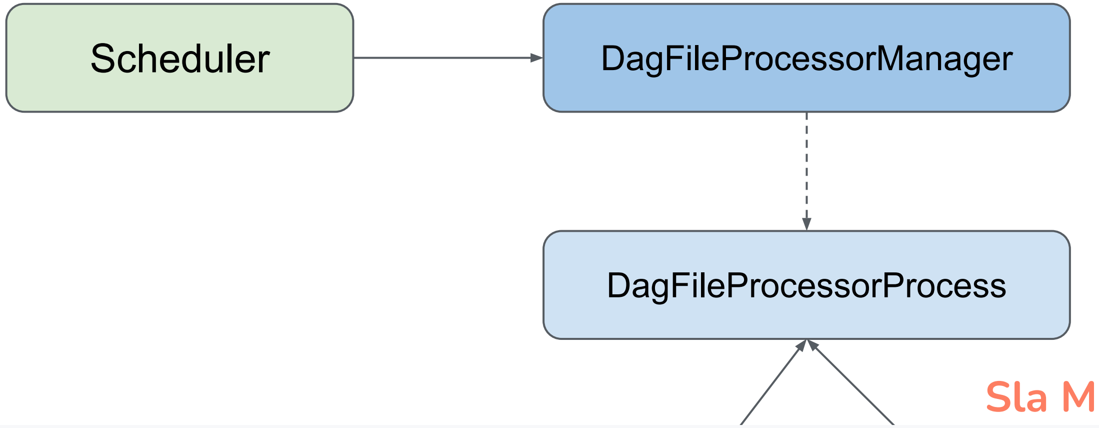
Failed:
- ➔ S3 client failure - rate limit
- ➔ Credentials issue
- ➔ Spark SQL transformation failure

Delay Detection:
- ➔ Undefined hanging Kubernetes Spark Job

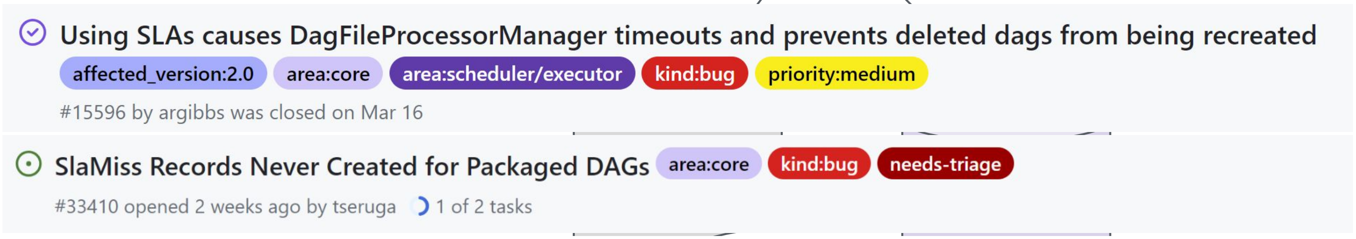
SLAs in Airflow (expected time of completion)

sort of works... with a lot of confusion... and with a lot of flaws

```
if start_date + sla < timezone.utcnow():
    sla_missed = True
```



Sla Missed??

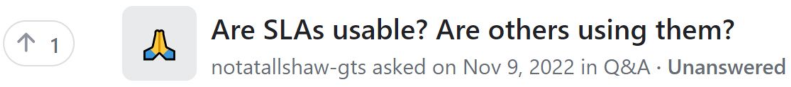


Using SLAs causes DagFileProcessorManager timeouts and prevents deleted dags from being recreated affected_version:2.0 area:core area:scheduler/executor kind:bug priority:medium

#15596 by argibbs was closed on Mar 16

SlaMiss Records Never Created for Packaged DAGs area:core kind:bug needs-triage

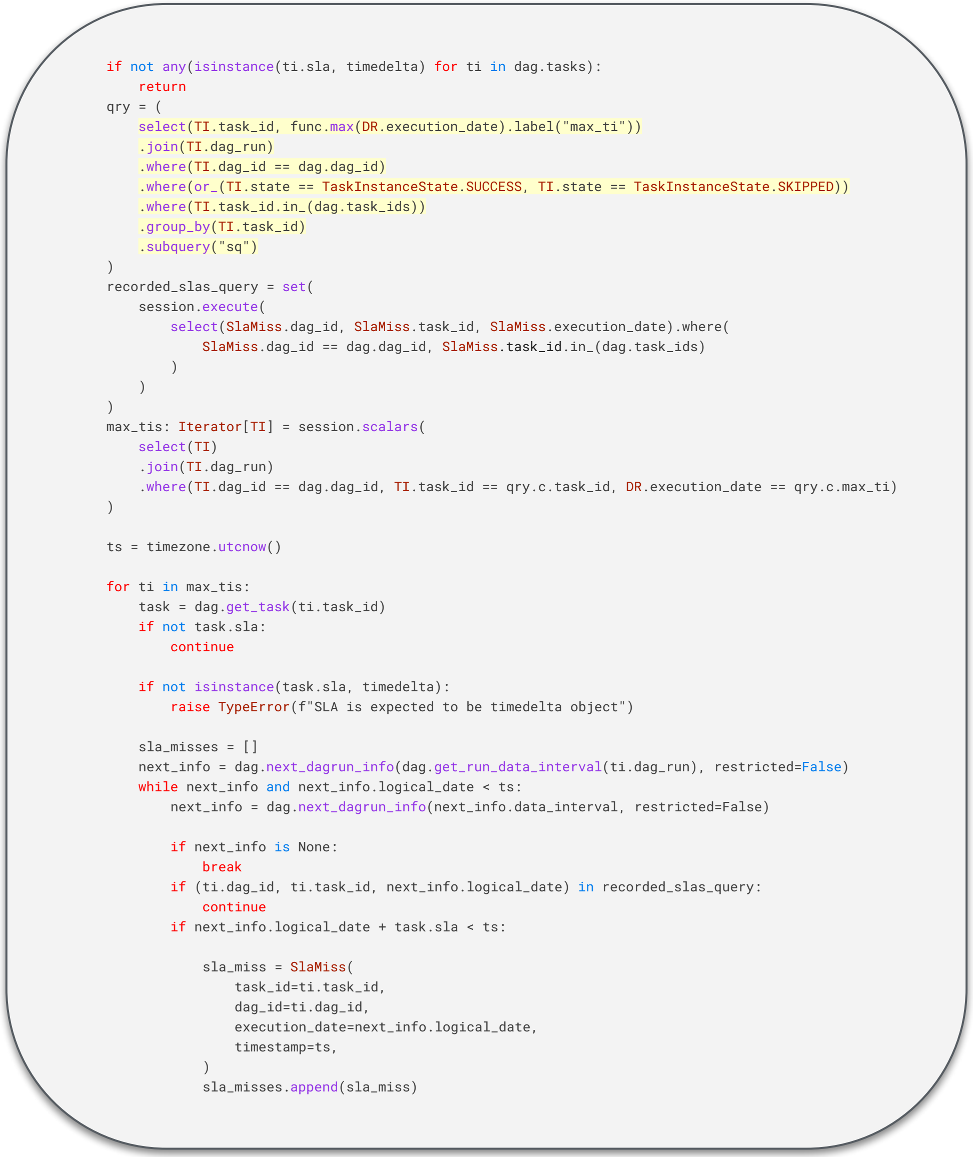
#33410 opened 2 weeks ago by tseruga 1 of 2 tasks



↑ 1 🙏 Are SLAs usable? Are others using them?

notatallshaw-gts asked on Nov 9, 2022 in Q&A · Unanswered

airflow.dag_processing.processor



```
if not any(isinstance(ti.sla, timedelta) for ti in dag.tasks):
    return
qry = (
    select(TI.task_id, func.max(DR.execution_date).label("max_ti"))
    .join(TI.dag_run)
    .where(TI.dag_id == dag.dag_id)
    .where(or_(TI.state == TaskInstanceState.SUCCESS, TI.state == TaskInstanceState.SKIPPED))
    .where(TI.task_id.in_(dag.task_ids))
    .group_by(TI.task_id)
    .subquery("sq")
)
recorded_slas_query = set(
    session.execute(
        select(SlaMiss.dag_id, SlaMiss.task_id, SlaMiss.execution_date).where(
            SlaMiss.dag_id == dag.dag_id, SlaMiss.task_id.in_(dag.task_ids)
        )
    )
)
max_tis: Iterator[TI] = session.scalars(
    select(TI)
    .join(TI.dag_run)
    .where(TI.dag_id == dag.dag_id, TI.task_id == qry.c.task_id, DR.execution_date == qry.c.max_ti)
)

ts = timezone.utcnow()

for ti in max_tis:
    task = dag.get_task(ti.task_id)
    if not task.sla:
        continue

    if not isinstance(task.sla, timedelta):
        raise TypeError(f"SLA is expected to be timedelta object")

    sla_misses = []
    next_info = dag.next_dagrun_info(dag.get_run_data_interval(ti.dag_run), restricted=False)
    while next_info and next_info.logical_date < ts:
        next_info = dag.next_dagrun_info(next_info.data_interval, restricted=False)

        if next_info is None:
            break
        if (ti.dag_id, ti.task_id, next_info.logical_date) in recorded_slas_query:
            continue
        if next_info.logical_date + task.sla < ts:

            sla_miss = SlaMiss(
                task_id=ti.task_id,
                dag_id=ti.dag_id,
                execution_date=next_info.logical_date,
                timestamp=ts,
            )
            sla_misses.append(sla_miss)
```

DAG or Task-level Feature?

Callback defined at DAG level,

but evaluated for each task

```
@dag(
    schedule="*/2 * * * *",
    start_date=pendulum.datetime(2021, 1, 1,
tz="UTC"),
    catchup=False,
    sla_miss_callback=sla_callback,
    default_args={"email": "email@example.com"},
)
def example_sla_dag():
    @task(sla=datetime.timedelta(seconds=10))
    def sleep_20():
        """Sleep for 20 seconds"""
        time.sleep(20)

    @task
    def sleep_30():
        """Sleep for 30 seconds"""
        time.sleep(30)

    sleep_20() >> sleep_30()


example_dag = example_sla_dag()
```

https://airflow.apache.org/docs/apache-airflow/stable/core-concepts/tasks.html#concepts-slas

Different Function Signature from Other Callbacks

Others

```python
def task_failure_alert(context):
    print(
         f"Task has failed, "
         "ti_key_str: {context['task_instance_key_str']}"
        )

def dag_success_alert(context):
    print(
         f"DAG has succeeded, "
         "run_id: {context['run_id']}"
        )
```

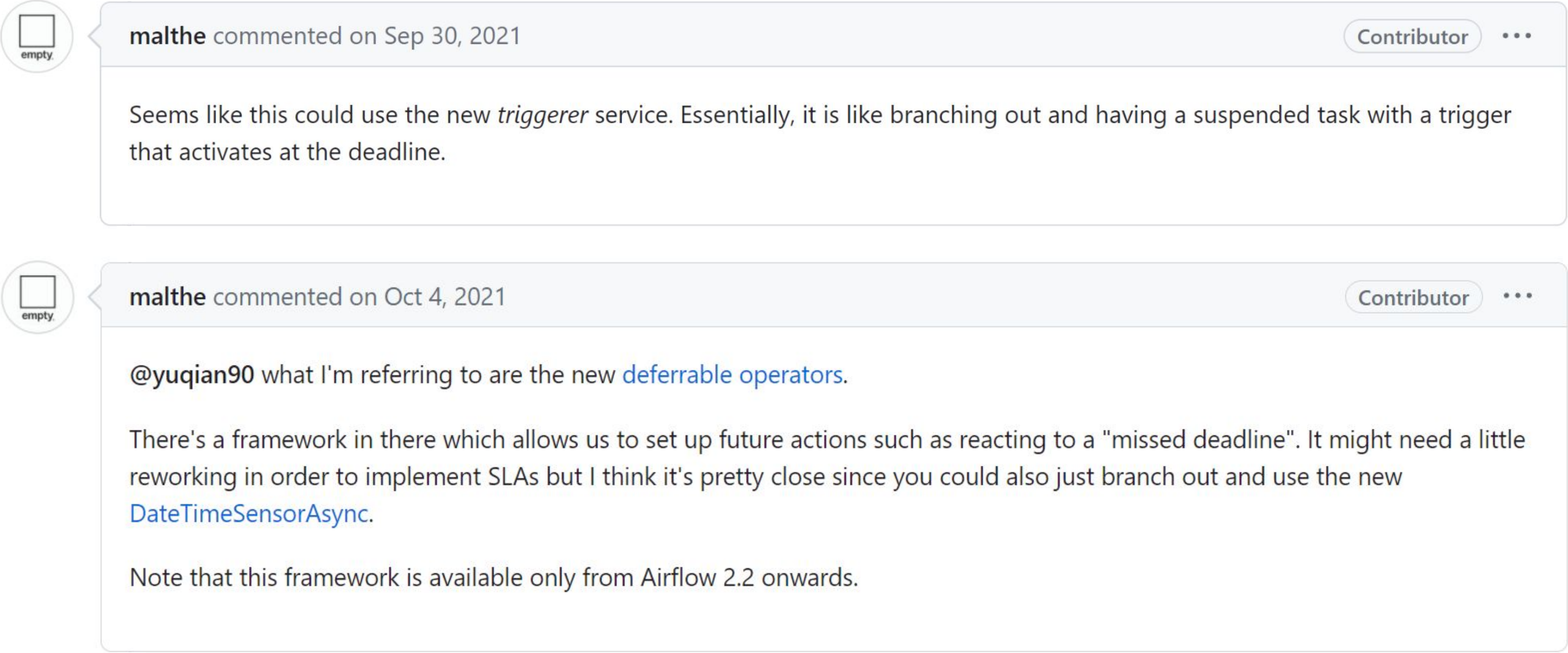
https://airflow.apache.org/docs/apache-airflow/stable/administration-and-deployment/logging-monitoring/callbacks.html#

SLA

```python
def sla_callback(
    dag,
    task_list,
    blocking_task_list,
    slas,
    blocking_tis
):
    print(
        "The callback arguments are: ",
        {
            "dag": dag,
            "task_list": task_list,
            "blocking_task_list": blocking_task_list,
            "slas": slas,
            "blocking_tis": blocking_tis,
        },
       )
```

https://airflow.apache.org/docs/apache-airflow/stable/core-concepts/tasks.html#concepts-slas

Custom SLAs



malthe commented on Sep 30, 2021

Seems like this could use the new *triggerer* service. Essentially, it is like branching out and having a suspended task with a trigger that activates at the deadline.

malthe commented on Oct 4, 2021

@yuqian90 what I'm referring to are the new deferrable operators.

There's a framework in there which allows us to set up future actions such as reacting to a "missed deadline". It might need a little reworking in order to implement SLAs but I think it's pretty close since you could also just branch out and use the new DateTimeSensorAsync.

Note that this framework is available only from Airflow 2.2 onwards.

Custom Operator: SLAMonitor

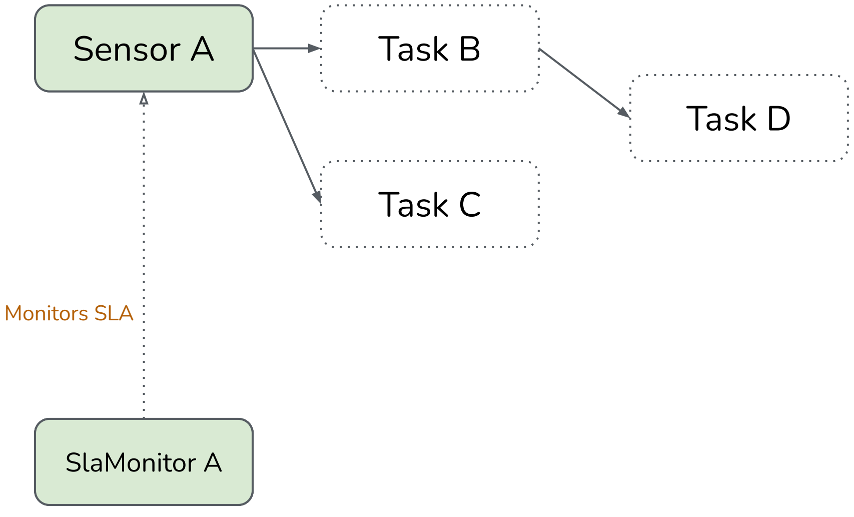
```python
from datetime import timedelta
from typing import Callable

from airflow.models.baseoperator import BaseOperator
from airflow.triggers.temporal import DateTimeTrigger
from airflow.utils.state import TaskInstanceState


class SlaMonitor(BaseOperator):
    def __init__(
        self,
        sla: timedelta,
        target_task_id: str,
        callback: Callable,
        **kwargs,
    ):
        super().__init__(**kwargs)
        self.sla = sla
        self.target_task_id = target_task_id

    def execute(self, context):
        # or define the SLA however else you see fit
        deadline = context[‘data_interval_end’] + self.sla
        self.defer(trigger=DateTimeTrigger(deadline), method_name=’execute_complete’)

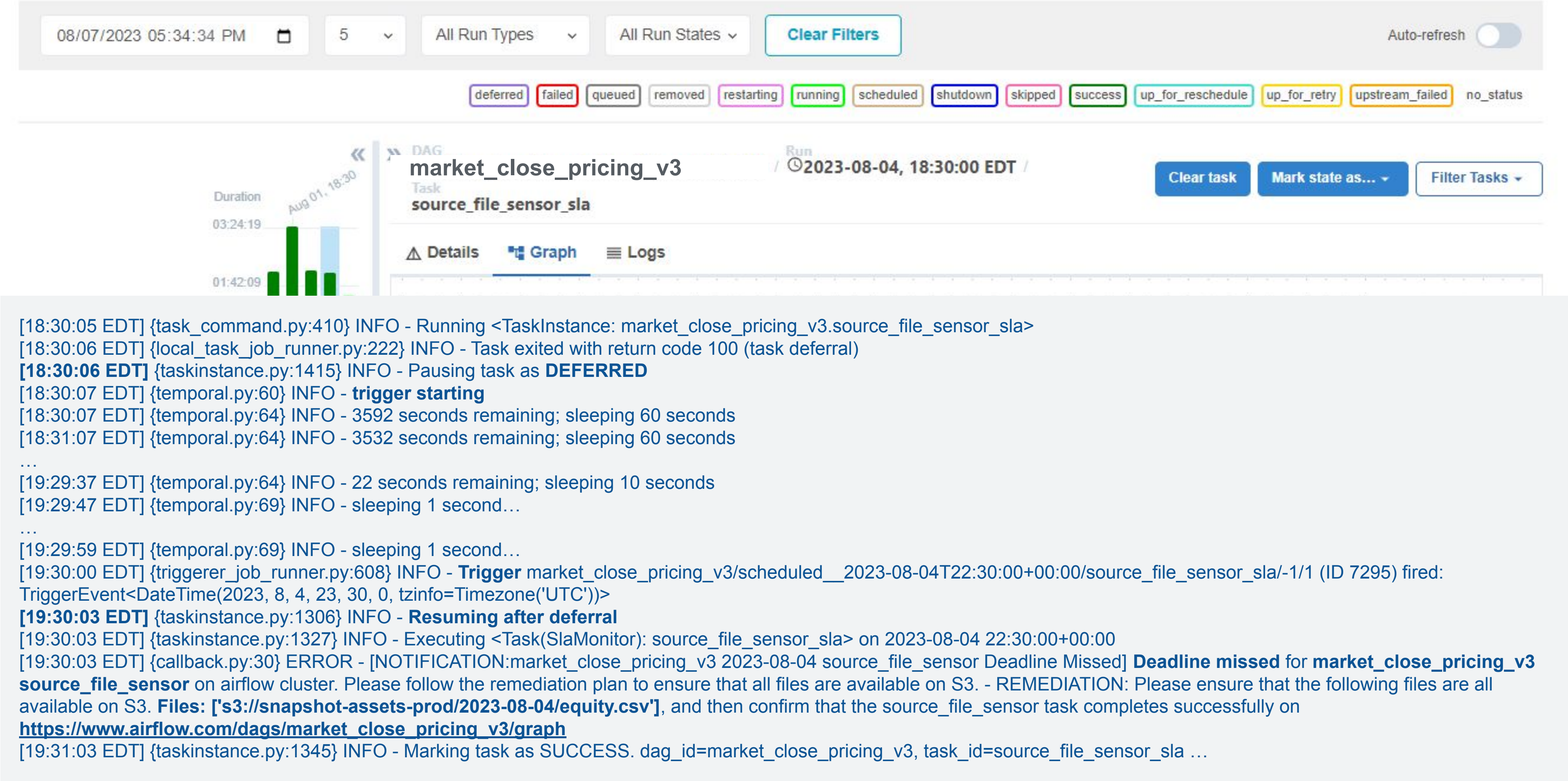
    def execute_complete(self, context, event=None):
        ti = context[‘dagrun’].get_task_instance(self.target_task_id)
        if ti and ti.state == TaskInstanceState.SUCCESS:
            self.log.info("SUCCEEDED")
            return
        else:
            # replace this with your choice of sla callback function
            self.log.error("Sla was just missed!!")
            self.callback(context)
            return
```



Executes callback -> “Sla was just missed!!”

Deferred for 1 hour

Custom Operator: SLAMonitor



```
[18:30:05 EDT] {task_command.py:410} INFO - Running <TaskInstance: market_close_pricing_v3.source_file_sensor_sla>
[18:30:06 EDT] {local_task_job_runner.py:222} INFO - Task exited with return code 100 (task deferral)
[18:30:06 EDT] {taskinstance.py:1415} INFO - Pausing task as DEFERRED
[18:30:07 EDT] {temporal.py:60} INFO - trigger starting
[18:30:07 EDT] {temporal.py:64} INFO - 3592 seconds remaining; sleeping 60 seconds
[18:31:07 EDT] {temporal.py:64} INFO - 3532 seconds remaining; sleeping 60 seconds
…
[19:29:37 EDT] {temporal.py:64} INFO - 22 seconds remaining; sleeping 10 seconds
[19:29:47 EDT] {temporal.py:69} INFO - sleeping 1 second…
…
[19:29:59 EDT] {temporal.py:69} INFO - sleeping 1 second…
[19:30:00 EDT] {triggerer_job_runner.py:608} INFO - Trigger market_close_pricing_v3/scheduled__2023-08-04T22:30:00+00:00/source_file_sensor_sla/-1/1 (ID 7295) fired:
TriggerEvent<DateTime(2023, 8, 4, 23, 30, 0, tzinfo=Timezone('UTC'))>
[19:30:03 EDT] {taskinstance.py:1306} INFO - Resuming after deferral
[19:30:03 EDT] {taskinstance.py:1327} INFO - Executing <Task(SlaMonitor): source_file_sensor_sla> on 2023-08-04 22:30:00+00:00
[19:30:03 EDT] {callback.py:30} ERROR - [NOTIFICATION:market_close_pricing_v3 2023-08-04 source_file_sensor Deadline Missed] Deadline missed for market_close_pricing_v3
source_file_sensor on airflow cluster. Please follow the remediation plan to ensure that all files are available on S3. - REMEDIATION: Please ensure that the following files are all
available on S3. Files: ['s3://snapshot-assets-prod/2023-08-04/equity.csv'], and then confirm that the source_file_sensor task completes successfully on
https://www.airflow.com/dags/market_close_pricing_v3/graph
[19:31:03 EDT] {taskinstance.py:1345} INFO - Marking task as SUCCESS. dag_id=market_close_pricing_v3, task_id=source_file_sensor_sla …
```

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from airflow.utils.state import TaskInstanceState


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        self,
        sla: timedelta,
        target_task_id: str,
        callback: Callable,
        **kwargs,
    ):
        super().__init__(**kwargs)
        self.sla = sla
        self.target_task_id = target_task_id

    def execute(self, context):
        # or define the SLA however else you see fit
        deadline = context[‘data_interval_end’] + self.sla
        self.defer(trigger=DateTimeTrigger(deadline), method_name=’execute_complete’)

    def execute_complete(self, context, event=None):
        ti = context[‘dagrun’].get_task_instance(self.target_task_id)
        if ti and ti.state == TaskInstanceState.SUCCESS:
            self.log.info("SUCCEEDED")
            return
        else:
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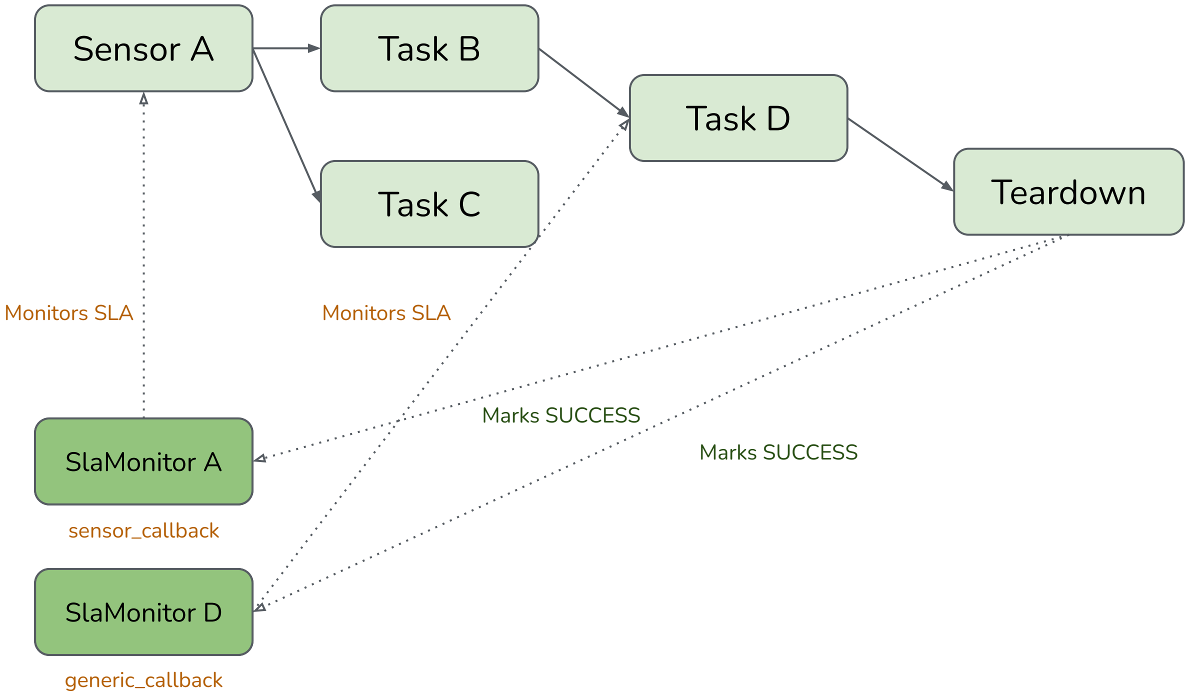
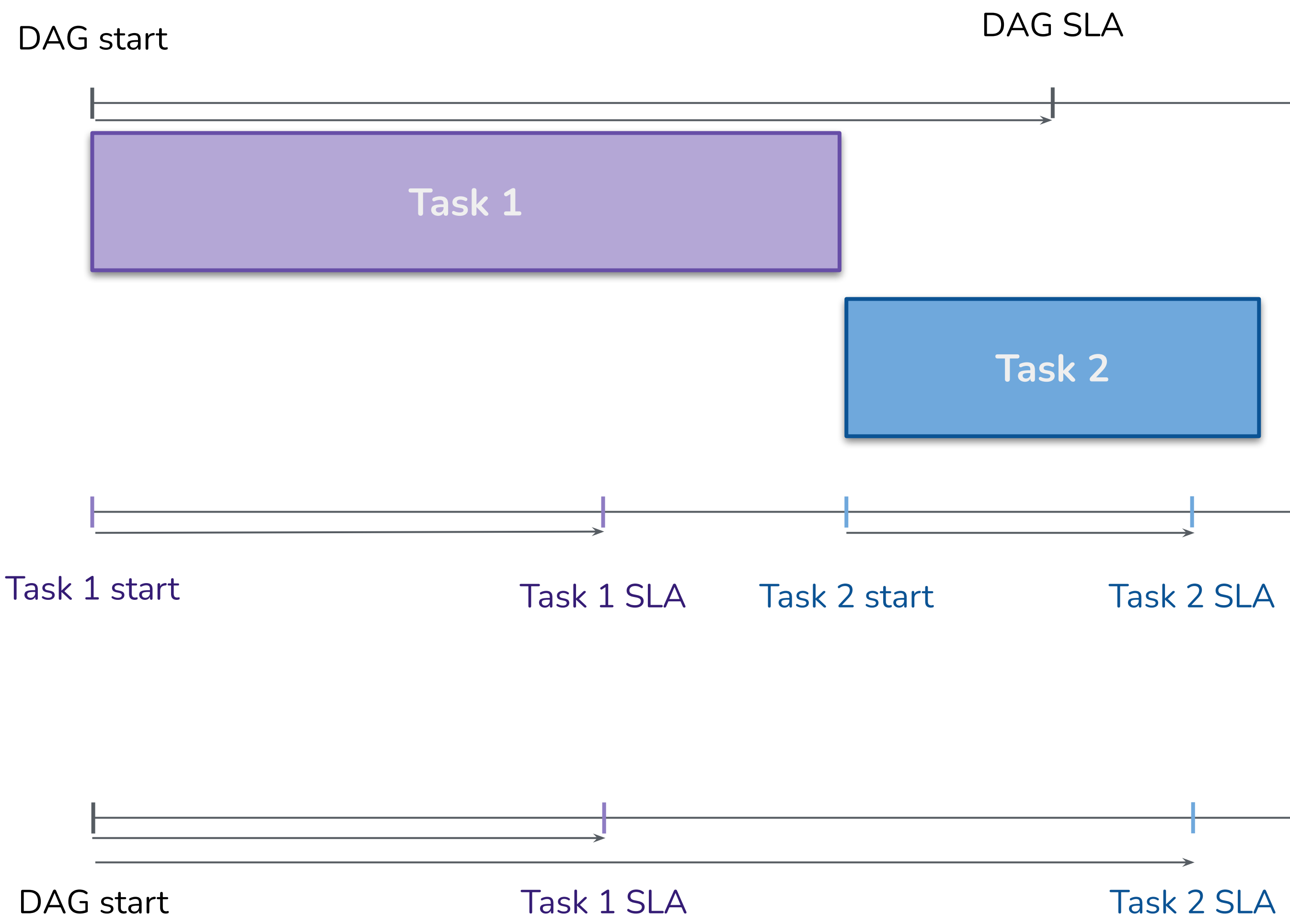
            self.log.error("Sla was just missed!!")
            self.callback(context)
            return
```



Questions?

https://www.linkedin.com/in/sung-yun-33451688

Future of SLAs?



DAG SLA measured within a DagRun

Task SLA measured within a Task Instance

Other definitions of SLAs as Custom Operators:
Costly to manage in Airflow Core

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