# Deep dive into Airflow's Scheduler

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# Scheduler: The load-bearing infinite loop of Apache Airflow

Thank you for coming to my talk

# Responsibilities of the scheduler

Start tasks on schedule

Check dependencies between tasks

Manage retries

Ensure task is actually still running

Deal with DST transitions

Be highly-available

SLAs

Trigger success/failure callbacks

Cope with changing DAG structure

Enforce concurrency limits

Emit metrics

Support trigger rules (one success, any failed etc.) including custom ones

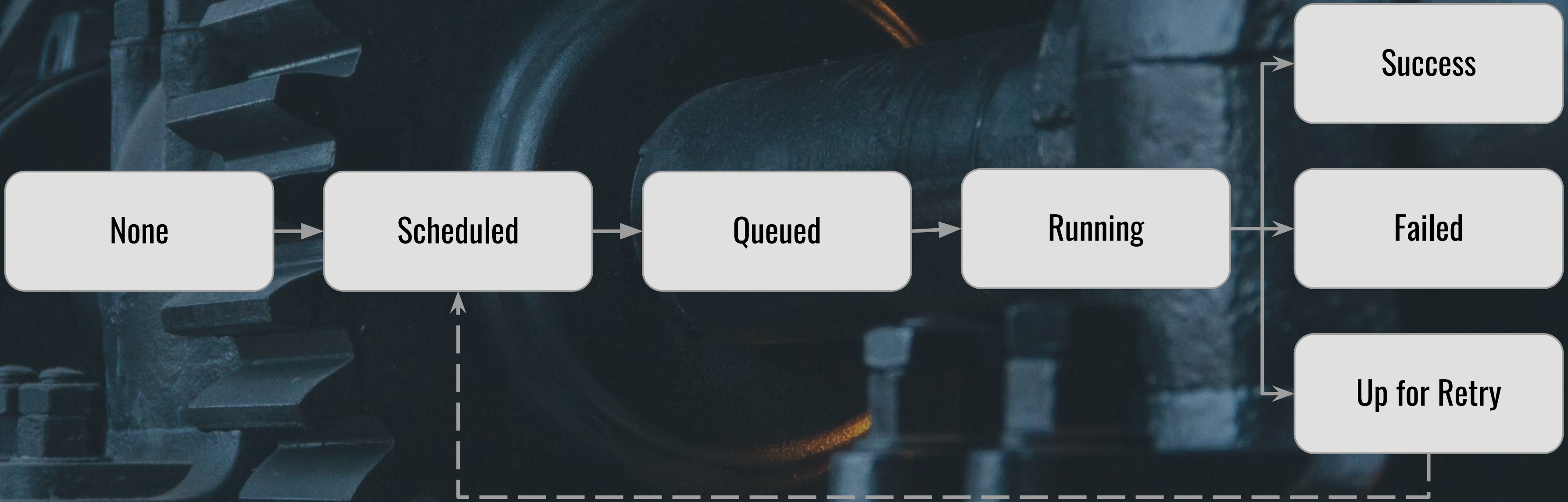
Respect differing start_dates for tasks

# Scheduler components

| | |
|---|---|
| SchedulerJob | ← State Machine for tasks and dag runs |
| Executor | ← Handles actual task execution |
| DagFileProcessor | ← Parses DAGs into serialized_dags table |

# "The" Scheduler

📦airflow.jobs.scheduler_job



None

Scheduled

Queued

Running

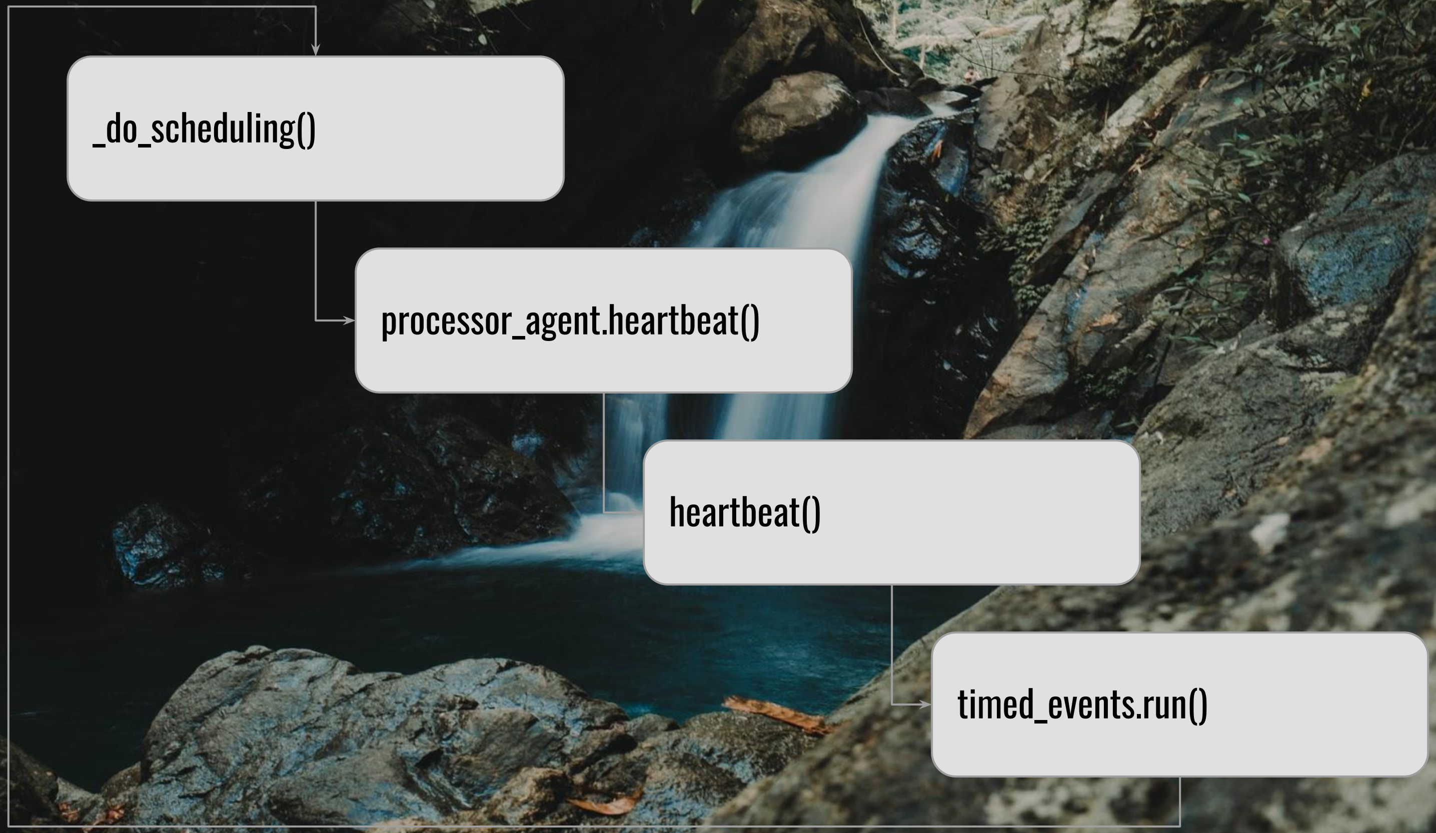
Success

Failed

Up for Retry

# Never load DAG code in to a long-running process

# Scheduling decisions are only made upon serialized DAG representation



_do_scheduling()

processor_agent.heartbeat()

heartbeat()

timed_events.run()

# SchedulerJob._do_scheduling()

```
self._create_dagruns_for_dags()

self._start_queued_dagruns()

dag_runs = self._get_next_dagruns_to_examine(State.RUNNING)
for dag_run in dag_runs:
    self._schedule_dag_run(dag_run)

num_queued_tis = self._critical_section_execute_task_instances()
```

# SchedulerJob._do_scheduling()

```
self._create_dagruns_for_dags()

self._start_queued

dag_runs = self._g
for dag_run in dag
    self._schedule

num_queued_tis = s                                                       )
```

For each DAG* needing a DagRun to be created (`next_dagrun_create_after < NOW()`):

- Create the dag run from the serialized representation
- Update next DagRun info columns on DAG table (`next_dagrun, next_dagrun_create_after`)

# SchedulerJob._do_scheduling()

```
self._create_dagruns_for_dags()

self._start_queued_dagruns()

dag_runs = self._g
for dag_run in dag
    self._schedule

num_queued_tis = self._critical_section_execute_task_instances()
```

For each DAG in 'queued' state:

- Check number of already running DagRuns against dag.max_active_runs
- If below limit set state to 'running'

# SchedulerJob._do_scheduling()

```
self._create_dagruns_for_dags()

self._start_queued_dagruns()

dag_runs = self._get_next_dagruns_to_examine(State.RUNNING)
for dag_run in dag_runs:
    self._schedule_dag_run(dag_run)

num_queued_tis = self._critical_section_execute_task_instances()
```

Get next *n* "oldest" DagRuns in 'running' state'

# SchedulerJob._do_scheduling()

```
self._create_dagruns

self._start_queued_d

dag_runs = self._get
for dag_run in dag_r
    self._schedule_dag_run(dag_run)

num_queued_tis = self._critical_section_execute_task_instances()
```

Check DagRun timeouts

Check if DAG structure (tasks) has changed

Compute which TaskInstances can now be 'scheduled' (via the currently-misnamed `DagRun.update_state` method)

Pass pending callbacks to DagFileProcessorManager

# SchedulerJob._do_scheduling()

```
self._create_dagruns_for_dags()

self._start_queued_dagruns()

dag_runs = self._get_next_dagruns_to_examine(State.RUNNING)
for dag_run in dag_runs:
    self._schedule_d

num_queued_tis = self._critical_section_execute_task_instances()
```

Check concurrency limits, and send as many tasks as possible to the executor

# Before enqueueing a TaskInstance

Checks that must pass:

- Enough open pool slots available for task (can be >1 slot per task)
- Per DAG max_active_tasks limit
- Per (DAG, Task) task_concurrency limit
- Executor slots available (parallelism)

Everything else (task state, upstream etc) is checked before TaskInstance is put in to "scheduled" state

# Executor

Send TaskInstance to runner to *actually* execute

# Executor interface

(Interface/responsibilities between Scheduler and Executor needs clarification)

Tasks report their own status directly back to DB

Executor responsible for watching when tasks *don't* do this

State kept *in memory*

# DAG parsing

# 📦`airflow.dag_processing`

Sole place where user DAG code is loaded

Previously split across `airflow.job.scheduler_job` and `airflow.utils.dag_processing`

# DagFileProcessorManager

Subprocess of main `airflow scheduler` command

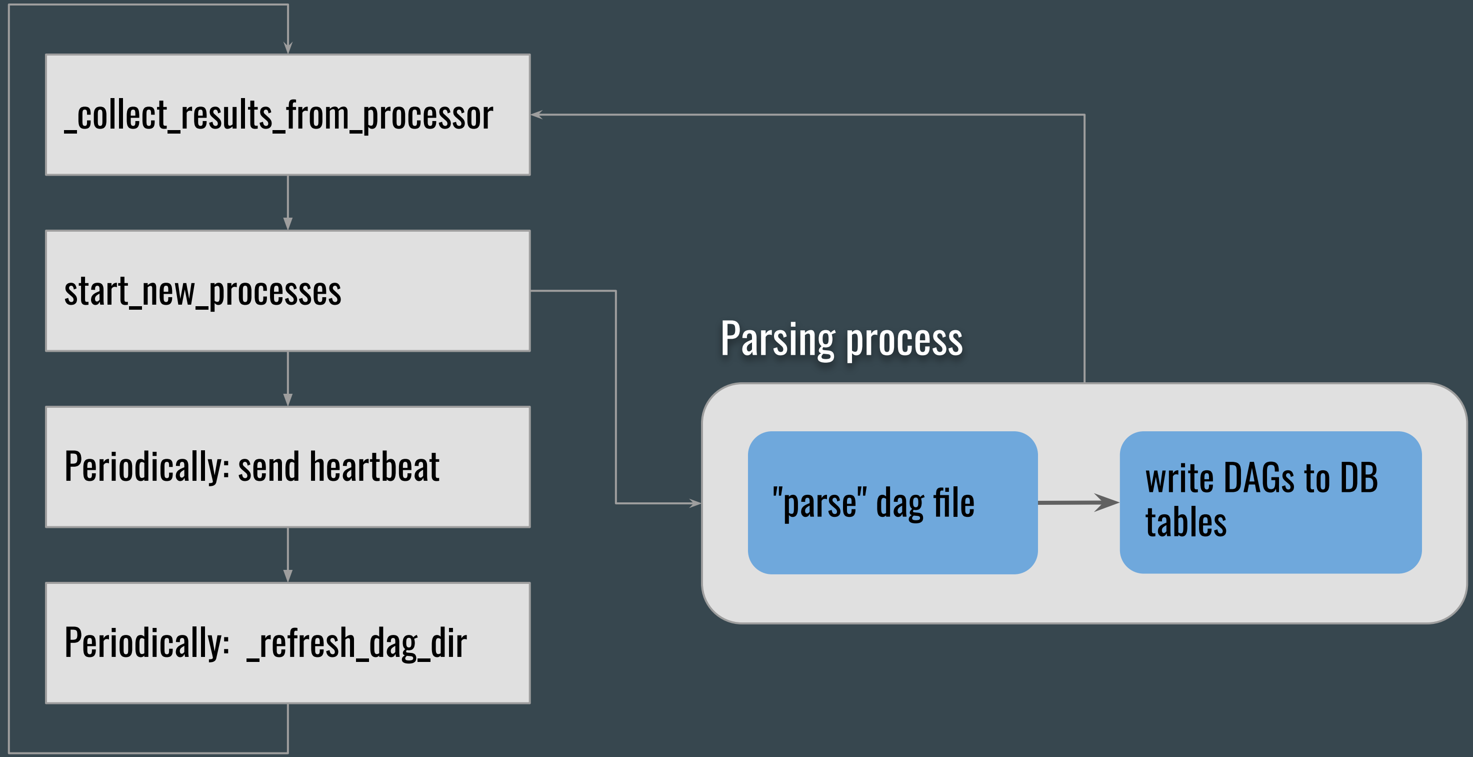
Infinite loop.

Maintains a pool of subprocess that:

- Parse a DAG file in to serialized_dag table
- Execute any pending DAG level callbacks

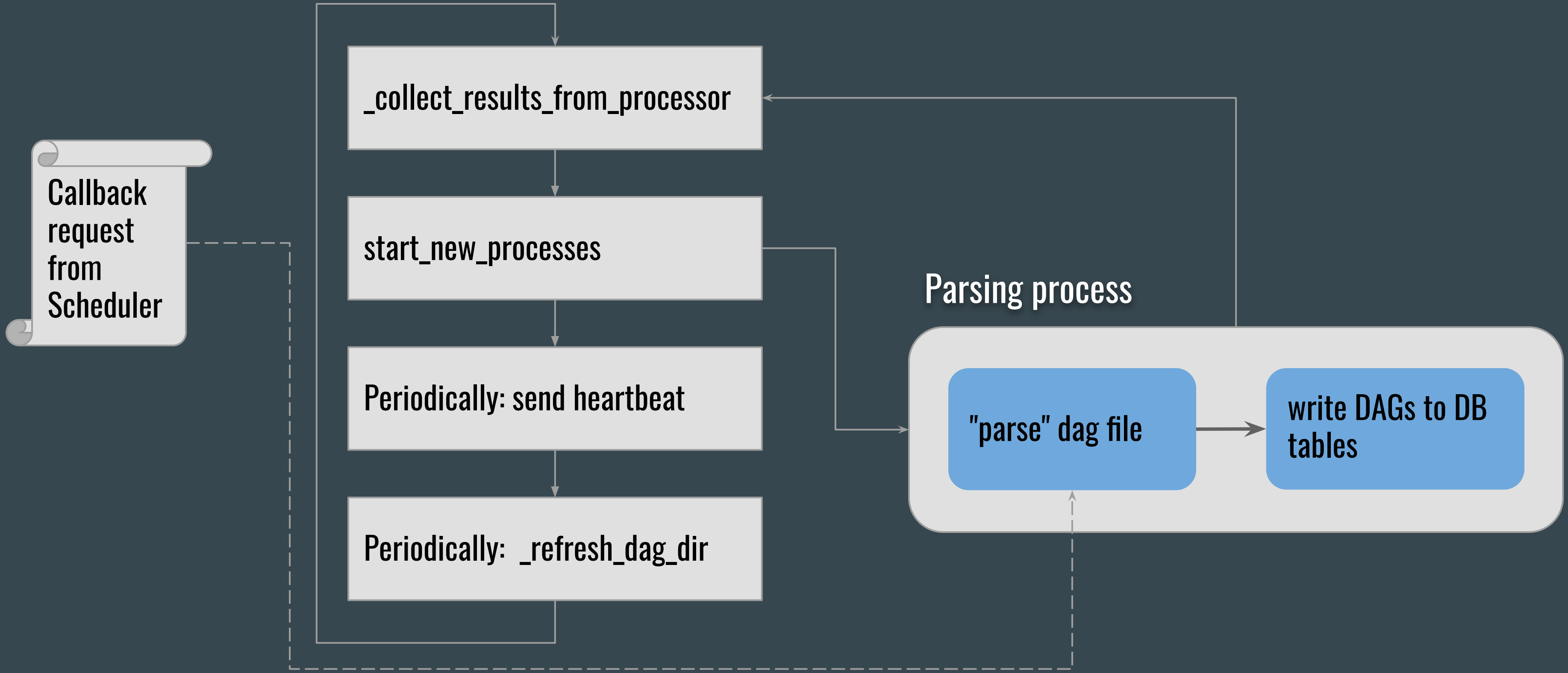
Periodically checks for new DAG files being added

# DagFileProcessorManager._run_parsing_loop



_collect_results_from_processor
start_new_processes
Periodically: send heartbeat
Periodically:  _refresh_dag_dir
Parsing process
"parse" dag file
write DAGs to DB tables

# DagFileProcessorManager._run_parsing_loop



Callback request from Scheduler
_collect_results_from_processor
start_new_processes
Periodically: send heartbeat
Periodically:  _refresh_dag_dir
Parsing process
"parse" dag file
write DAGs to DB tables

# High Availability

# Use the existing metadata DB for synchronisation

## Scheduler 1

```
SELECT * FROM task_instance
LIMIT 2
```

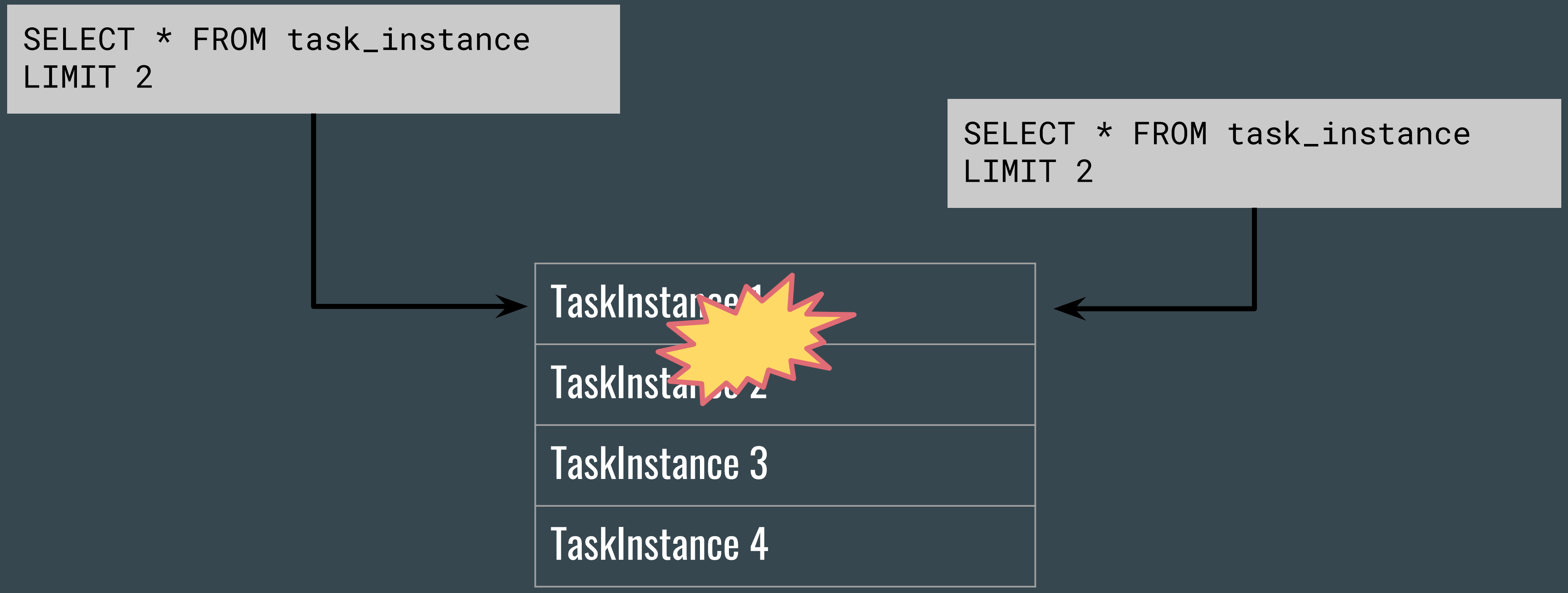
## Scheduler 2

```
SELECT * FROM task_instance
LIMIT 2
```

| |
|---|
| TaskInstance 1 |
| TaskInstance 2 |
| TaskInstance 3 |
| TaskInstance 4 |

## Scheduler 1

## Scheduler 2



```
SELECT * FROM task_instance
LIMIT 2
```

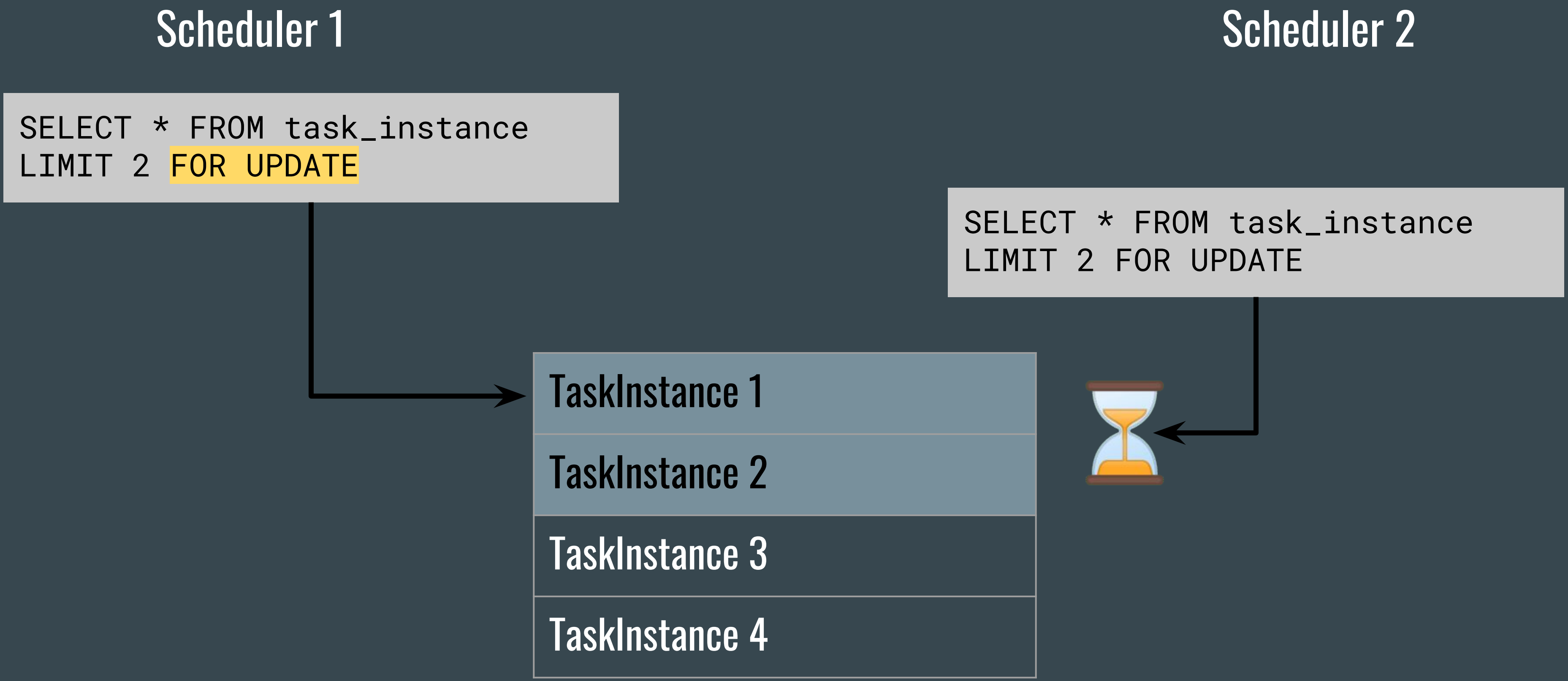
```
SELECT * FROM task_instance
LIMIT 2
```

TaskInstance 1

TaskInstance 2

TaskInstance 3

TaskInstance 4



Scheduler 1

```
SELECT * FROM task_instance
LIMIT 2 FOR UPDATE
```

Scheduler 2

```
SELECT * FROM task_instance
LIMIT 2 FOR UPDATE
```

TaskInstance 1

TaskInstance 2

TaskInstance 3

TaskInstance 4

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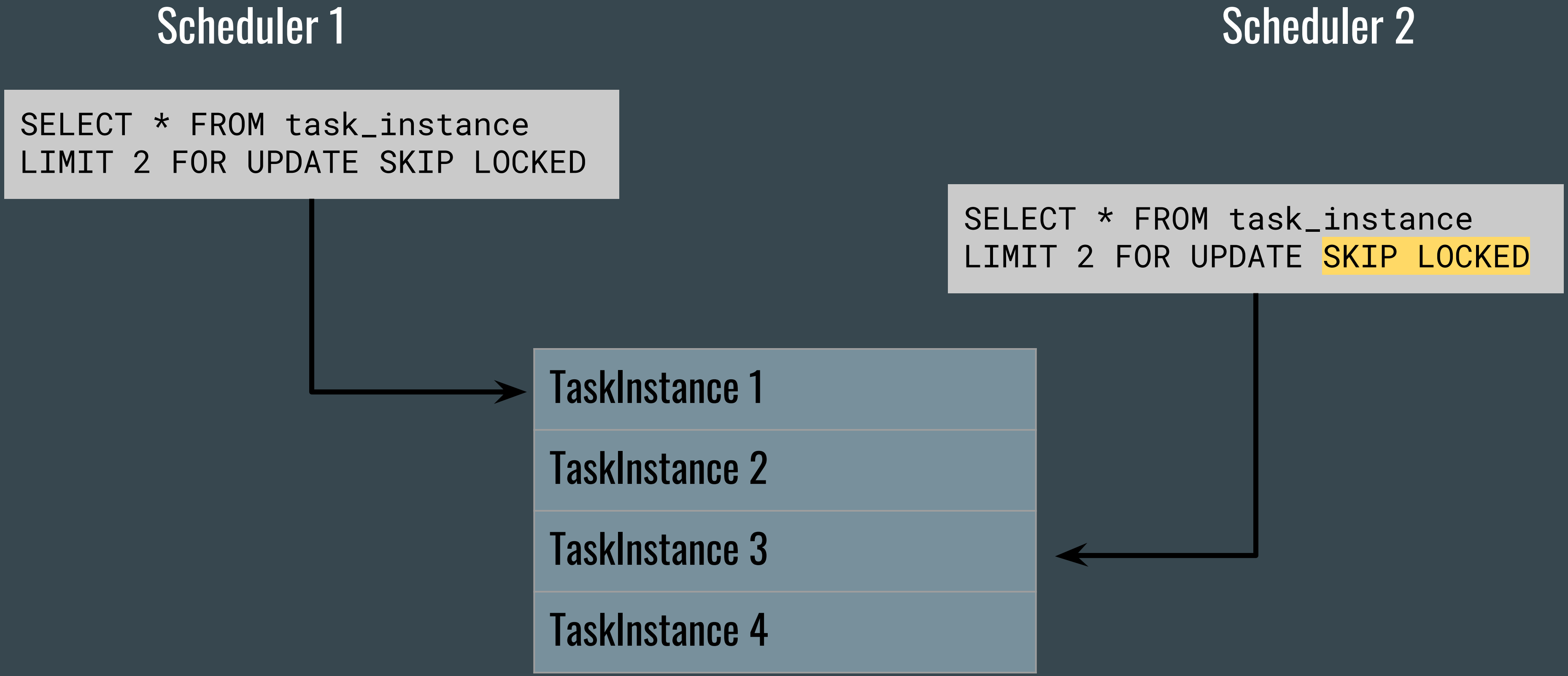


Scheduler 1

```
SELECT * FROM task_instance
LIMIT 2 FOR UPDATE SKIP LOCKED
```

Scheduler 2

```
SELECT * FROM task_instance
LIMIT 2 FOR UPDATE SKIP LOCKED
```

TaskInstance 1

TaskInstance 2

TaskInstance 3

TaskInstance 4

# SchedulerJob._do_scheduling()

```
self._create_dagruns_for_dags()

self._start_queued_dagruns()

dag_runs = self._get_next_dagruns_to_examine(State.RUNNING)
for dag_run in dag_runs:
    self._schedule_dag_run(dag_run)

num_queued_tis = self._critical_section_execute_task_instances()
```

# SchedulerJob._do_scheduling()

```python
with prohibit_commit(session) as guard:
    self._create_dagruns_for_dags(guard)

    self._start_queued_dagruns(session)
    guard.commit()
    dag_runs = self._get_next_dagruns_to_examine(State.RUNNING, session)
    for dag_run in dag_runs:
        self._schedule_dag_run(dag_run)
    guard.commit()
    num_queued_tis = self._critical_section_execute_task_instances()
```

# _critical_section_execute_task_instances

```
SELECT * FROM pool FOR UPDATE NOWAIT;
```

```
SELECT * FROM pool FOR UPDATE NOWAIT;
```

If we can't lock any rows, abort rather than wait

# Adopting tasks

Periodically detect dead schedulers

"Adopt" tasks from dead executors

Means a scheduler/executor can go away (or partition) at any point

Active-active model.

# Other responsibilities

Detecting dead schedulers

"Adopting" tasks from dead schedulers

Detecting zombie tasks

Managing SLAs

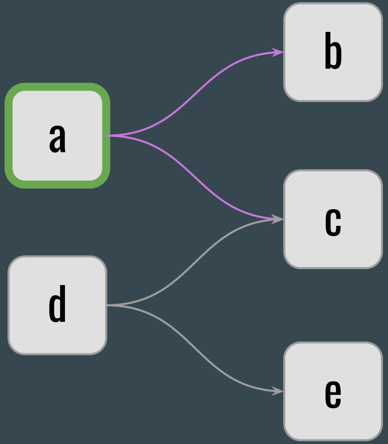
# Optimization: check downstream states after task completion

After a Task executes, we have all the info to check it's downstream tasks.

Only goes as far as 'scheduled'

If "a" just finished, we can *possibly* schedule tasks b and c

Happens in the worker!



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# Questions?