



Lessons learned for scaling up Airflow 3 in Public Cloud

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3.0



Nice to meet you!

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Nice to meet you!

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Agenda

- Performance testing framework
- Test results
 - Airflow 3 vs Airflow 2
 - Tweaking various parameters
- Conclusions



Performance Framework

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Goals

- Compare Airflow 2 and Airflow 3
- Test scaling limits
- Make the tests
 - easy to run
 - reproducible
- Continuously monitor Airflow code performance





Testing framework – AIP-59

- Test performance of Airflow components
- Detect performance changes between Airflow versions
- Improve transparency of performance changes in Apache Airflow releases
- Identify changes that have impact on performance
- Let users test their setup





Testing framework - concepts

- **Instance** – definition of Airflow installation setup
- **Performance DAG** – definition of DAG that is executed during the test
- **Test suite** – combination of Instance and Performance DAG



Testing framework - instance

- Instance type – e.g. Docker Compose, Kubernetes
- number of schedulers and workers
- component CPU and memory
- machine types

Instance configuration file can include Jinja style placeholders that are populated in Test suite





Instance config

Sample configuration with template parameters

```
{  
    "environment_type": "VANILLA_GKE",  
    "project_id": "{{project_id}}",  
    "airflow_image_tag": "{{airflow_image_tag}}",  
    "docker_image": "{{docker_image}}",  
    "env_variable_sets": {{env_variable_sets}},  
    "helm_chart_sets": {{helm_chart_sets}},  
    "force_routing": {{force_routing}},  
    "values_file": "{{values_file}}",  
    "cluster_config": {  
        "name": "{{cluster_id}}",  
        "locations": [  
            "{{zone_id}}"  
        ],  
        "node_pools": [  
            {  
                "name": "default-pool",  
                "config": {  
                    "machine_type": "{{machine_type}}",  
                    "disk_size_gb": {{disk_size_gb}},  
                    "oauth_scopes": ["https://www.googleapis.com/auth/cloud-platform"],  
                },  
                "initial_node_count": {{node_count}}  
            }  
        ],  
        "default_max_pods_constraint": {  
            "max_pods_per_node": {{max_pods_per_node}}  
        },  
        "network_config": {  
            "network": "projects/{{project_id}}/global/networks/{{network_id}}",  
            "subnetwork": "projects/{{project_id}}/regions/{{location_id}}/subnetworks/{{subnet_id}}"  
        },  
        "ip_allocation_policy": {  
            "use_ip_aliases": {{use_ip_aliases}}  
        },  
        "node_pool_labels": {{node_pool_labels}}  
    }  
}
```



Testing framework - performance DAG

Example configuration options:

- `PERF_DAG_FILES_COUNT`
- `PERF_DAGS_COUNT`
- `PERF_TASKS_COUNT`
- `PERF_SHAPE` - “no_structure”, “linear”, “binary_tree”, “star”, “grid”
- `PERF_OPERATOR_TYPE` - “python”, “bash”, etc.



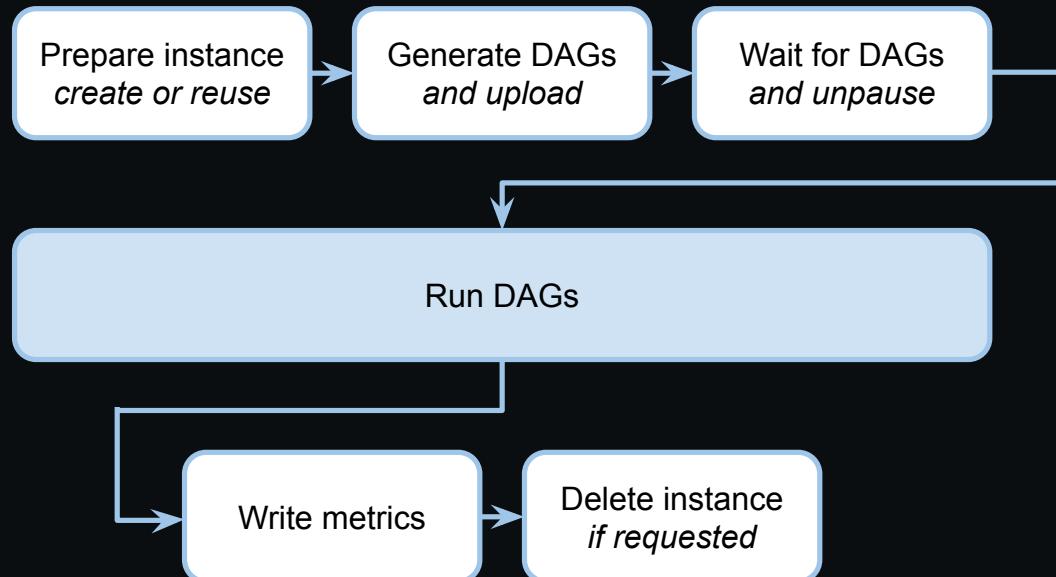
Test suite

- multiple tests in a single “study”
- load template values from file
- override at any level

```
1  {
2      "study_components": [
3          {
4              "component_name": "vanilla_gke_airflow_2",
5                  "args": {
6                      "environment_specification_file_path": "configurations/config_generic.json",
7                      "jinja_variables": {
8                          "airflow_image_tag": "2.10.5"
9                      }
10                 }
11            },
12            {
13                "component_name": "vanilla_gke_airflow_3",
14                    "args": {
15                        "environment_specification_file_path": "configurations/config_generic.json",
16                        "jinja_variables": {
17                            "airflow_image_tag": "3.0.0"
18                        }
19                    }
20            }
21        ],
22        "default_args": {
23            "results_project_id": "airflow-performance-tests",
24            "results_dataset": "airflow-performance-tests-dataset",
25            "jinja_variables": {
26                "location_id": "us-central1",
27                "machine_type": "n1-standard-8",
28                "node_count": "6",
29                "values_file": "values/environment.yaml"
30            }
31        },
32        "default_flags": [
33            "delete_if_exists",
34            "delete_upon_finish"
35        ],
36        "default_attempts": 3
37    }
```



Testing framework - test suite





Results – metrics

- Resource utilization
 - CPU
 - Memory
 - Network
- Monitored components
 - Worker
 - Scheduler
 - Triggerer
 - database
- Durations
 - Total time
 - DAG run time
 - Task run time



How are the results stored?

- CSV files
- BigQuery tables
- Low-level metrics
- High-level statistics

Row	Id	run_at	configuration	configuration_id	airflow_sched...	airflow_sc...	airflow_sche...	airflow_sch...	airflow_sche...	airflow_sched...
2	415...	2025-09-24T09:15:31	{"AIRFLOW__CORE__STO...": "Unknown", "airflow_version": "3.0.0", "composer_api_endpoint": "http://localhost:5050"}	5bb3ee69238...	0.442061658...	0.44	112390144.0	112.39 MB	695173120.0	695.17 MB
3	8a2...	2025-09-26T16:46:09	{"AIRFLOW__CORE__STO...": "Unknown", "airflow_version": "2.10.5", "composer_api_endpoint": "http://localhost:5050"}	ecfcf653994a...	1.1774829652...	1.18	155245468.9...	155.25 MB	941590098.5...	941.59 MB
4	3c5...	2025-09-24T09:15:31	{"AIRFLOW__CORE__STO...": "Unknown", "airflow_version": "2.10.5", "composer_api_endpoint": "http://localhost:5050"}	fd6eb285e31...	0.423571309...	0.42	155912192.0	155.91 MB	833375232.0	833.38 MB
5	b5ff...	2025-09-22T14:57:00	{"AIRFLOW__CORE__STO...": "Unknown", "airflow_version": "2.10.5", "composer_api_endpoint": "http://localhost:5050"}	bf2afe18d8ab8...	0.596778456...	0.60	103871093.1...	103.87 MB	582683761.7...	582.68 MB
6	93a...	2025-09-25T09:02:19	{"AIRFLOW__CORE__STO...": "Unknown", "airflow_version": "3.0.0", "composer_api_endpoint": "http://localhost:5050"}	27493d941c1...	1.7942445586...	1.79	110429440.0	110.43 MB	1011907072.0	1.01 GB

Performance Test Results

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Baseline scenario

Instance setup

- Google Kubernetes Engine (GKE)
- 6 workers (2 vCPU, 7.5 GB memory, 20 GB disk)
- 2 schedulers (1 vCPU, 4 GB memory, 5 GB storage)
- Postgres database



Tests overview

- Airflow 3.0.0
- Airflow 2.10.5
- 10 DAGs with z tasks each ($n = 10z$)
 - $n = 100, 1k, 5k, 10k$
 - No-op python operator tasks

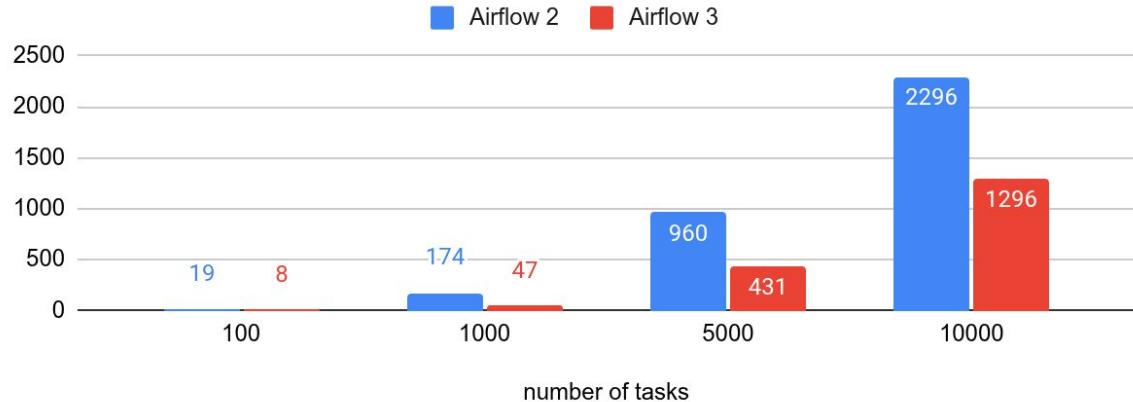


Airflow 2 vs Airflow 3

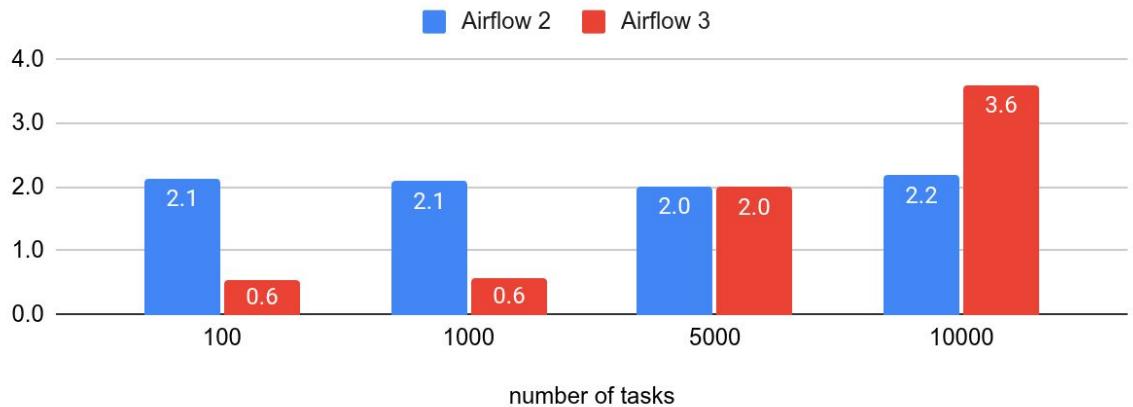
Test total duration

Task average duration

Test duration [seconds]



Average task duration [seconds]

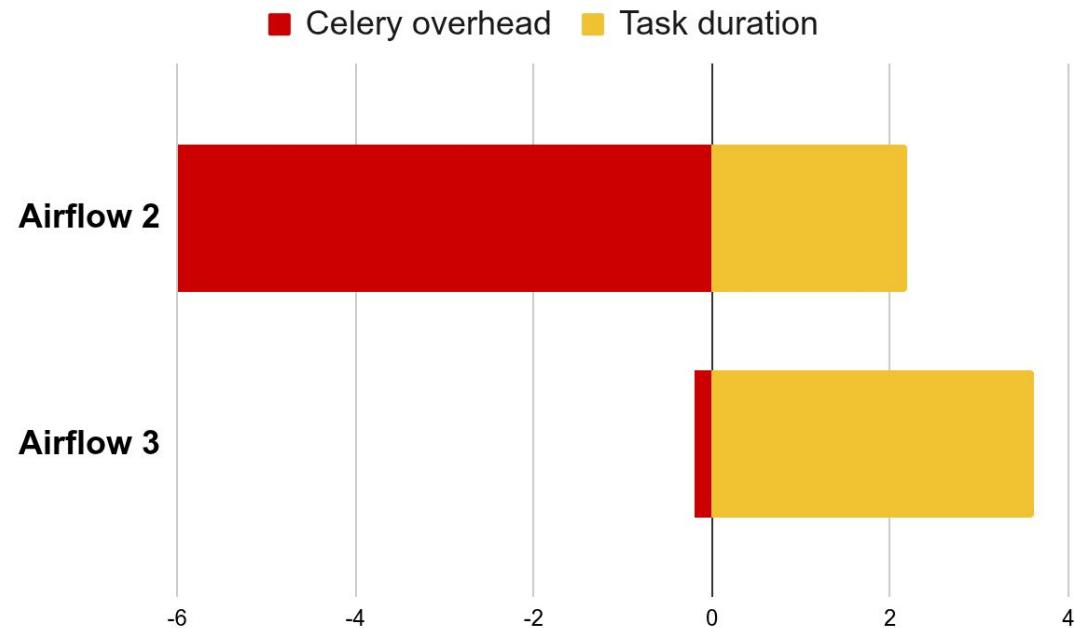




Airflow 2 vs Airflow 3

Task average duration

Task duration breakdown [seconds]

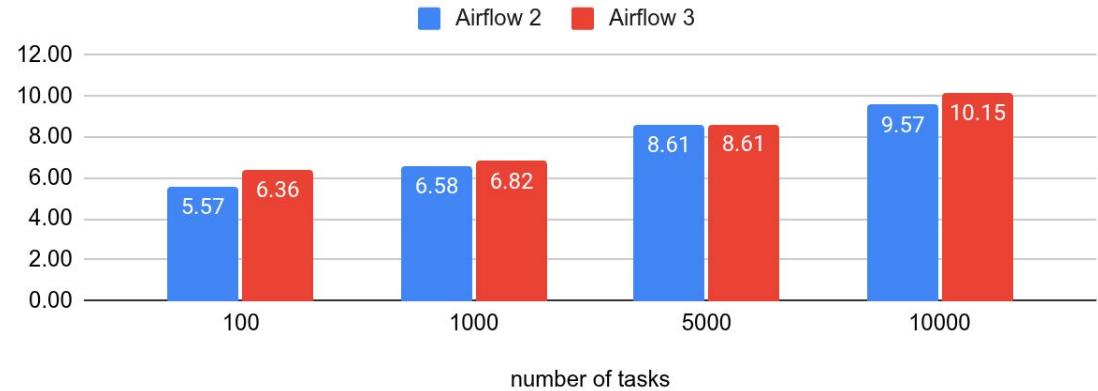




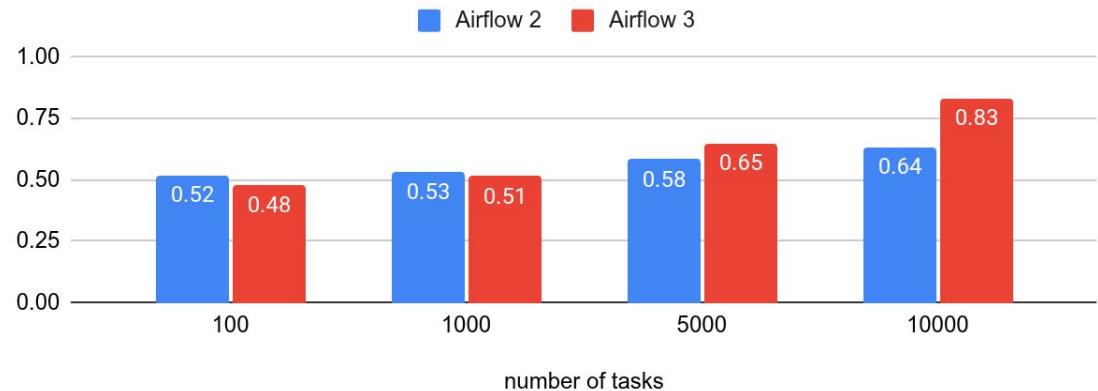
Airflow 2 vs Airflow 3

Memory consumption

Worker memory [GB]



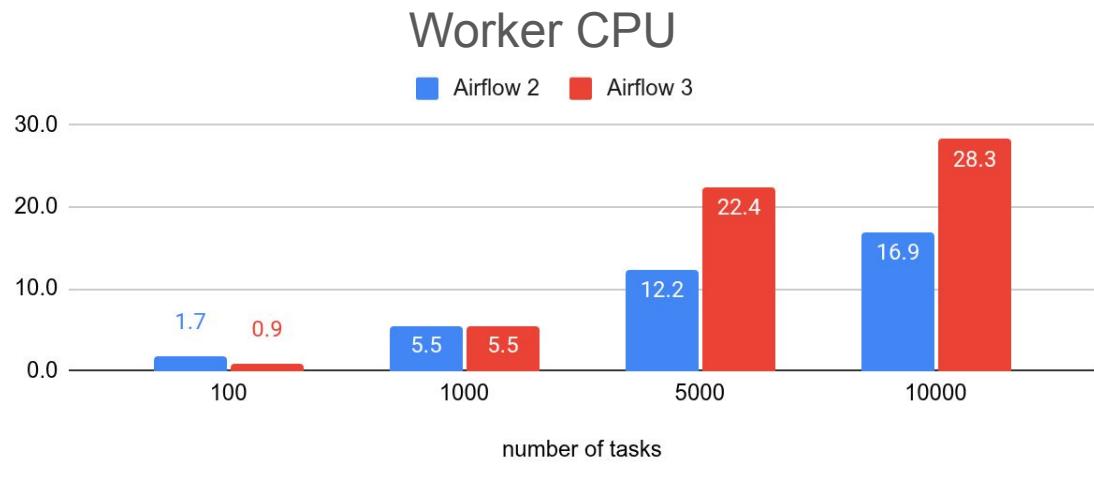
Scheduler memory [GB]



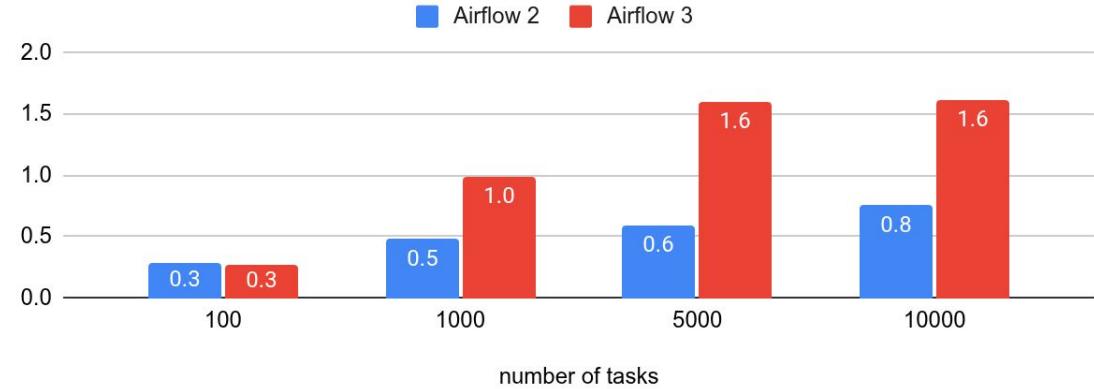


Airflow 2 vs Airflow 3

CPU usage



Scheduler CPU





First conclusions

- **Airflow 3** overall performs better than Airflow 2
- **Airflow 3** utilizes resources better (faster to finish using more CPU)
- **Airflow 3** uses a bit more memory



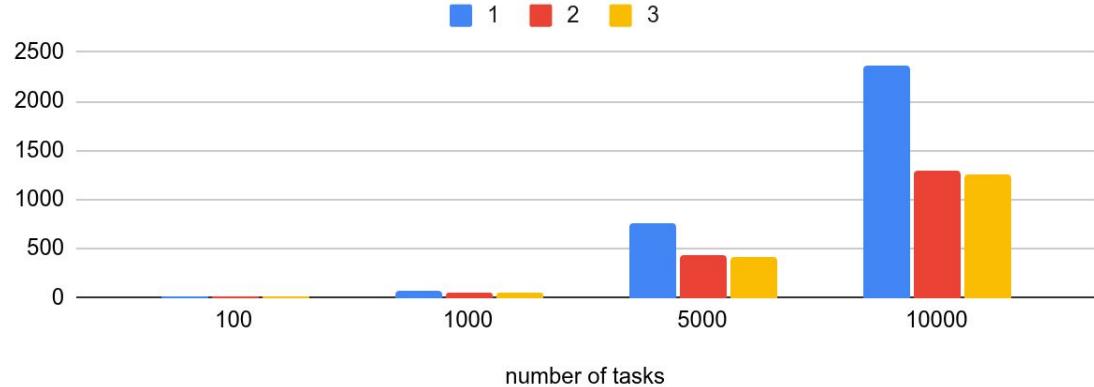
Number of schedulers

Running with 1, 2 or 3 schedulers

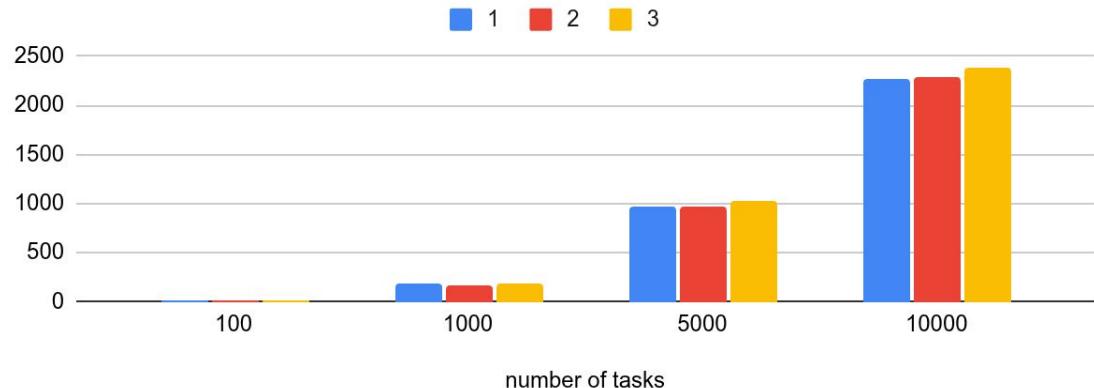
Conclusions

- **Airflow 3** benefits from having 2 schedulers
- **Airflow 2** does not benefit from having more than 1 scheduler
- No benefit from having third scheduler

Airflow 3 – test duration [seconds]



Airflow 2 – test duration [seconds]





Number of workers

Running with 3, 6 or 9 workers

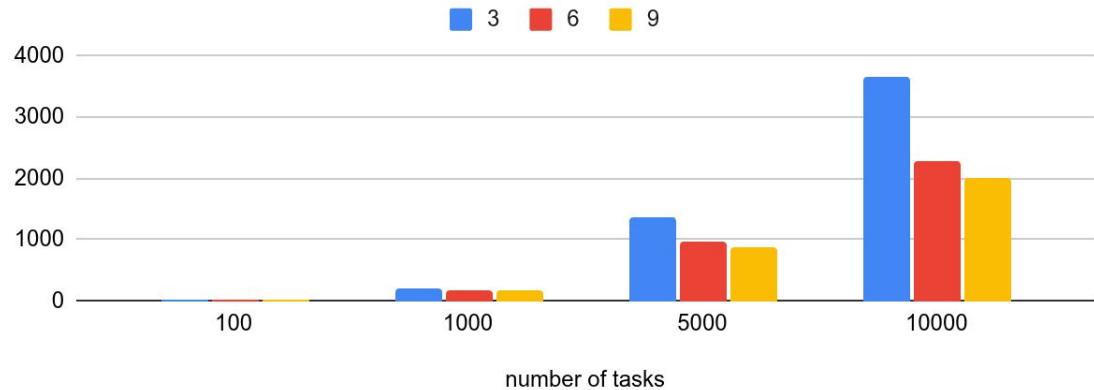
Conclusions

- **Airflow 3** scales better with number of workers
- 3 → 6 workers – linear scaling
- 6 → 9 workers – smaller benefit

Airflow 3 – test duration [seconds]



Airflow 2 – test duration [seconds]



Conclusions

3.0



Conclusions

- Performance tests can show performance improvement and degradation
- The developed framework makes it possible to run various scenarios
- **Airflow 3** is more performant than **Airflow 2**
- **Airflow 3** better utilizes resources
- 3 schedulers are unnecessary, unless used for availability
- Scaling workers is linear until a certain point



Future

- Publish performance framework code
- Run performance tests on each release
- Run performance tests daily

Questions?

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