



Semiconductor (Chip) Design Workflow Orchestration with Airflow

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3.0



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Agenda

- About Us
- Life Before Airflow
- Airflow @ Qualcomm
 - Dynamic Celery Workers
 - Multiple Executors: Celery + Edge
 - Multi DC Architecture
- Contributions
- Methodologies

About Us - Qualcomm

We make CPUs!

Qualcomm Oryon CPU – Our Snapdragon SOC Lineup :



Compute >

The industry leader in performance and power efficiency.



Mobile >

Transforming performance with the world's fastest mobile CPU.



Automotive >

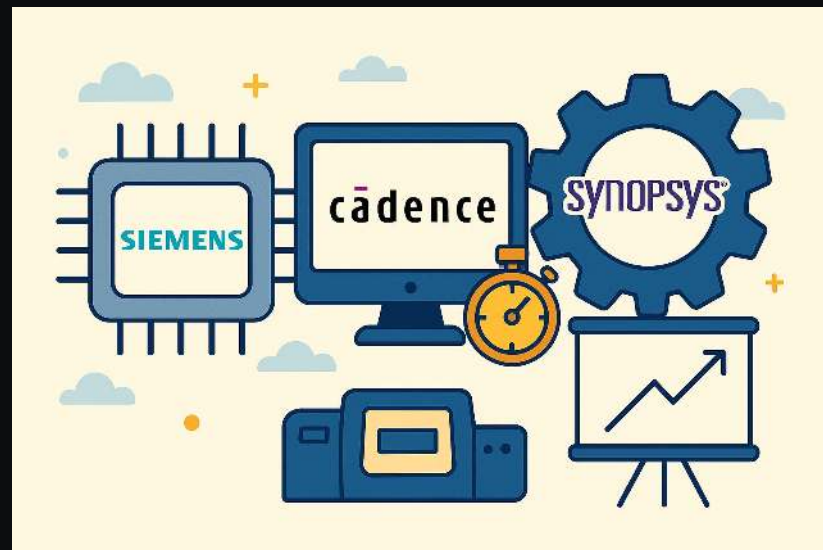
Unlocking a new era of automotive intelligence.

About Us – EDA Tools

EDA tools are specialized software used to automate and manage the complex processes of chip design and verification.

EDA tools demand:

- **Massive Compute:** tasks can run 7+ days, consume >256 GB RAM, generate 100s of GBs of output.
- **Rigid Vendor Constraints:** strict licensing, environment setup, and version dependencies
- **Scale of Orchestration:** Thousands of jobs must be scheduled and managed daily across multiple sites and compute grids.



EDA in Docker?

Requires Root Privileges → Security risk on multi-user clusters.

No Native Scheduler Integration → Hard to enforce resource limit policies.

OverlayFS Overhead → Slows down I/O-heavy EDA flows (millions of small files).

Limited Shared Memory & Ulimits → Manual tweaks needed; admins restrict flags.

Complex HPC Networking → MPI, Infiniband need extra config.

Unstable Host Identity → Breaks FlexNet licensing.



SLURM/LSF + Singularity

SLURM/LSF = Job Scheduler , Singularity = HPC-friendly container

Runs as Non-Root → Secure for shared HPC environments.

Native Scheduler Hooks → Accurate resource tracking & fair-share scheduling.

Direct Host Filesystem Access → No overlay penalty; ideal for PDKs & scratch.

Inherits Host Limits → /dev/shm and ulimits work out-of-the-box.

Seamless HPC Features → MPI, GPUs, Infiniband supported natively.

Preserves Host Identity → Stable for floating license servers.

Life Before Airflow

“Before there was automation, before there was orchestration... there was chaos.

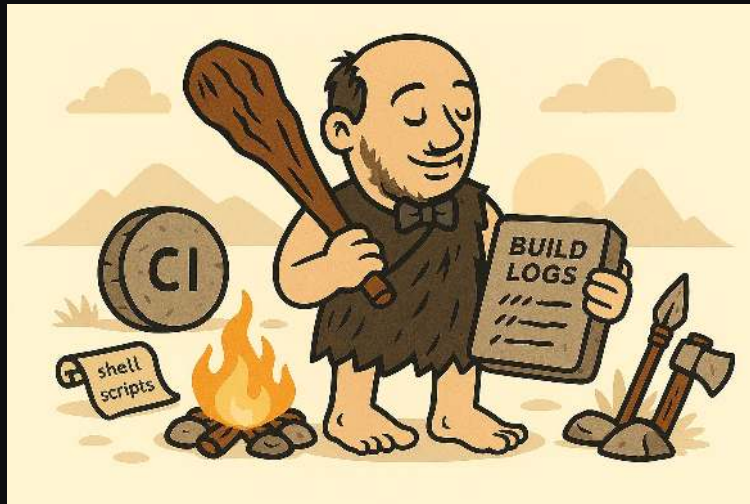
And before there was chaos... there was Jenkins.”



Life Before Airflow - Jenkins

The Bad:

- **Unstable Executor Nodes:** Frequent failures (resource, network, software, grid) → cascading regressions failures & delays.
- **Fragile Infrastructure:** Node failures require manual recovery; high maintenance overhead.
- **Siloed Freestyle Workflows:** Hard to share or generalize methodologies across teams.
- **No Version Control for Jobs:** Configurations live only on Jenkins host → risk of loss, no audit trail.
- **Poor Scalability for Complex Pipelines:** Designed for simple CI/CD; struggles with large distributed workflows.



Life Before Airflow - Jenkins

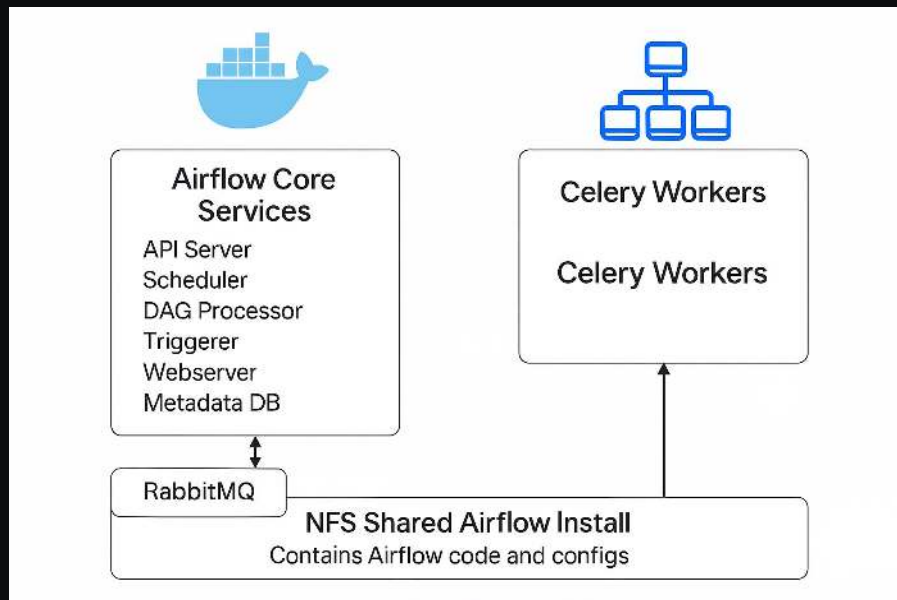
The Good:



Airflow @ QCOM

Our Airflow Instance:

- Core services run in Docker container
- Airflow install/code/configs shared via NFS
- Celery workers run as LSF jobs



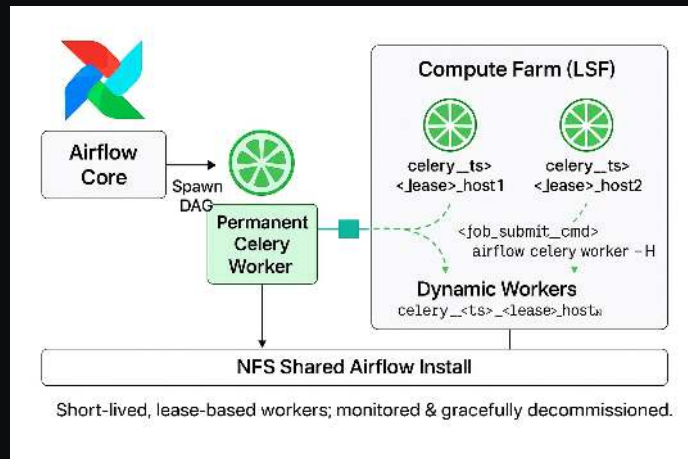
Dynamic Celery Workers

Spawning Celery Workers:

- Single always-on worker leases temporary workers on multi-day lease
- Temp workers created/shutdown via DAG:

```
job --cpus 8 --mem 64GB -- airflow celery worker -H  
celery_<timestamp>_<lease_hrs>_<hostname>
```

- We contributed this for remote celery worker management!



🔗 **Add CLI command to remove all queues from Celery worker** ✓ area:providers provider:celery

#56195 by dheerajturaga was merged yesterday • Approved

🔗 **Enhance Celery CLI with Worker and Queue Management Features** ✓ area:providers provider:celery

#51257 by dheerajturaga was merged on Jun 1 • Approved

🔗 **Add worker_umask to celery provider.yaml** ✓ area:providers provider:celery

#51218 by dheerajturaga was merged on Jun 1 • Approved

Usage: airflow celery [-h] COMMAND ...

Start celery components. Works only when using CeleryExecutor. For more information, see <https://airflow.apache.org/docs/apache-airflow/stable/executor/celery.html>

Positional Arguments:

COMMAND	
add-queue	Subscribe Celery worker to specified queues
flower	Start a Celery Flower
list-workers	List active celery workers
remove-queue	Unsubscribe Celery worker from specified queues
shutdown-all-workers	Request graceful shutdown of all active celery workers
shutdown-worker	Request graceful shutdown of celery workers
stop	Stop the Celery worker gracefully
worker	Start a Celery worker node

How do we scale up from here???

Challenges:

- Data Center is FULL -> Need more compute
- Compute availability is spread across many DCs
- Need to access Emulation resources
- Need to run on hosts hooked up to custom silicon

Can a single Airflow instance handle EVERYTHING?



Multi Executors: Celery + Edge3

Celery → Local jobs in the same data center

Edge → Remote jobs & special hardware, anywhere!

Why it rocks:

- ✓ One Airflow to rule them all
- ✓ Global compute orchestration
- ✓ No more DC handcuffs

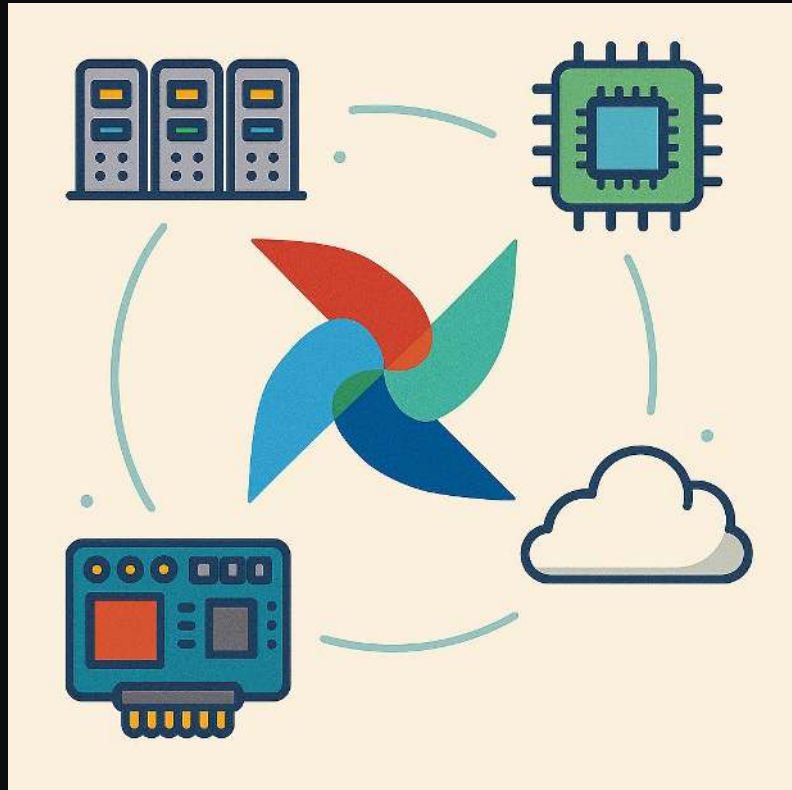
How we do it:

- Permanent Edge Workers in each DC (always-on gateways)
- Dynamic Edge Workers spin up on demand
- Smart Routing: Celery for local, Edge for remote
- Load Balancing across DCs

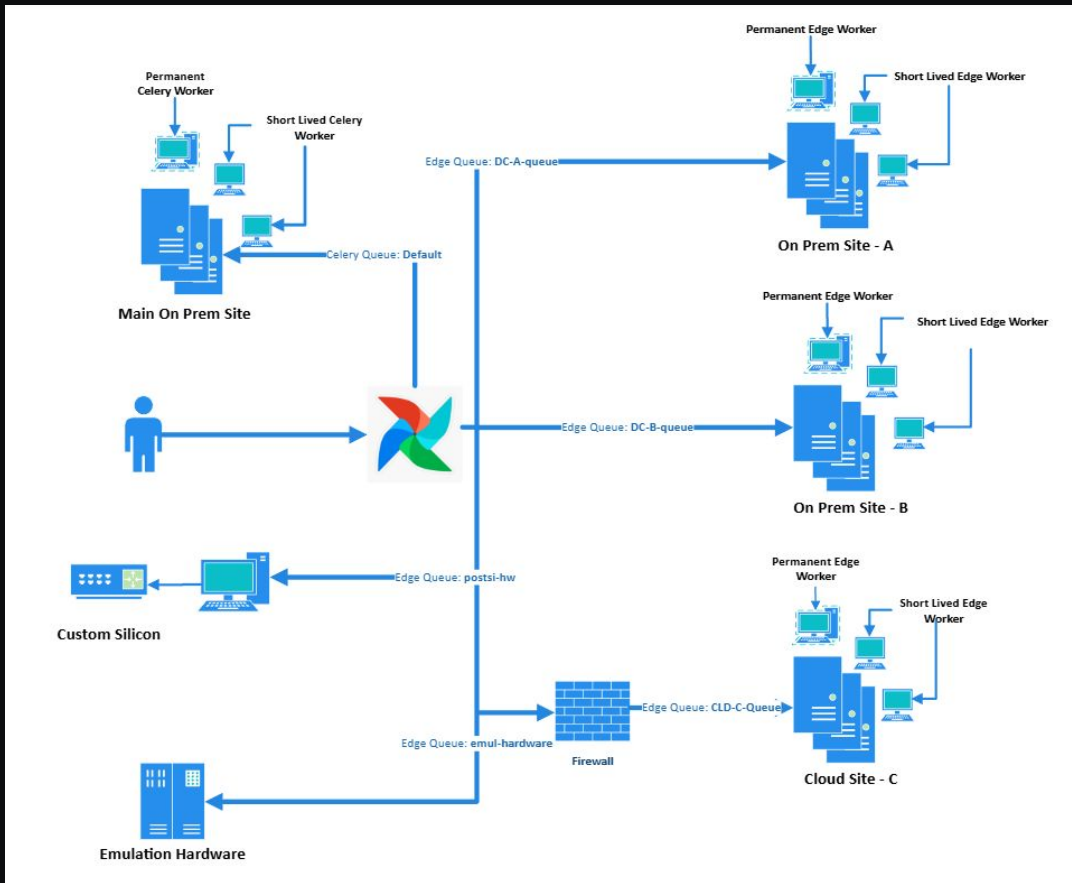
Use Cases:

Pre-Silicon: Build on HPC, run on emulators

Post-Silicon: Validate on custom boards

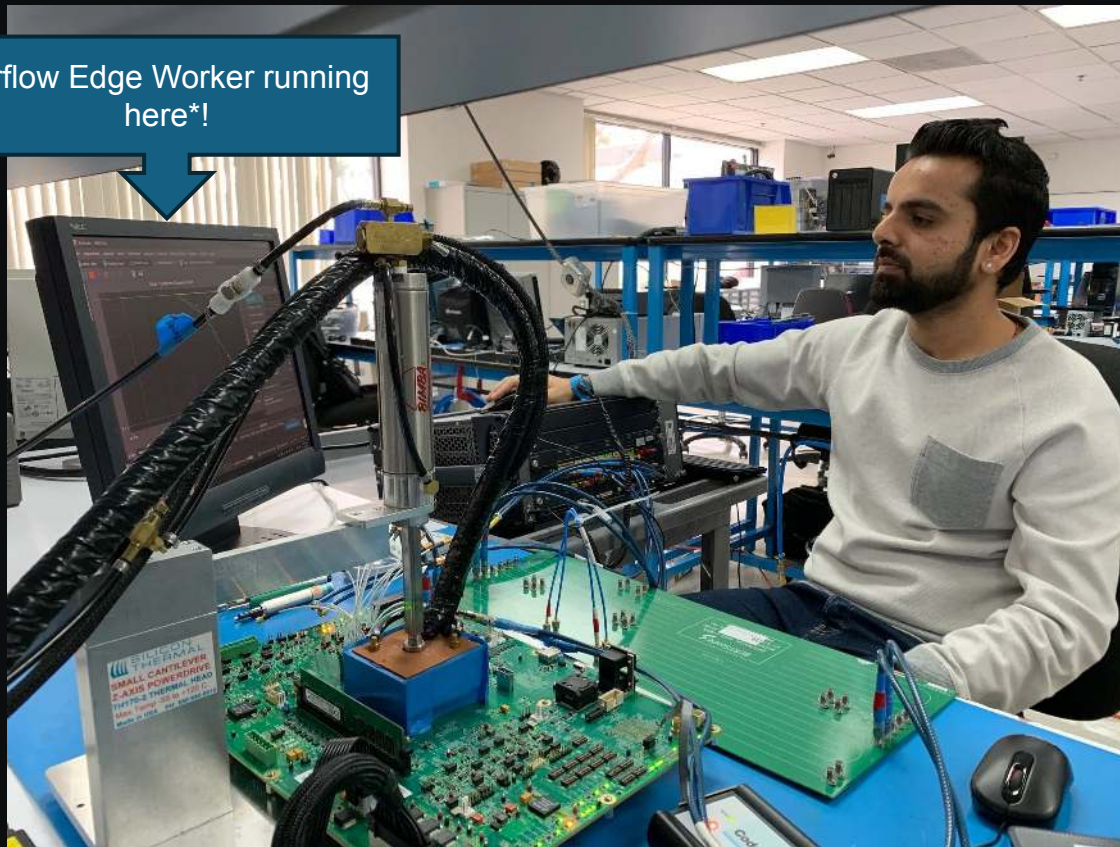


Airflow @ QCOM – Multi-DC Architecture



Airflow @ QCOM – Custom Silicon

Airflow Edge Worker running here*!



*This is a representative image only.

Edge/Celery Contributions

- 🔗 **Add revoke_task implementation to EdgeExecutor for task queued timeout support** ✓ area:providers provider:edge
#56240 by dheerajturaga was merged 3 days ago • Approved
- 🔗 **Add CLI command to remove all queues from Celery worker** ✓ area:providers provider:celery
#56195 by dheerajturaga was merged 3 days ago • Approved
- 🔗 **Add yellow hover background to enter maintenance icon** ✓ area:providers provider:edge
#55631 by dheerajturaga was merged 3 weeks ago • Approved
- 🔗 **Add shutdown-all-workers command to Edge CLI** ✓ area:providers provider:edge
#55626 by dheerajturaga was merged 3 weeks ago • Approved
- 🔗 **Add queue management UI buttons for Edge workers** ✓ area:providers provider:edge
#55625 by dheerajturaga was merged 3 weeks ago • Approved
- 🔗 **feat: Add delete button for offline edge workers** ✓ area:providers provider:edge
#55529 by dheerajturaga was merged 3 weeks ago • Approved
- 🔗 **feat: Add shutdown button for edge workers with confirmation dialog** ✓ area:providers provider:edge
#55513 by dheerajturaga was merged 3 weeks ago • Approved
- 🔗 **Add confirmation dialog for exit maintenance action in Edge Worker Page** ✓ area:providers provider:edge
#55400 by dheerajturaga was merged 3 weeks ago • Approved
- 🔗 **Add worker maintenance mode functionality to Edge3 provider UI** ✓ area:providers provider:edge
#55301 by dheerajturaga was merged last month • Approved
- 🔗 **Fix EdgeWorker multiprocessing pickle error on Windows** ✓ area:providers provider:edge
#55284 by dheerajturaga was merged last month • Approved
- 🔗 **Add queue and remove queue cli commands for EdgeExecutor** ✓ area:providers provider:edge
#53505 by dheerajturaga was merged on Jul 19 • Approved
- 🔗 **Edge list worker cli command to list active job metrics** ✓ area:providers provider:edge
#51720 by dheerajturaga was merged on Jun 14 • Approved

- 🔗 **Extend command column in the edge job table to accomodate more chars** ✓ area:providers provider:edge
#51716 by dheerajturaga was merged on Jun 14 • Approved
- 🔗 **Enhance Celery CLI with Worker and Queue Management Features** ✓ area:providers provider:celery
#51257 by dheerajturaga was merged on Jun 1 • Approved
- 🔗 **Add worker_umask to celery provider.yaml** ✓ area:providers provider:celery
#51218 by dheerajturaga was merged on Jun 1 • Approved
- 🔗 **Support For Edge Worker in Daemon Mode** ✓ area:providers provider:edge
#50425 by dheerajturaga was merged on May 11 • Approved
- 🔗 **Ability to request shutdown of a remote edge worker** ✓ area:providers provider:edge
#50278 by dheerajturaga was merged on May 6 • Approved
- 🔗 **Extend Edge Worker CLI commands operate on remote edge workers** ✓ area:providers provider:edge
#49915 by dheerajturaga was merged on May 2 • Approved
- 🔗 **Minor doc fix in edge_executor** ✓ area:providers kind:documentation provider:edge
#49755 by dheerajturaga was merged on Apr 25 • Approved

View all our contributions here:

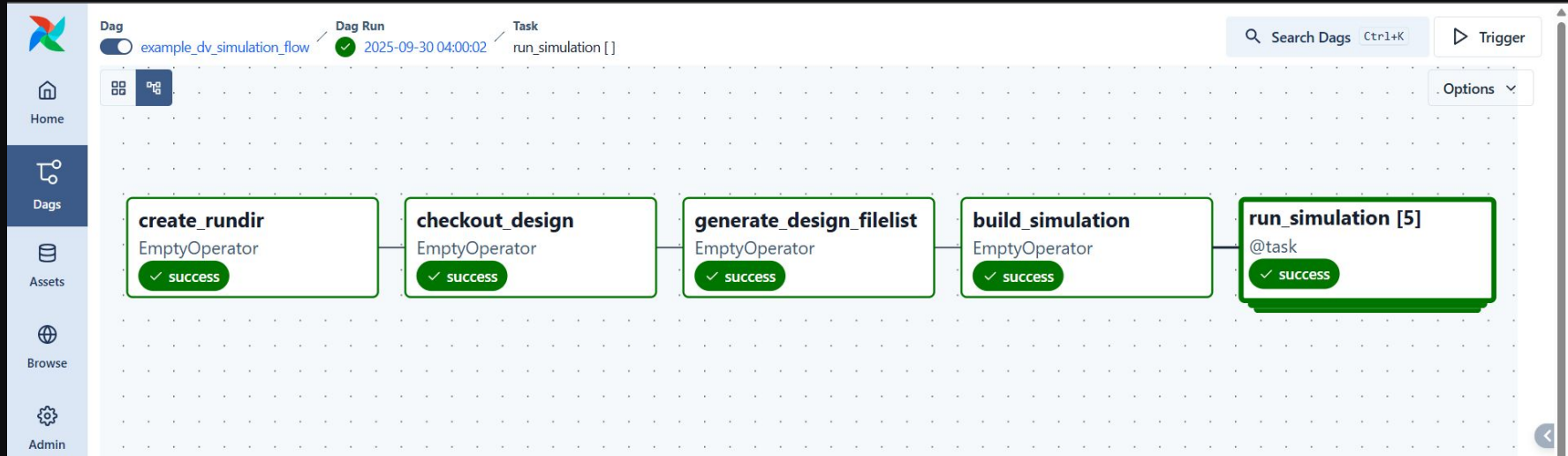


Methodologies



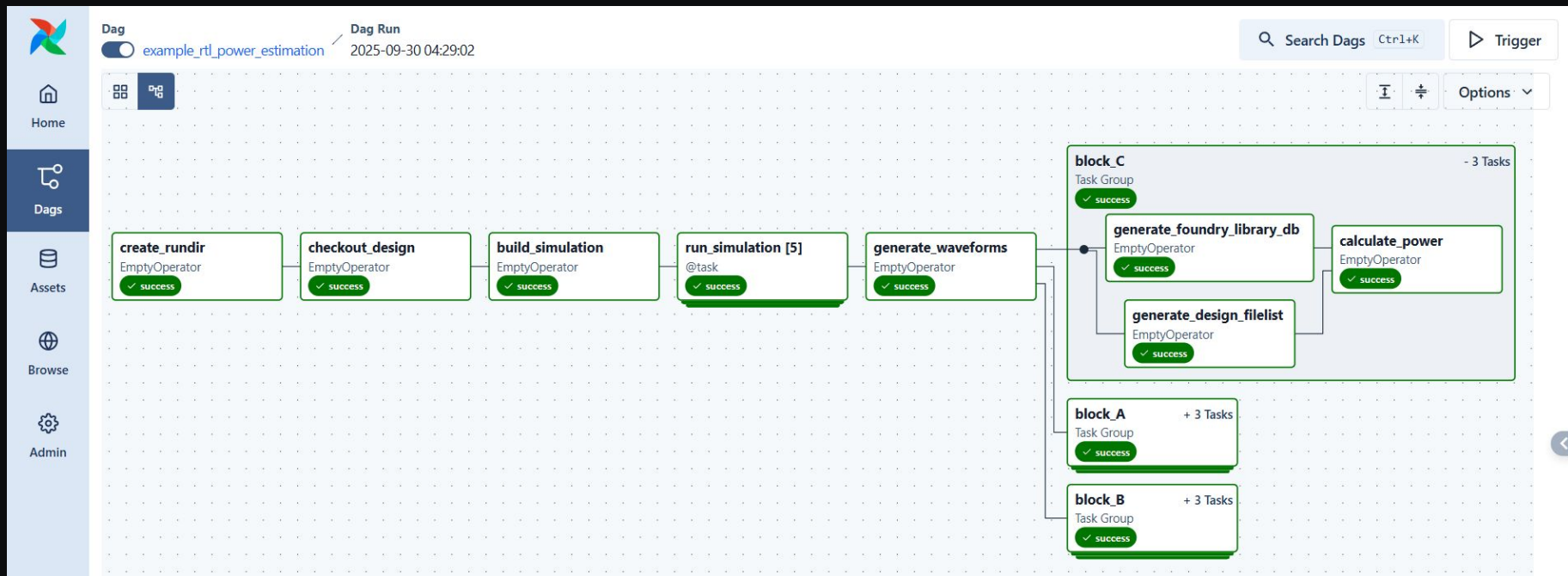
Chip Design Workflow – Examples (DV)

Design Verification (DV) is debugging hardware before it's built — to catch costly mistakes early.



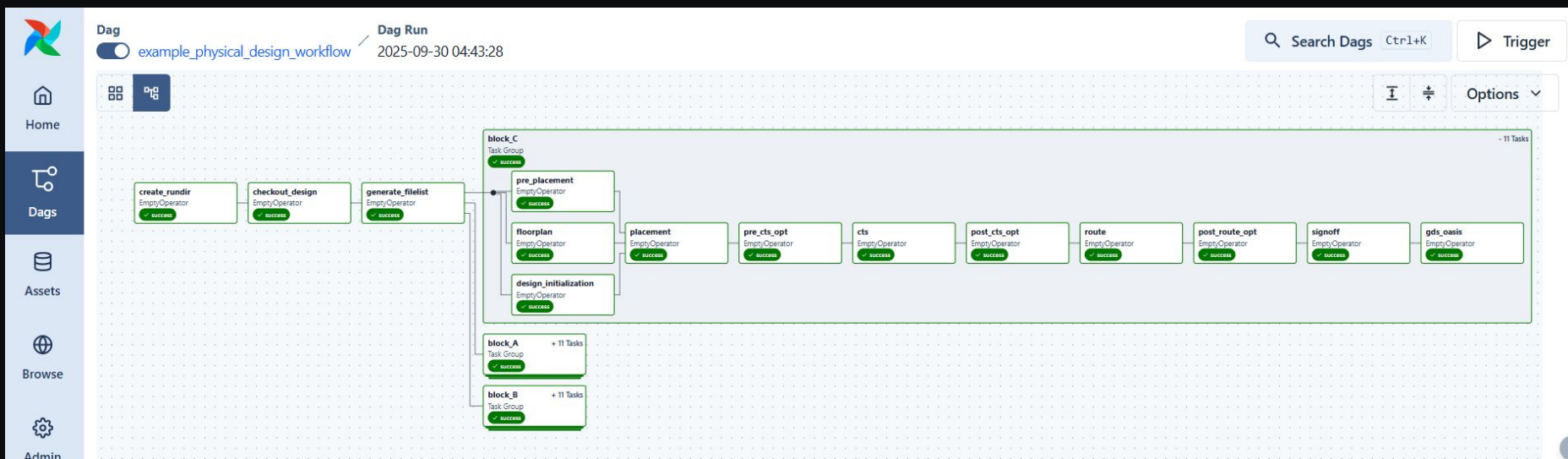
Chip Design Workflow – Examples (Power Estimation)

RTL power estimation is simulating the chip's power efficiency using its design plans before fabrication.



Chip Design Workflow – Examples (Physical Design)

Physical Design is the process of converting a chip's logical design into a layout that can be manufactured on silicon..



Pytest Plugin for Airflow

Unit testing an Airflow codebase:

- 'airflow dags list-import errors' is not enough!
- No official Pytest support 😞
- Custom Pytest plugin -> [apache-airflow-devel-common](#) -> [pytest_plugin.py](#) source code

```
@pytest.mark.db_test
@pytest.mark.smoke
@pytest.mark.execution_timeout(3000)
def test_integrity(dags_path):
    """
    Replaces `airflow dags list-import-errors`
    """
    dag_bag = DagBag(
        dag_folder=dags_path, include_examples=False, read_dags_from_db=False
    )
    assert not dag_bag.import_errors, "DAG import errors are present :("
    slowpokes = [
        s for s in dag_bag.dagbag_stats if s.duration > duration(seconds=10)
    ]
    assert not slowpokes, "Slowpokes are present :("
```


Pytest Plugin for Airflow

```
@pytest.mark.db_test
@pytest.mark.execution_timeout(300)
def test_a_dag(dag_maker, session, default_args):
    """
    Test a DAG!
    """
    DAG_CFG = {
        # something relevant
    }
    with dag_maker(
        dag_id="test_a_dag",
        bundle_name="dags-folder",
        default_args=default_args,
        params=BASE_PARAMS(DAG_CFG),
        session=session,
    ):
        ...
    dr = dag_maker.create_dagrun(run_type=DagRunType.MANUAL)
    for ti in dr.get_task_instances(
        session=session
    ): # Mimic the specific order the scheduling would run the tests.
        ti.run(session=session)
        assert ti.state == TaskInstanceState.SUCCESS, f"{ti} failed!"
    dr.update_state(session=session)
    assert dr.state == DagRunState.SUCCESS, f"{dr} failed!"
    # more asserts
```

```
class TestCustomOperator:

    @pytest.mark.db_test
    def test_templated_fields(self, create_task_instance_of_operator, session):
        ti = create_task_instance_of_operator(
            CustomOperator,
            # Templated fields
            bash_command='echo "{{ dag_run.dag_id }}"',
            env={"FOO": "{{ ds }}"},
            cwd="{{ task.dag.folder }}",
            # Other parameters
            dag_id="test_templated_fields_dag",
            task_id="test_templated_fields_task",
            session=session,
        )
        context = ti.get_template_context(session=session)
        ti.render_templates(context=context)
        task: CustomOperator = ti.task
        assert task.bash_command.endswith('echo "test_templated_fields_dag"')
        assert task.cwd == Path(__file__).absolute().parent.as_posix()
```

Custom Shell Operators

Shell Operators:

- Source global shell .rc file
- Modify SubprocessHook to pass entire stdout/output log path
- Custom pre/post-processing via pre_execute/post_execute
- Enables smart retries + scraping XComs from shell output

```
class SubprocessHook(BaseHook): <- class CustomHook(SubprocessHook)
    ...
    def run_command(
        self,
        command: list[str],
        env: dict[str, str] | None = None,
        output_encoding: str = "utf-8",
        cwd: str | None = None, <- Add optional output_log
    ) -> SubprocessResult:
        """
```

```
class BashOperator(BaseOperator): <- class CustomOperator(BashOperator)
    ... <- def execute() uses CustomHook
    def __init__(
        self,
        *,
        bash_command: str | ArgNotSet, <- Prepend env setup commands
        env: dict[str, str] | None = None,
        append_env: bool = False,
        output_encoding: str = "utf-8",
        skip_on_exit_code: int | Container[int]
        cwd: str | None = None,
        **kwargs,
    ) -> None:
```


DAG Templates

Generalizing Workflows:

- DAG Factories but very different!
- Use symlinks to DAG templates + YAML dictionary configuration
- Enforce methodology with a unit test!
- `.airflowignore`:
 - `**/templates/`
 - `**/*_template.py`

```
my_dag/  
├─ cfg.yml  
├─ dag.py -> templates/dag_template.py  
└─ templates/  
    └─ dag_template.py
```

```
@pytest.mark.db_test  
@pytest.mark.smoke  
def test_symlink_methodology(dags_path):  
    """  
    Enforce my rules!  
    """  
  
    for p in dags_path.rglob("**"):  
        if p.is_symlink():  
            # check if broken link  
            # check for adjacent cfg.yml
```

Questions?

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in

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in

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Automation Engineer –
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