AIRFLOW SUMMIT

Navigating Secure and Cost-Efficient Flink Batch on Kubernetes with Airflow 3.0

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Cost Optimization

The Challenge: Batch Processing for the Ad Team at Yahoo

Reduced Learning Curve

- Reuse existing Flink expertise to seamlessly extend into batch processing.

Lower Operational Overhead

- One platform for streaming and batch simplifies operations and reduces effort.

Cost Efficiency

- Scale resources on demand to run batch jobs more affordably.

Enterprise-Grade Security

- Built-in compliance with Yahoo’s data protection and security standards.

Why Flink?

Unified Processing Engine

- One runtime for both **streaming** and **batch** (DataStream, Batch, Table/SQL).
- Simplifies ETL + real-time pipelines in a single framework.

Autoscaling & auto-tuning

Autoscaling: Flink on EKS automatically scales TaskManagers up or down based on workload needs.

Autotuning: It adjusts memory and task settings on the fly to keep jobs efficient and stable.

EKS Operator Ecosystem

The Flink Kubernetes Operator can manage end-to-end lifecycle of Flink applications, including submission, upgrades, rollbacks, and savepoints.

Enhanced Resource Isolation

Better isolation for batch jobs with per-application Flink clusters.

Cloud-Native S3 Integration

Batch pipelines on EKS work seamlessly with S3 without relying on Hadoop.

The Solution Apache Flink & The Flink Kubernetes Operator

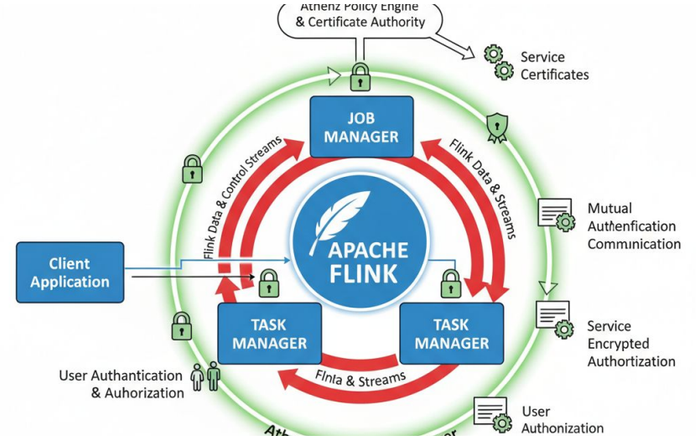
Apache Flink: Stream & Batch Processing

Flink is an open-source engine for stream and batch processing, built for fast, reliable, and fault-tolerant real-time analytics.

The Flink Kubernetes Operator

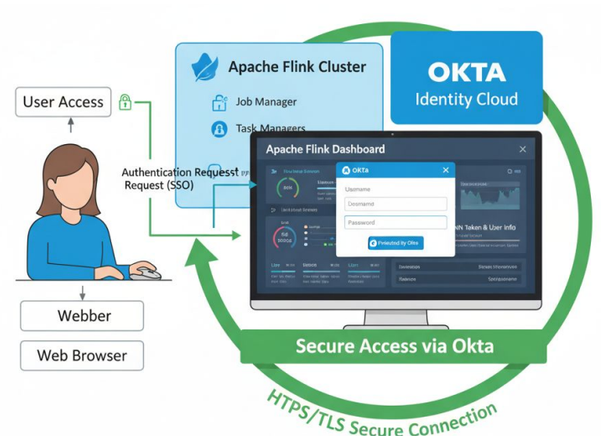
The operator streamlines running Flink on Kubernetes, managing job lifecycles, handling autoscaling and autotuning, performing rolling updates, and ensuring recovery.

Security Recommendations



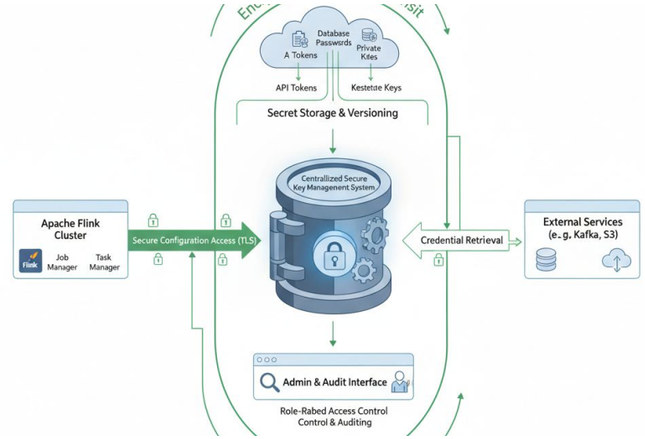
mTLS for Cluster Communication

Secure all Flink cluster communication with Athenz mTLS, using certificates to protect data and verify users and services.



Secure Flink UI with Okta Authentication

Secure Flink UI with Okta, allowing access only to authorized users.



Centralized Secret Management

Keep Flink secrets, including keystore and truststore passwords, in Yahoo's Managed Key Service for better security.

mTLS - External Communication (Outside the Cluster)

When an external client or service connects to Flink (e.g., submitting a job, accessing the REST API, or metrics endpoint), it must present a client certificate.

1

Certificate Common Name (CN) Pattern

The certificate's Common Name (CN) must match a pattern:

```
# Regex applied to client certificate's CNcheck =
<Athenz-domain>:([0-9a-z_-]+).*
```

Example: `finance:([0-9a-z_-]+).*`

2

Security Assurances

- Only users with valid roles in the Athenz domain can connect.

mTLS - Internal Communication (Inside the Cluster)

Communication between Flink components (JobManager ↔ TaskManager, TaskManager ↔ TaskManager) also requires certificates.

Certificate Common Name (CN) Exact Match

Here, the CN must match exactly:

```
<Athenz-domain>.app-1
```

Example: `finance.app-1`

Security Assurances

- A rogue TaskManager or compromised pod cannot impersonate another component.

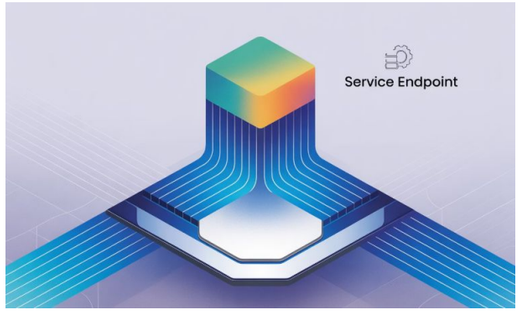
Okta Integration for Flink UI Authentication: Flow

Add Okta Sidecar

Okta Token Validation

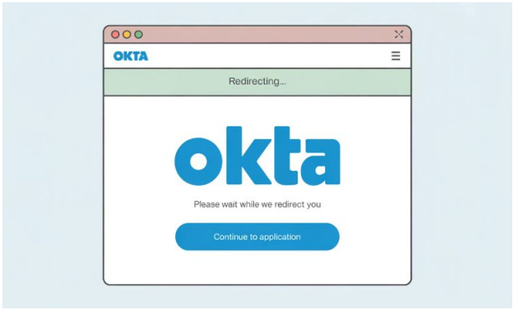
Invalid Token: Access Denied

Endpoint Exposure

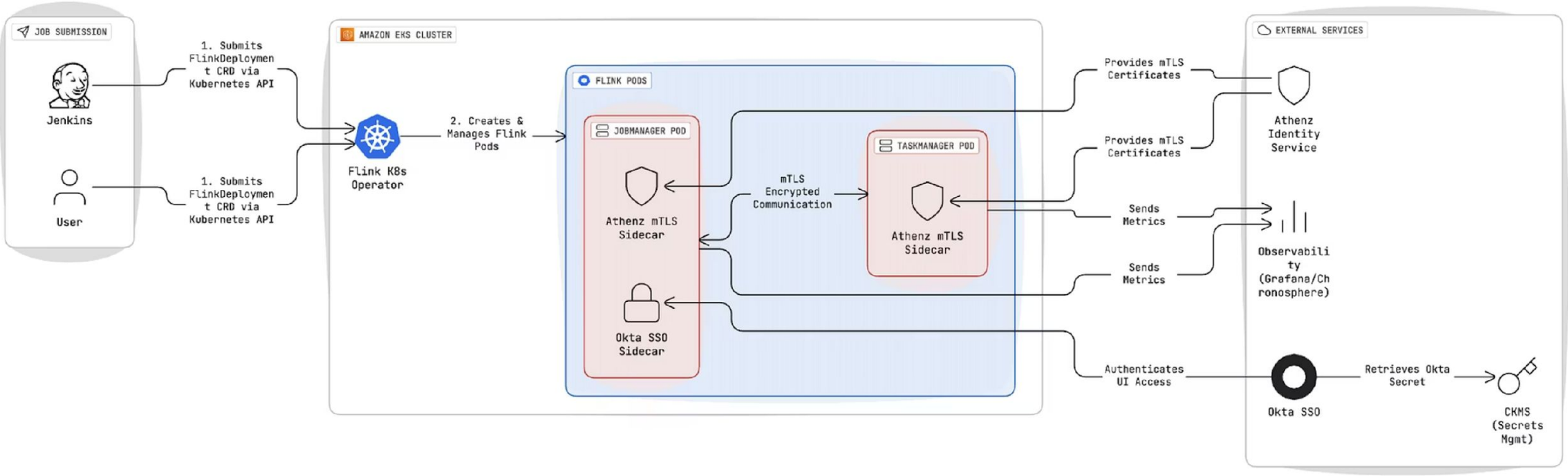


Valid Token: Access Granted

No Token: Redirect to Okta



Flink Deployment - Architecture



The Problem: Scaling Data Ingestion

At Yahoo, we faced the critical challenge of processing massive amounts of conversion data from a multitude of partners. This involved ingesting and analyzing **millions of records every single hour**, demanding a robust and highly scalable batch processing solution.

The Legacy Pains: Our Old Stack

Our existing Oozie + EMR + Pig stack was struggling to keep up with our evolving security and performance needs.

Old & Unreliable Workflows

Oozie workflows were XML-based, making them difficult to write, maintain, and debug.

Inefficient Resource Usage:

Persistent EMR clusters led to significant costs from idle compute resources.

Security and Compliance Gaps:

Retrofitting modern security standards like mTLS and granular IAM was complex and unreliable.

Airflow to the Rescue

Apache Airflow

Enables workflow orchestration with DAG scheduling, dependency management, and monitoring for data pipelines

FlinkKubernetesOperator

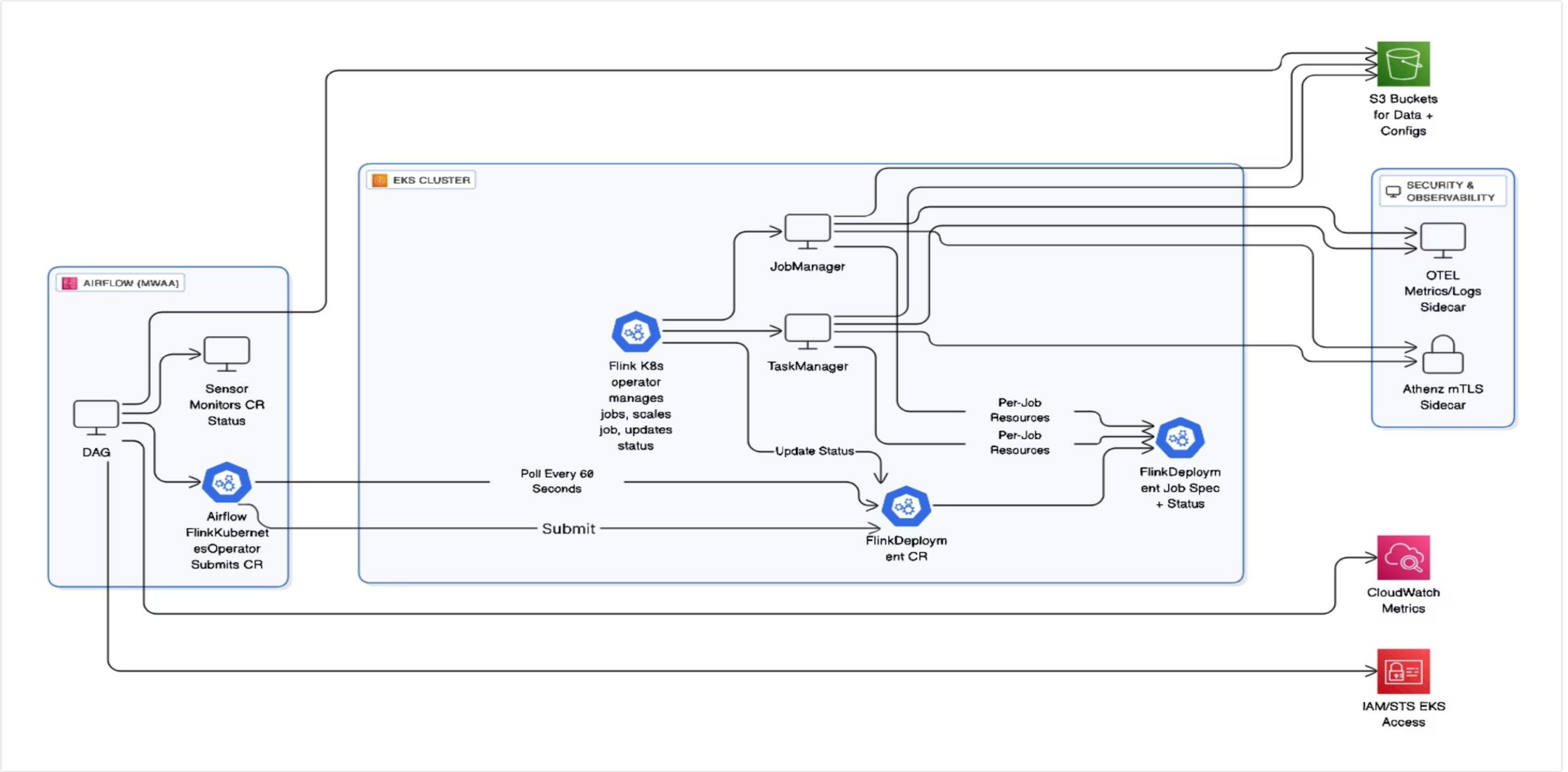
Custom Airflow operator for declarative Flink job management via Kubernetes integration.

Automated Lifecycle

Automates Flink cluster setup, job execution, monitoring, and cleanup—minimizing manual effort.

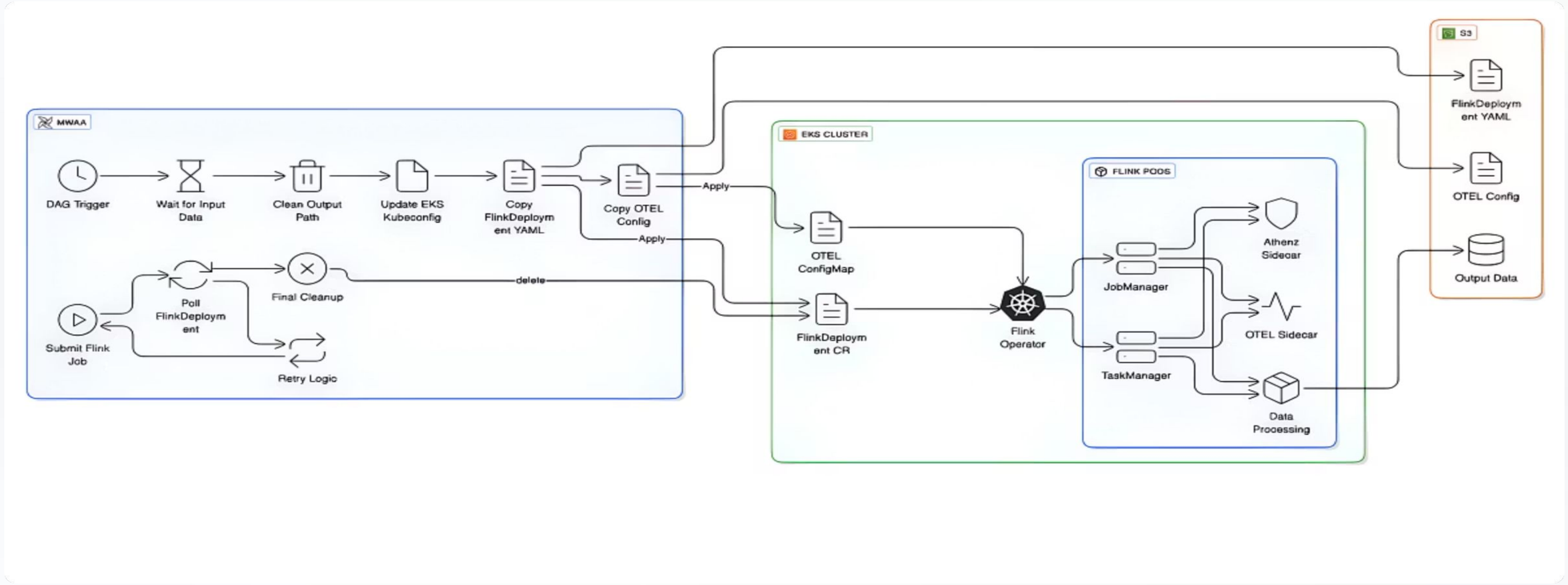
Result: From manual & error-prone → automated, scalable, reliable pipelines.

High Level Architecture



- Isolated compute per job
- Strict access control
- No hardcoded credentials
- Observability

End Flow to End Flow



Security Model Challenges

1 EKS Athenz Integration

No IAM support, requires custom cert management.

2 MWAA Athenz Gap

No native Athenz integration for cert fetch/refresh.

3 IAM Bridge Solution

MWAA↔EKS via IAM, Flink internal via Athenz.

4 Monitoring Workaround

MWAA monitors via Flink CRDs using EKS IAM.

Hybrid model ensures Yahoo-compliance + AWS integration.

Cost Controls: How We Achieve Efficiency

Immediate Cleanup

Cleanup Flink clusters and Kubernetes operators immediately upon job completion - no lingering resources consuming costs.

Per-Job Isolation

Each job gets its own dedicated cluster, ensuring optimal resource allocation and preventing resource contention between different workloads.

Automated Lifecycle

Full automation eliminates manual intervention, reducing operational overhead and ensuring consistent resource management practices.

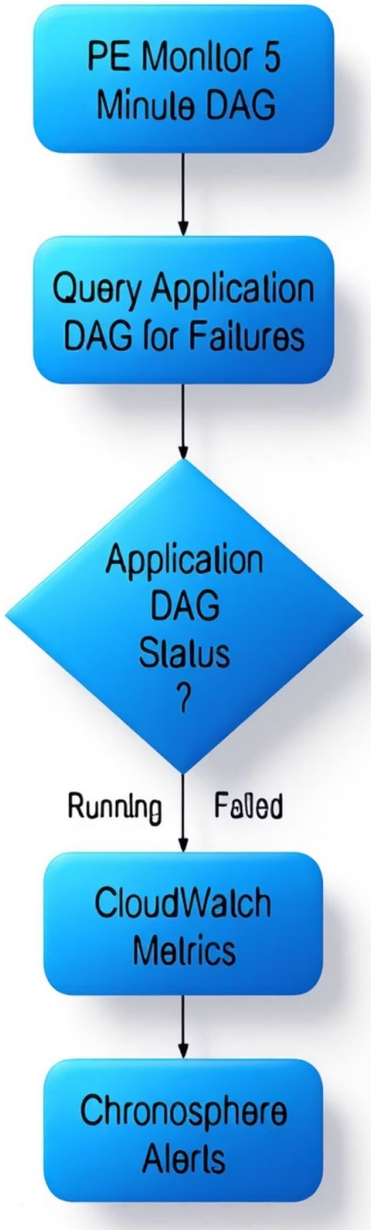
Production Health Monitoring - Production Engineering DAG

Why Monitor the Monitors?

- Data pipelines are only as reliable as their orchestration
- Failed DAGs = missed SLAs and data gaps
- Proactive monitoring prevents reactive firefighting

PE (Production Engineering) DAG: Our Watchdog

- Runs every 5 minutes - continuous health checks
- Queries all application DAGs for failure states
- Publishes metrics to CloudWatch - FailedDagCount per DAG
- Triggers Chronosphere alerts - immediate notification to on-call teams



Takeaways

Airflow + EKS + Flink Operator = strong pattern for secure batch.

Simple deployment

Simplified idle flink cluster removal

Per-job clusters reduce cost and improve isolation.

Security must be baked into orchestration, not added later.

Observability and cleanup are not optional.

Reference

Flink Kubernetes Operator: https://nightlies.apache.org/flink/flink-kubernetes-operator-docs-main/

MWAA Best Practices: https://docs.aws.amazon.com/mwaa/latest/userguide/best-practices.html

Questions?

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