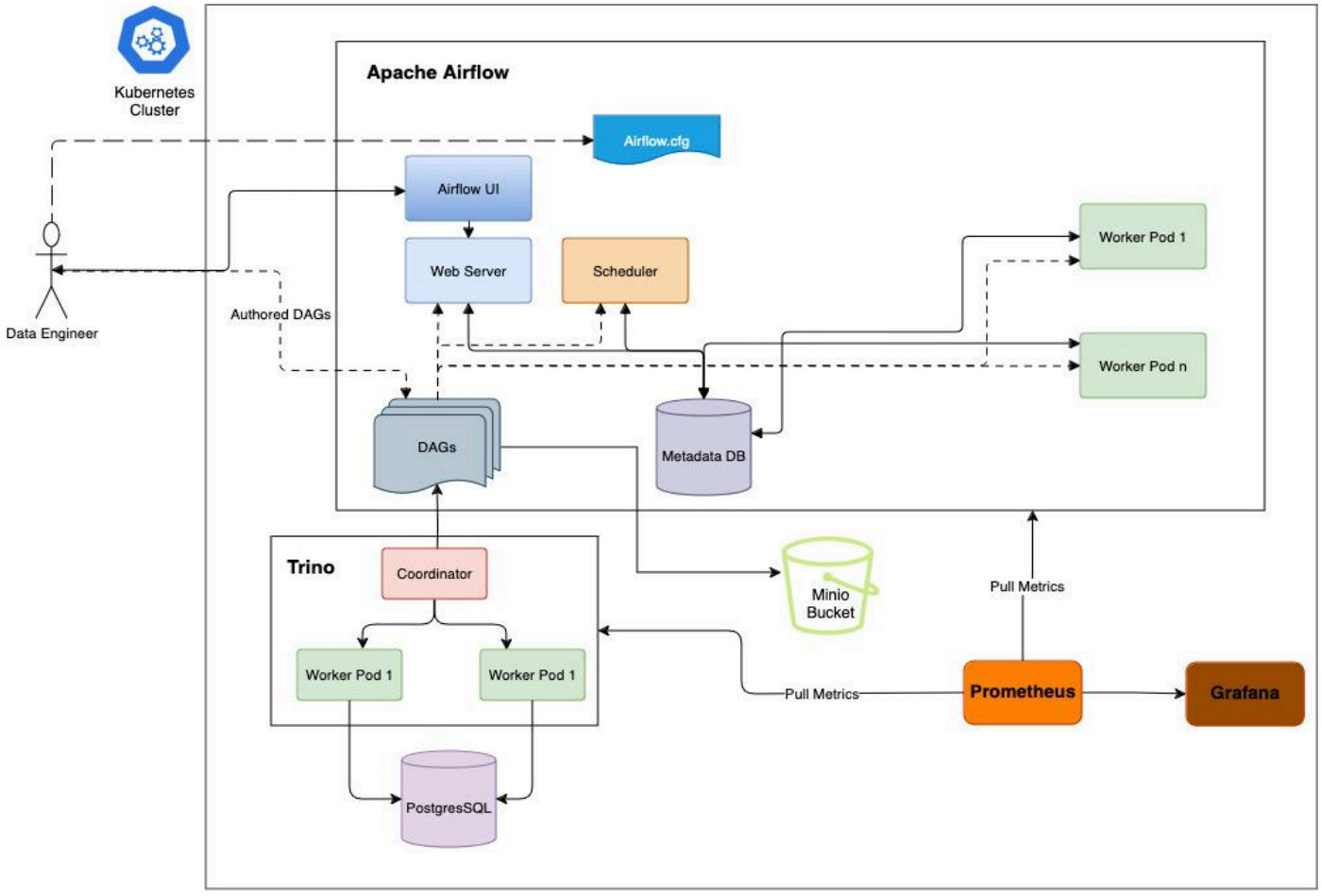
Platform | Hiring | Quidditch

Overview

This document provides detailed instructions for deploying a scalable Apache Airflow and Starburst Presto setup on Kubernetes. The goal is to demonstrate the orchestration of complex workflows with Airflow and the execution of distributed SQL queries on Presto, while ensuring scalability and efficient resource management on Kubernetes.

Architecture Diagram:



Prerequisites

- **Kubernetes Cluster**: Minikube.
- **kubectl**: Command-line tool to interact with your Kubernetes cluster.
- **Helm**: Kubernetes package manager for managing applications.

1. Kubernetes Setup

1.1 Minikube Setup

1. **Start Minikube with Multiple Nodes:**
    - minikube start --nodes=3

1.2 Challenges:

Minikube wasn't starting as it was giving Docker is out of disk space error. Also upon checking minikube status (minikube status -p minikube), it was returning host: InsufficientStorage, so cleaned up docker by running the following commands:

- docker builder prune
- docker system prune
- docker image prune
- docker rm -f $(docker ps -a -q)

Then it started giving another error which is Enabling 'default-storageclass' returned an error. After doing some digging came up with the following commands that actually fixed all the errors above:

- rm -rf ~/.minikube
- minikube delete --all --purge
- docker system prune
- minikube start --nodes=3

Output of minikube status -p minikube:

minikube status
minikube
type: Control Plane
host: Running
kubelet: Running
apiserver: Running
kubeconfig: Configured

2. Apache Airflow Deployment

2.1 Deployment with Helm

1. **Pull custom docker image:**
    - docker pull pratishmahajan26/airflow-trino:latest
2. **Install Airflow using Helm:**
    - cd quidditch/helm-chart
    - helm install airflow ./airflow \
      --set images.airflow.repository=pratishmahajan26/airflow-trino \
      --set images.airflow.tag=latest \
      --set images.airflow.pullPolicy=Always
3. **Access Airflow UI:**
    - **Airflow Webserver:** kubectl port-forward svc/airflow-webserver 8080:8080 --namespace airflow
    - Visit http://127.0.0.1:8080 to use the application
    - Default Webserver (Airflow UI) Login credentials:
        - username: admin
        - password: admin
    - Default Airflow Postgres connection credentials:
        - username: postgres
        - password: postgres
        - port: 5432
4. **To check pods:**
    - kubectl get pods -o wide

2.2 Scaling Airflow

1. **Horizontal Pod Autoscaler (HPA):**
    - kubectl autoscale deployment airflow-worker --namespace airflow --min=3 --max=10 --cpu-percent=80
2. **Manual Scaling:**
    - kubectl scale deployment airflow-worker --replicas=5 --namespace airflow

2.3 Secure Airflow Web Interface

1. **Basic Authentication:**

```
web:
  auth:
      basicAuth:
      enabled: true
      username: admin
      password: admin
```

3. PostgreSQL Deployment

3.1 Deployment with Helm

1. **Install Postgres Using Helm:**
    - helm install my-postgres oci://registry-1.docker.io/bitnamicharts/postgresql
2. **Get Password:**
    - export POSTGRES_PASSWORD=$(kubectl get secret --namespace default my-postgres-postgresql -o jsonpath="{.data.postgres-password}" | base64 -d)
    - echo $POSTGRES_PASSWORD
3. **Expose Postgres port for connecting it with SQL client:**
    - kubectl port-forward --namespace default svc/my-postgres-postgresql 5432:5432

4. Trino Deployment

4.1 Deployment with Helm

1. **Install Trino Using Helm:**
    - helm install -f trino/custom-values.yml trino ./trino
    - In custom-values.yml, port value has been changed to 8085 as Airflow is utilizing 8080. Also, a connector for postgresql is added under additionalCatalogs as rdbms. Only these values are overridden with the default values in values.yaml.
2. **Access Trino Dashboard:**
    - export POD_NAME=$(kubectl get pods --namespace default --selector "app.kubernetes.io/name=trino,app.kubernetes.io/instance=example-trino-cluster, app.kubernetes.io/component=coordinator" --output name)
    - echo $POD_NAME
    - kubectl port-forward $POD_NAME 8085:8085
3. **Run local Trino server for executing queries on shell:**
    - brew install trino
    - trino --server http://localhost:8080
    - select count(*) from rdbms.public.sales;
4. **Reference to create your own yaml file:** https://trino.io/docs/current/installation/kubernetes.html#creating-your-own-yaml

5. Challenges Faced

5.1 Running Trino and Airflow pods:

- One of the biggest challenges I faced was running Airflow and Trino pods simultaneously. When Trino was being deployed after Airflow and PostgreSQL, the pods couldn't initialize, and the Airflow scheduler also started failing.
- After struggling and experimenting with the configurations, I finally figured out that the issue was due to insufficient resources allocated to Minikube. It wasn't able to provide enough memory to both Airflow and Trino. All pods are dependent on the resources (CPU and memory) that Minikube has.
- To resolve this, I restarted Minikube after deleting the existing Minikube cluster, allocating more resources by providing 6 CPUs and 8192 MB of memory, by running the following command:
  `minikube start --cpus=6 --memory=8192`
- Additionally, the minikube dashboard was very handy for checking error logs when deploying pods, which can be activated by running the following command:
  `minikube dashboard`
- I also had to change the port of Trino, as both Airflow and Trino were initially configured to run on the same port, 8080. Because of this conflict, the Airflow webserver couldn't start since the port was already bound to Trino.

5.2 Connect Trino to Postgres

The problem was addressed as follows:

Add additional catalog:

- Create custom-values.yaml file in trino helm-chart directory
- Add the following:

```
additionalCatalogs:
  rdbms: |-
        connector.name=postgresql
        connection-url=jdbc:postgresql://my-postgres-postgresql.default.svc.cluster
.local:5432/postgres
        connection-user=postgres
        connection-password=<postgres password>
```

Resolve connection failed error:

- I was using the wrong host, i.e., `localhost` and the IP address of the PostgreSQL pod, in the connection-url above, for creating the connection with PostgreSQL. After digging into the issue and checking the output logs of the `helm install postgres` command, I discovered that PostgreSQL can be accessed via port 5432 on the following DNS name from within the cluster:
  `my-postgres-postgresql.default.svc.cluster.local`.
- After adding this DNS name as the host, Trino was able to connect with PostgreSQL and fetch the data successfully. Additionally, it's important to ensure that both pods are in the same Kubernetes namespace for seamless communication.

Upgrade trino with reinstalling:

- helm upgrade -f trino/custom-values.yml trino ./trino

5.3 Connect Airflow to Trino

Installation of trino provider for apache airflow:

- After trying to install it using `pip install apache-airflow-providers-trino`, directly on the running container, it was not getting active and couldn't see Trino in connection type dropdown in Airflow Connections. So I created the docker file for building the custom docker image for Airflow having this provider installed, which can be found here: https://github.com/pratishmahajan26/quidditch/blob/main/airflow.Dockerfile
- Docker build command:
    - `cd quidditch && docker build -t airflow-trino:latest -f airflow.Dockerfile .`
- But I couldn't figure out how to use this image with helm charts, so I came up with the following solution, after trying out multiple ways and it took me a lot of time to figure this out as I couldn't create helm charts locally to use the custom image.
- Solution:
    - Check the latest version of apache/airflow which is pulled through helm install, by running docker images command.
    - Update the tag of the custom image to the latest version of apache/airflow, so next time whenever helm installs airflow, it will automatically use the updated tag and it will deploy airflow using the custom image.
    - docker tag airflow-custom:latest apache/airflow:2.9.2
      helm install airflow apache-airflow/airflow
      kubectl exec -ti airflow-scheduler-88575d458-k5ckv -- bash
    - As both are using same namespace, so airflow can only connect to trino using trino-coordinator ip which could be get using:
      kubectl get pods -o wide
    - Also this had to be added in Extra when adding the connection for trino
      `{ "impersonate_as_owner": "true"}`

5.4 Helm charts on local:

Installation of Airflow using helm charts on local:

- **Push docker image to docker hub**
    - Build docker image
      `cd quidditch && docker build -t airflow-trino:latest -f airflow.Dockerfile .`
    - Login to docker hub**:**
      `docker login -u "<user_name>" -p '<password>'`
    - Tag docker image to repository on docker hub:
      `docker tag airflow-trino:latest pratishmahajan26/airflow-trino:latest`

- Push docker image

  ```
  docker push pratishmahajan26/airflow-trino:latest
  ```

- **Install airflow:**
  - cd quidditch/helm-chart
  - Change the following properties in airflow/values.yaml:

    ```
    airflow:
      repository: pratishmahajan26/airflow-trino
      tag: latest
    ```

  - Helm install by passing values in the command:

    ```
    helm install airflow ./airflow \
    --set images.airflow.repository=pratishmahajan26/airflow-trino \
    --set images.airflow.tag=latest \
    --set images.airflow.pullPolicy=Always
    ```

- **Managing dags:**
  - If there is any change in the dag or in the custom operator, then the above procedure can be followed, as it is required to deploy airflow in order to reflect the changes.
  - For development purposes the dag changes can be copied directly in all the containers running for Scheduler, Webserver & Woker:

    ```
    kubectl cp ~/quidditch/airflow-dags/trino_minio.py -n default
    airflow-scheduler-98f9f996f-9fg8n:/opt/airflow/dags
    kubectl cp ~/quidditch/airflow-dags/trino_minio.py -n default
    airflow-webserver-5644b4bb95-nkzdm:/opt/airflow/dags
    kubectl cp ~/quidditch/airflow-dags/trino_minio.py -n default
    airflow-worker-0:/opt/airflow/dags
    ```

6. MiniO Deployment

6.1 Deployment with Helm

1. **Install Minio Using Helm:**
   - helm install --set resources.requests.memory=512Mi --set replicas=1 --set persistence.enabled=false --set mode=standalone --set rootUser=rootuser,rootPassword=rootpass123 --generate-name minio/minio
2. **Access MinIO server:**
   - export POD_NAME=$(kubectl get pods --namespace default -l "release=minio-1721640558" -o jsonpath="{.items[0].metadata.name}")
   - kubectl port-forward $POD_NAME 9000:9001 --namespace default
   - Access MinIO server on http://localhost:9000
3. **Connect Airflow to MiniO:**

- Add connection on Airflow by selecting Amazon Web Services in Connection Type and provide the following details:
- Conn Id: **`my_s3_conn`**
- Get the Ip of minio pod and add it to the below config
- Extra:

```
{
  "aws_access_key_id": "rootuser",
  "aws_secret_access_key": "rootpass123",
  "endpoint_url": "http://10.244.0.136:9000"
}
```

- Create bucket by accessing MinIO server on http://localhost:9000

7. Scalability and Monitoring

7.1 Scaling Airflow and Trino

- **Airflow Manual Scaling:**
  - kubectl scale statefulset airflow-worker --replicas=1 -n default
- **Trino Scaling:**
  - kubectl scale deployment trino-woker --replicas=6 --namespace trino
  - kubectl autoscale deployment trino-woker --namespace default --min=1 --max=10 --cpu-percent=80
- **Auto Scaling in Airflow Workers:**
  - In airflow values.yaml enable :

```
# Allow HPA (KEDA must be disabled).
hpa:
 enabled: true

 # Minimum number of workers created by HPA
 minReplicaCount: 1

 # Maximum number of workers created by HPA
 maxReplicaCount: 3

 # Specifications for which to use to calculate the desired
replica count
 metrics:
   - type: Resource
     resource:
       name: cpu
       target:
         type: Utilization
         averageUtilization: 80
```

- Upgrade Airflow to apply settings above:
  helm upgrade airflow ./airflow \
  --set images.airflow.repository=pratishmahajan26/airflow-trino \
  --set images.airflow.tag=latest \
  --set images.airflow.pullPolicy=Always

- Using kubectl get pods, check if airflow-worker pod is running
- Now to check if everything is in place for Auto Scaling, set **minReplicaCount to 2** and upgrade airflow again. A new airflow worker will be added having the name **airflow-worker-1**.
- Set **minReplicaCount to 1** again and upgrade the Airflow. Ideally **airflow-worker-1** added in the previous step, should be scaled down (delete automatically based on the hpa configuration). But it won't as there are some issues which have to be fixed first.
- To check the issue run:
  i. kubectl get hpa -n default
  ii. kubectl get hpa airflow-worker

```
[pratish.mahajan@Pratishs-MacBook-Pro Documents % kubectl get hpa
NAME              REFERENCE                    TARGETS              MINPODS   MAXPODS   REPLICAS   AGE
airflow-worker    StatefulSet/airflow-worker   cpu: <unknown>/80%   1         3         2          2m53s
```

  iii. kubectl describe hpa airflow-worker -n default
  failed to get cpu utilization: unable to get metrics for resource cpu: no metrics returned from resource metrics API
  invalid metrics (1 invalid out of 1), first error is: failed to get cpu resource metric value: failed to get cpu utilization: did not receive metrics for targeted pods (pods might be unready)
  invalid metrics (1 invalid out of 1), first error is: failed to get cpu resource metric value: failed to get cpu utilization: unable to get metrics for resource cpu: unable to fetch metrics from resource metrics API: the server could not find the requested resource (get pods.metrics.k8s.io)
  failed to get cpu utilization: missing request for cpu in container worker-log-groomer of Pod airflow-worker-0
  iv. There could be issues related to fetching of metrics which can be resolved by performing various steps.
- Steps to resolve the above issues:
  i. Enable kubernetes metrics-server:
  [kubectl apply -f https://github.com/kubernetes-sigs/metrics-server/releases/latest/download/components.yaml]
  minikube addons enable metrics-server
  Reference:
  Hello Minikube | Kubernetes
  How to fix failed get resource metric in Kubernetes HPA

  ii. To Verify:
  `kubectl get deployment metrics-server -n kube-system`
  `kubectl logs deployment/metrics-server -n kube-system`

```
kubectl top pods
```

iii. Update airflow values.yaml:
Under workers, set resources to:

```yaml
resources:
   requests:
     cpu: 100m
     memory: 500Mi
```

And resource under `workers.logGroomerSidecar` to:

```yaml
logGroomerSidecar:
  # Whether to deploy the
  enabled: true
  # Command to use when r
  command: ~
  # Args to use when runn
  args: ["bash", "/clean-
  # Number of days to ret
  retentionDays: 15
  resources:
  #  limits:
  #    cpu: 100m
  #    memory: 128Mi
    requests:
      cpu: 100m
      memory: 128Mi
  # Detailed default secu
  securityContexts:
    container: {}
```

Explanation of this is given in
[How to fix failed get resource metric in Kubernetes HPA]

- Upgrade airflow again, and check pods, the worker pds will scale down to 1.
- Run: kubectl get hpa airflow-worker

```
pratish.mahajan@Pratishs-MacBook-Pro Documents % kubectl get hpa airflow-worker
NAME             REFERENCE                     TARGETS        MINPODS   MAXPODS   REPLICAS   AGE
airflow-worker   StatefulSet/airflow-worker   cpu: 25%/80%   1         3         1          87m
```

- Autoscaling with KEDA:
  - [Autoscaling with KEDA — helm-chart Documentation]
- Additional Commands:
  - minikube addons disable metrics-server
  - kubectl top pods
  - kubectl get pod,svc -n kube-system
  - minikube delete
  - kubectl get --raw /apis/[metrics.k8s.io/v1beta1]
  - kubectl hpa delete airflow-worker
  - kubectl get deployment metrics-server -n kube-system
  - kubectl get statefulset
  - kubectl get statefulset <statefulset-name> -n <namespace>

7.2 Monitoring with Prometheus and Grafana

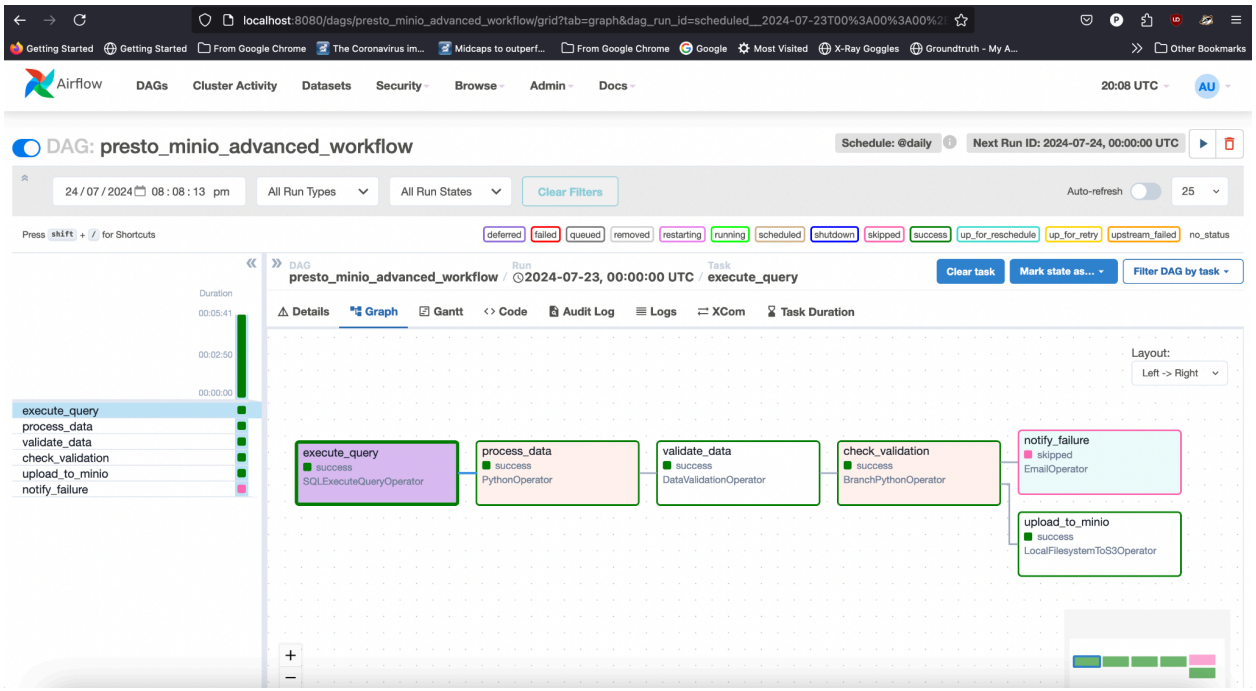
1. **Deploy Prometheus and Grafana:**

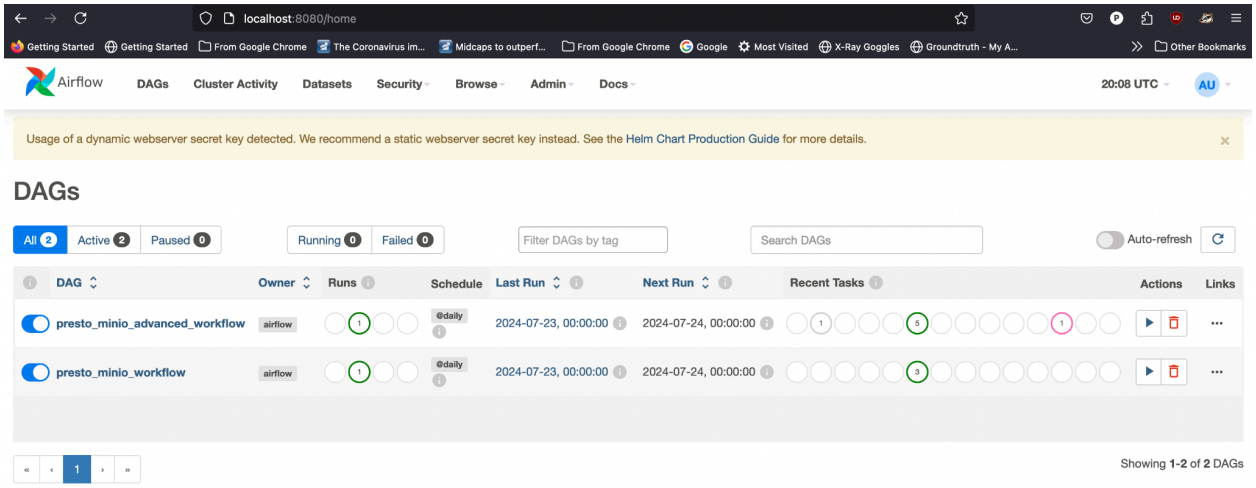
```
## Prometheus
- helm repo add prometheus-community
https://prometheus-community.github.io/helm-charts
- helm repo update
- helm install prometheus prometheus-community/prometheus
- export POD_NAME=$(kubectl get pods --namespace default -l
"app.kubernetes.io/name=prometheus,app.kubernetes.io/instance=prometheus"
-o jsonpath="{.items[0].metadata.name}")
- kubectl --namespace default port-forward $POD_NAME 9090
- Visit http://127.0.0.1:9090 to use the application

## Grafana
- helm repo add grafana https://grafana.github.io/helm-charts
- helm repo update
- helm install grafana grafana/grafana
- Prometheus Server for Grafana:
http://prometheus-server.default.svc.cluster.local
- Get your 'admin' user password by running:
 - kubectl get secret --namespace default grafana -o
jsonpath="{.data.admin-password}" | base64 --decode ; echo
```

```
- export POD_NAME=$(kubectl get pods --namespace default -l
"app.kubernetes.io/name=grafana,app.kubernetes.io/instance=grafana" -o
jsonpath="{.items[0].metadata.name}")
- kubectl --namespace default port-forward $POD_NAME 3000
- Visit http://127.0.0.1:3000 to use the application

## Minikube Dashboard
- minikube dashboard
- It will automatically open a new tab on the browser
- Enable & disable Metrics Server:
- minikube addons enable  metrics-server
- minikube addons disable metrics-server
```

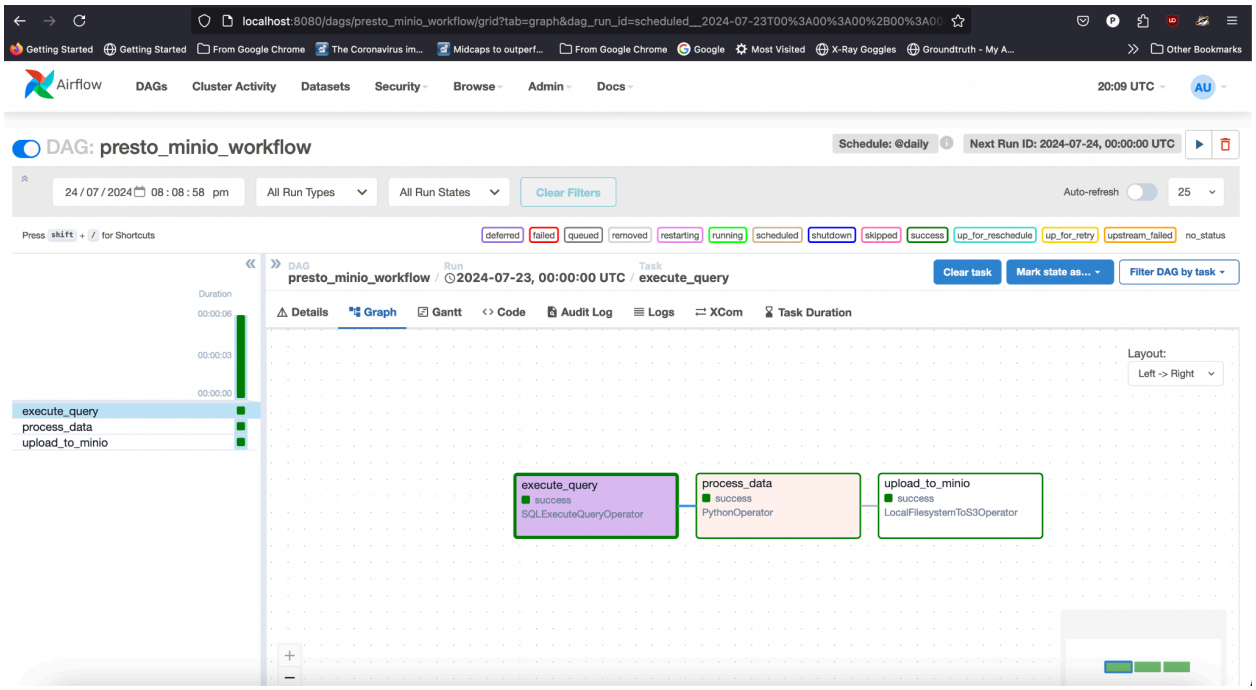
8. Screenshots

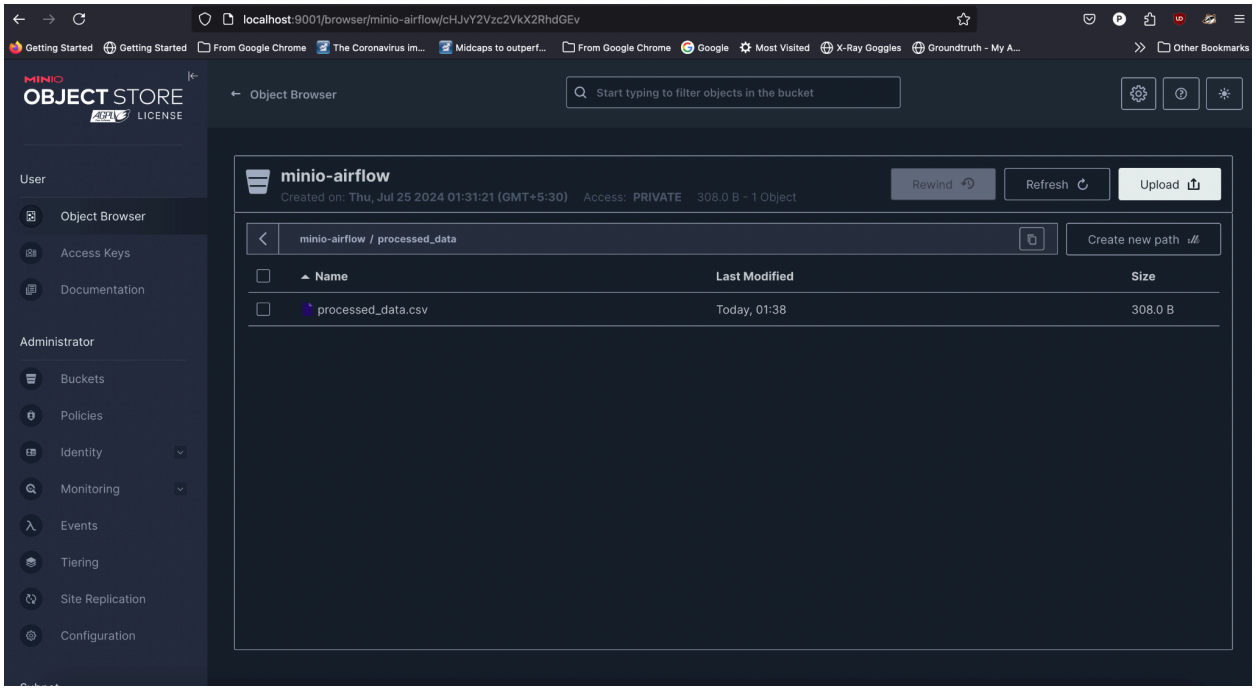
```
pratish.mahajan@Pratishs-MacBook-Pro h1-data % trino --server http://localhost:8085
trino> select * from rdbms.public.sales;
 sale_id | sale_date  | customer_name | product_name | quantity |  price  |  total
---------+------------+---------------+--------------+----------+---------+---------
       1 | 2023-07-01 | John Doe      | Laptop       |        1 | 1200.00 | 1200.00
       2 | 2023-07-02 | Jane Smith    | Smartphone   |        2 |  600.00 | 1200.00
       3 | 2023-07-03 | Alice Johnson | Tablet       |        1 |  300.00 |  300.00
       4 | 2023-07-04 | Bob Brown     | Smartwatch   |        3 |  150.00 |  450.00
       5 | 2023-07-05 | Charlie Davis | Headphones   |        5 |   80.00 |  400.00
(5 rows)

Query 20240724_153853_00002_8cs77, FINISHED, 1 node
Splits: 1 total, 1 done (100.00%)
0.76 [5 rows, 0B] [6 rows/s, 0B/s]

trino>
```

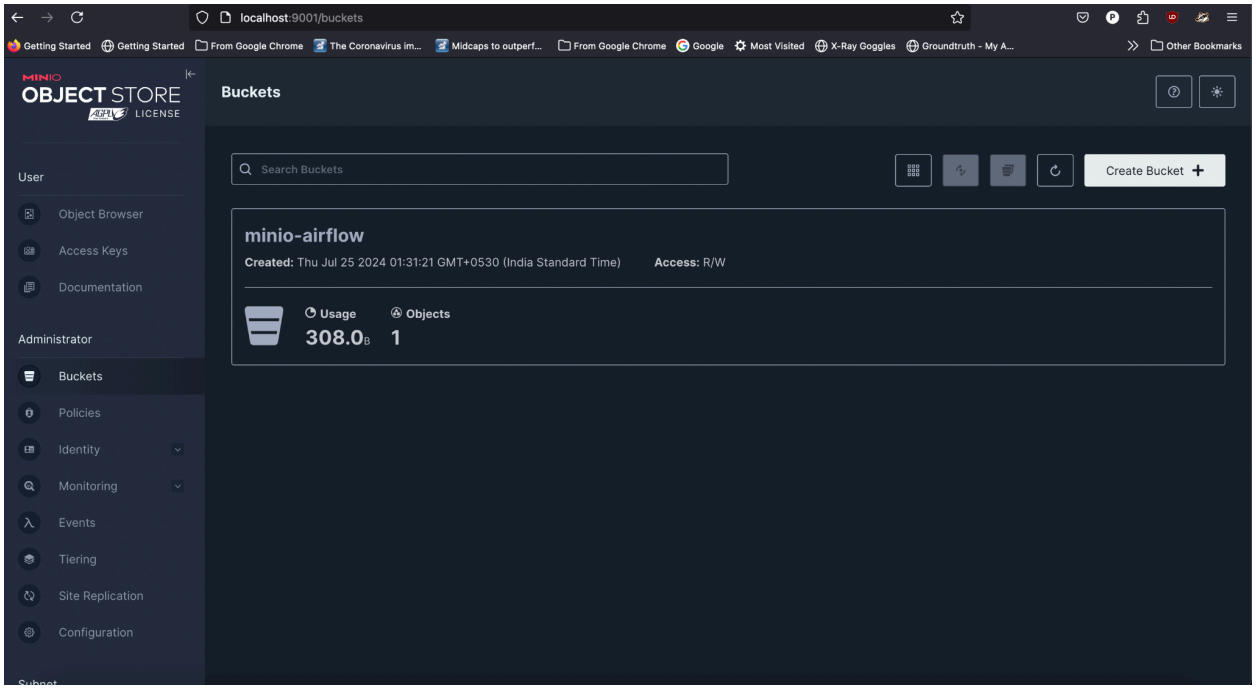


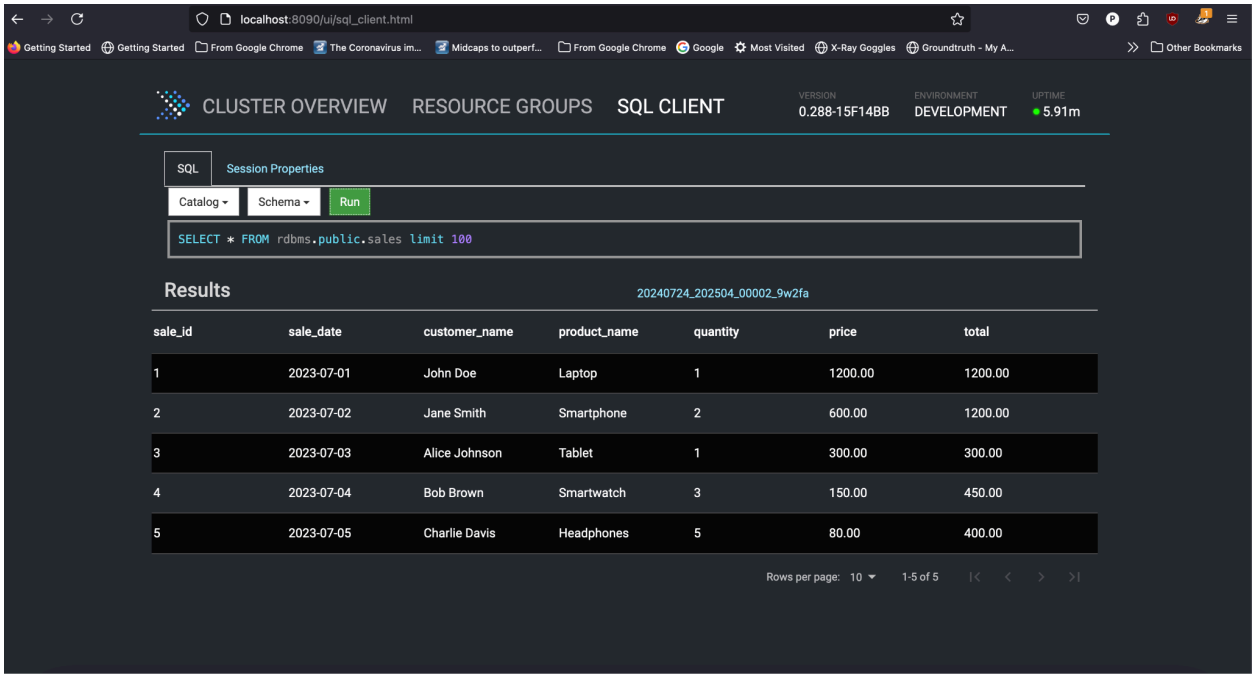


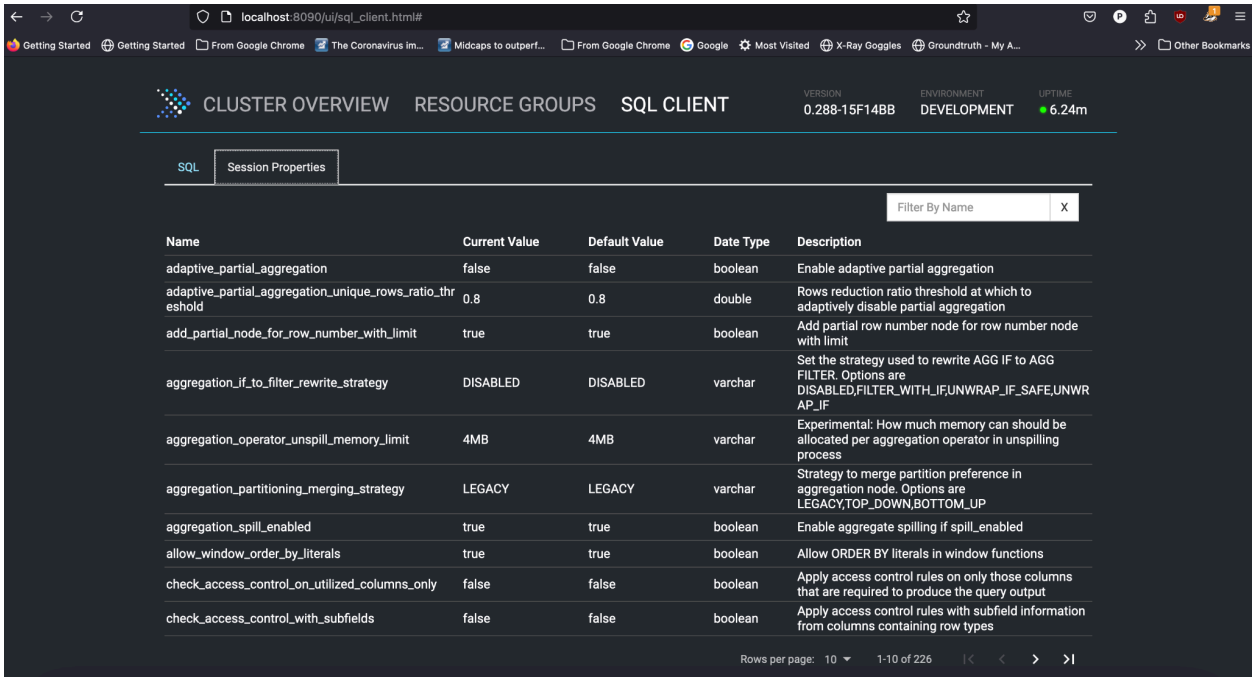
Version: v2.9.2
Git Version: .release:f56f13442613912725d307aafc537cc76277c2d1

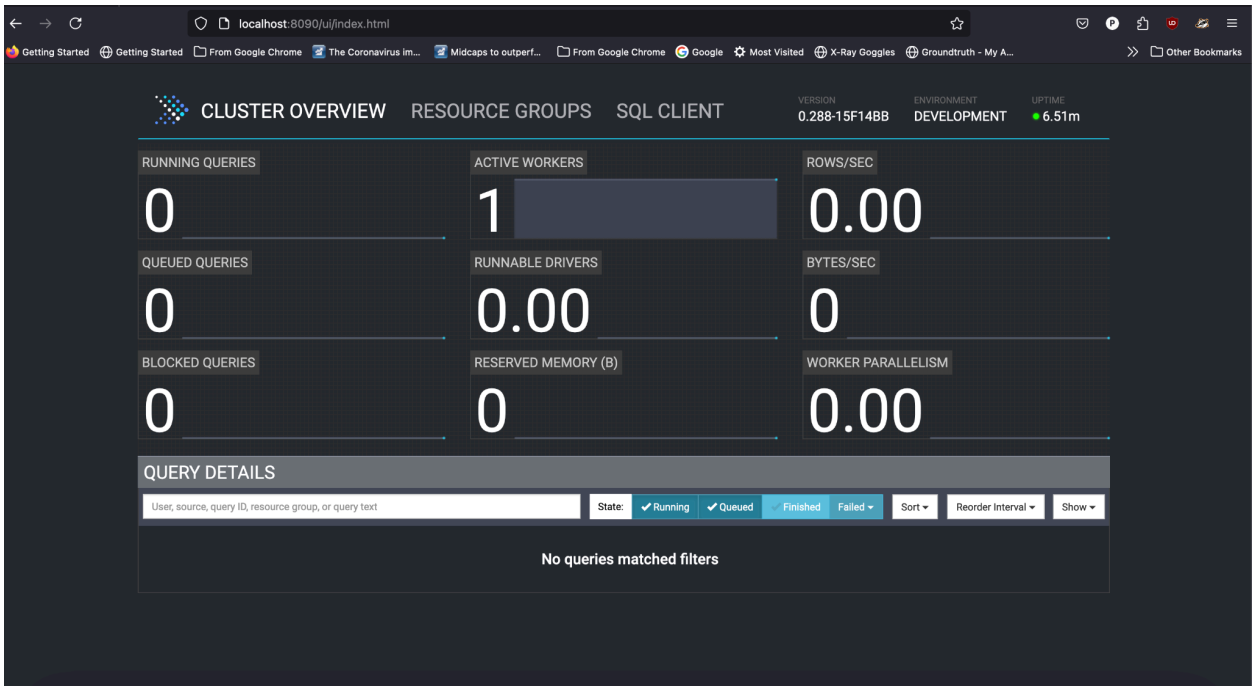


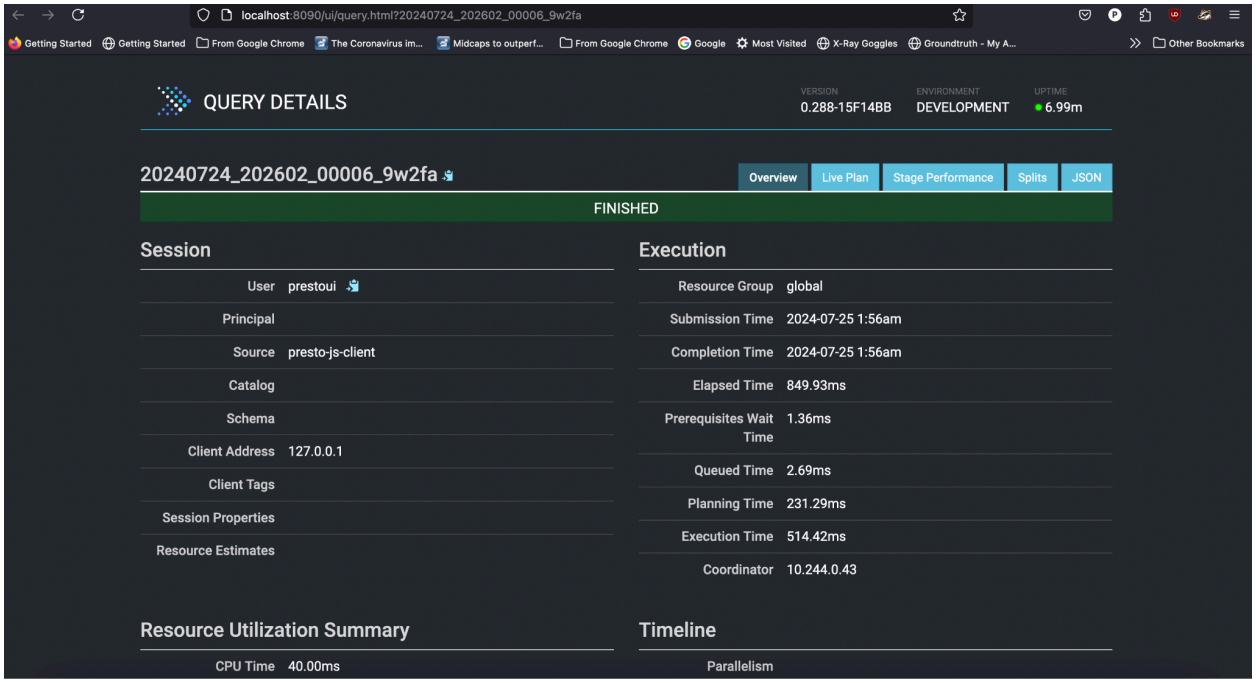

localhost:9001/browser/minio-airflow/cHJvY2Vzc2VkX2RhdGEv
MINIO
OBJECT STORE
LICENSE
Object Browser
Start typing to filter objects in the bucket
User
Object Browser
Access Keys
Documentation
Administrator
Buckets
Policies
Identity
Monitoring
Events
Tiering
Site Replication
Configuration
minio-airflow
Created on: Thu, Jul 25 2024 01:31:21 (GMT+5:30)
Access: PRIVATE
308.0 B - 1 Object
Rewind
Refresh
Upload
minio-airflow / processed_data
Create new path
Name
Last Modified
Size
processed_data.csv
Today, 01:38
308.0 B


localhost:9001/buckets
MINIO
OBJECT STORE
LICENSE
Buckets
Search Buckets
Create Bucket
User
Object Browser
Access Keys
Documentation
Administrator
Buckets
Policies
Identity
Monitoring
Events
Tiering
Site Replication
Configuration
minio-airflow
Created: Thu Jul 25 2024 01:31:21 GMT+0530 (India Standard Time)
Access: R/W
Usage
308.0B
Objects
1


localhost:8090/ui/sql_client.html
CLUSTER OVERVIEW
RESOURCE GROUPS
SQL CLIENT
VERSION
0.288-15F14BB
ENVIRONMENT
DEVELOPMENT
UPTIME
5.91m
SQL
Session Properties
Catalog
Schema
Run
SELECT * FROM rdbms.public.sales limit 100
Results
20240724_202504_00002_9w2fa
sale_id
sale_date
customer_name
product_name
quantity
price
total
1
2023-07-01
John Doe
Laptop
1
1200.00
1200.00
2
2023-07-02
Jane Smith
Smartphone
2
600.00
1200.00
3
2023-07-03
Alice Johnson
Tablet
1
300.00
300.00
4
2023-07-04
Bob Brown
Smartwatch
3
150.00
450.00
5
2023-07-05
Charlie Davis
Headphones
5
80.00
400.00
Rows per page: 10
1-5 of 5


localhost:8090/ui/sql_client.html#
CLUSTER OVERVIEW
RESOURCE GROUPS
SQL CLIENT
VERSION
0.288-15F14BB
ENVIRONMENT
DEVELOPMENT
UPTIME
6.24m
SQL
Session Properties
Filter By Name
X
Name
Current Value
Default Value
Date Type
Description
adaptive_partial_aggregation
false
false
boolean
Enable adaptive partial aggregation
adaptive_partial_aggregation_unique_rows_ratio_threshold
0.8
0.8
double
Rows reduction ratio threshold at which to adaptively disable partial aggregation
add_partial_node_for_row_number_with_limit
true
true
boolean
Add partial row number node for row number node with limit
aggregation_if_to_filter_rewrite_strategy
DISABLED
DISABLED
varchar
Set the strategy used to rewrite AGG IF to AGG FILTER. Options are DISABLED,FILTER_WITH_IF,UNWRAP_IF_SAFE,UNWRAP_IF
aggregation_operator_unspill_memory_limit
4MB
4MB
varchar
Experimental: How much memory can should be allocated per aggregation operator in unspilling process
aggregation_partitioning_merging_strategy
LEGACY
LEGACY
varchar
Strategy to merge partition preference in aggregation node. Options are LEGACY,TOP_DOWN,BOTTOM_UP
aggregation_spill_enabled
true
true
boolean
Enable aggregate spilling if spill_enabled
allow_window_order_by_literals
true
true
boolean
Allow ORDER BY literals in window functions
check_access_control_on_utilized_columns_only
false
false
boolean
Apply access control rules on only those columns that are required to produce the query output
check_access_control_with_subfields
false
false
boolean
Apply access control rules with subfield information from columns containing row types
Rows per page: 10
1-10 of 226


localhost:8090/ui/index.html
CLUSTER OVERVIEW
RESOURCE GROUPS
SQL CLIENT
VERSION
0.288-15F14BB
ENVIRONMENT
DEVELOPMENT
UPTIME
6.51m
RUNNING QUERIES
0
ACTIVE WORKERS
1
ROWS/SEC
0.00
QUEUED QUERIES
0
RUNNABLE DRIVERS
0.00
BYTES/SEC
0
BLOCKED QUERIES
0
RESERVED MEMORY (B)
0
WORKER PARALLELISM
0.00
QUERY DETAILS
User, source, query ID, resource group, or query text
State:
Running
Queued
Finished
Failed
Sort
Reorder Interval
Show
No queries matched filters


localhost:8090/ui/query.html?20240724_202602_00006_9w2fa
QUERY DETAILS
VERSION
0.288-15F14BB
ENVIRONMENT
DEVELOPMENT
UPTIME
6.99m
20240724_202602_00006_9w2fa
Overview
Live Plan
Stage Performance
Splits
JSON
FINISHED
Session
User prestoui
Principal
Source presto-js-client
Catalog
Schema
Client Address 127.0.0.1
Client Tags
Session Properties
Resource Estimates
Execution
Resource Group global
Submission Time 2024-07-25 1:56am
Completion Time 2024-07-25 1:56am
Elapsed Time 849.93ms
Prerequisites Wait Time 1.36ms
Queued Time 2.69ms
Planning Time 231.29ms
Execution Time 514.42ms
Coordinator 10.244.0.43
Resource Utilization Summary
CPU Time 40.00ms
Timeline
Parallelism

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Minikube Dashboard (Addon: metrics-server)