Airflow & Bigtop: Modernize and integrate time-proven OSS stack with Apache Airflow 3.0

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Who we are

- Open source software developers / data engineers @NTT DATA
- Kengo Seki
  - Committer & PMC member of Apache Airflow and Apache Bigtop
  - ASF member
- Masatake Iwasaki
  - Committer & PMC member of Apache Hadoop and Apache Bigtop
  - ASF member

Agenda

- What is Apache Bigtop
- Introducing Bigtop features using the Airflow component
- Why we chose Airflow as our workflow orchestrator
- BigPetStore example DAG

What is Apache Bigtop

What is Apache Bigtop

- "Bigtop is an ASF project for Infrastructure Engineers and Data Scientists looking for comprehensive packaging, testing, and configuration of the leading open source big data components." (from https://bigtop.apache.org/)

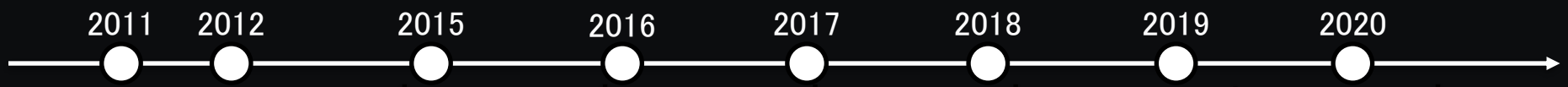
- Bigtop is a Hadoop distribution developed by an open-source community and makes it easier for users to build and test their data platform.

Bigtop Features

1. Building components and packaging on widely-used Linux distributions
2. Deployment automation
3. Smoke tests
4. Provisioning components onto Docker containers

Each detail will be explained later.

History of Bigtop



	1.0.0	1.1.0	1.2.1	1.3.0	1.4.0	1.5.0
Ambari			2.5.0	2.6.1	2.6.1	2.6.1
Flink			1.1.3	1.4.2	1.6.4	1.6.4
Hadoop	2.6.0	2.7.1	2.7.3	2.8.4	2.8.5	2.10.1
HBase	0.98.12	0.98.12	1.1.9	1.3.2	1.3.2	1.5.0
Hive	1.0.0	1.2.1	1.2.1	2.3.3	2.3.3	2.3.6
Kafka	0.8.1.1	0.8.1.1	0.10.1.1	0.10.2.2	0.10.2.2	2.4.0
Oozie	4.0.1	4.2.0	4.3.0	4.3.0	4.3.0	4.3.0
Spark	1.3.1	1.5.1	2.1.1	2.2.1	2.2.3	2.4.5
Zeppelin		0.5.6	0.7.2	0.7.3	0.7.3	0.8.2
Zookeeper	3.4.6	3.4.6	3.4.6	3.4.6	3.4.6	3.4.13

History of Bigtop

	3.0.0	3.0.1	3.1.0	3.1.1	3.2.0	3.2.1
Ambari	2.7.5	2.7.5	2.7.5	2.7.5	2.7.5	2.8.0
Flink	1.11.3	1.11.6	1.11.6	1.11.6	1.15.0	1.15.3
Hadoop	3.2.2	3.2.2	3.2.3	3.2.4	3.3.4	3.3.5
HBase	2.2.6	2.2.6	2.4.8	2.4.8	2.4.13	2.4.13
Hive	3.1.2	3.1.2	3.1.2	3.1.2	3.1.3	3.1.3
Kafka	2.4.1	2.4.1	2.8.1	2.8.1	2.8.1	2.8.1
Oozie	5.2.1	5.2.1	5.2.1	5.2.1	5.2.1	5.2.1
Spark	3.0.1	3.0.1	3.1.2	3.1.2	3.2.1	3.2.1
Zeppelin	0.9.0	0.10.0	0.10.0	0.10.0	0.10.1	0.10.1
Zookeeper	3.4.14	3.4.14	3.5.9	3.5.9	3.5.9	3.5.9

History of Bigtop

	3.3.0	3.4.0	3.5.0
Airflow			2.10.5
Ambari			
Flink	1.16.2	1.20.0	1.20.1
Hadoop	3.3.6	3.3.6	3.3.6
HBase	2.4.17	2.6.1	2.6.2
Hive	3.1.3	4.0.1	4.0.1
Kafka	2.8.2	3.4.1	3.4.1
Oozie			
Ranger	2.4.0	2.6.0	2.7.0
Spark	3.3.4	3.5.3	3.5.6
Zeppelin	0.11.0	0.11.2	0.11.2
Zookeeper	3.7.2	3.8.4	3.8.4

Introducing Bigtop features using the Airflow component

Bigtop Features

1. Build components as native packages of widely-used Linux distributions
2. Deployment automation
3. Smoke tests
4. Provisioning components onto Docker containers

Building packages locally

1. Download and extract Bigtop tarball

```
$ curl -sLO https://downloads.apache.org/bigtop/bigtop-3.5.0/bigtop-3.5.0-project.tar.gz
$ tar zxf bigtop-3.5.0-project.tar.gz
$ cd bigtop-3.5.0
```

2. Install Puppet then tools including compilers and libraries

```
$ sudo bigtop_toolchain/bin/puppetize.sh
$ sudo puppet apply ¥
 --modulepath=".:/etc/puppet/modules:/usr/share/puppet/modules:/etc/puppet/code/modules" ¥
 -e "include bigtop_toolchain::installer"
(or `./gradlew toolchain` if supported JDK is already available)
```

3. build RPM/DEB packages then create YUM/APT repository

```
$ ./gradlew bigtop-utils-pkg airflow-pkg repo
$ ls output
```

Building packages in containers

```
(installing Docker)

$ curl -sLO https://downloads.apache.org/bigtop/bigtop-3.5.0/bigtop-3.5.0-project.tar.gz
$ tar zxf bigtop-3.5.0-project.tar.gz
$ cd bigtop-3.5.0


$ ./gradlew bigtop-utils-pkg-ind airflow-pkg-ind repo-ind ¥
    -POS=rockylinux-9 ¥
    -Pprefix=3.5.0 ¥
    -Pdocker-run-option="--privileged" ¥
    -Pmvn-cache-volume=true

$ ls output
```

1. Download and extract Bigtop tarball

2. build RPM/DEB packages then create YUM/APT repository in Docker container

Installing Bigtop pre-built RPM packages (Rocky Linux 9)

1. Download and install repository definition

```
$ sudo curl -L -o /etc/yum.repos.d/bigtop.repo ¥
    https://downloads.apache.org/bigtop/bigtop-3.5.0/repos/rockylinux-9/bigtop.repo
```

2. Import GPG key

```
$ sudo rpm --import ¥
    https://downloads.apache.org/bigtop/bigtop-3.5.0/repos/GPG-KEY-bigtop
```

3. Update repository information and Install components via package manager

```
$ sudo dnf install airflow bigtop-utils
$ /usr/lib/airflow/bin/airflow version
2.10.5
```

Installing Bigtop pre-built DEB packages (Ubuntu 24.04)

1. Download and install repository definition

```
$ sudo curl -o /etc/apt/sources.list.d/bigtop.list ¥
    https://downloads.apache.org/bigtop/bigtop-3.5.0/repos/ubuntu-24.04/bigtop.list
```

2. Import GPG key

```
$ curl -s https://downloads.apache.org/bigtop/bigtop-3.5.0/repos/GPG-KEY-bigtop ¥
    | sudo apt-key add -
```

3. Update repository information and Install components via package manager

```
$ sudo apt-get update
$ sudo apt-get install airflow bigtop-utils
$ /usr/lib/airflow/bin/airflow version
2.10.5
```

Provisioning by Puppet manifest on Rocky Linux 9

```
$ curl -sLO https://downloads.apache.org/bigtop/bigtop-3.5.0/bigtop-3.5.0-project.tar.gz
$ tar zxf bigtop-3.5.0-project.tar.gz
$ cd bigtop-3.5.0
$ sudo bigtop_toolchain/bin/puppetize.sh
$ cat > bigtop-deploy/puppet/hieradata/site.yaml <<'EOF'
bigtop::bigtop_repo_uri: http://repos.bigtop.apache.org/releases/3.5.0/rockylinux/9/$basearch
bigtop::hadoop_head_node: "host1.example.com"
hadoop_cluster_node::cluster_nodes: ["host1.example.com ", "host2.example.com ", host3.example.com "]
hadoop_cluster_node::cluster_components: ["bigtop-utils", "airflow"]
EOF

$ cp -r bigtop-deploy/puppet/hiera* /etc/puppet/
$ puppet apply ¥
      --hiera_config=/etc/puppet/hiera.yaml ¥
      --modulepath=./bigtop-deploy/puppet/modules:/usr/share/puppet/modules:etc/puppet/code/modules ¥
      ./bigtop-deploy/puppet/manifests
```

Provisioning by Puppet manifest on Ubuntu 24.04

```
$ curl -sLO https://downloads.apache.org/bigtop/bigtop-3.5.0/bigtop-3.5.0-project.tar.gz
$ tar zxf bigtop-3.5.0-project.tar.gz
$ cd bigtop-3.5.0
$ sudo bigtop_toolchain/bin/puppetize.sh
$ cat > bigtop-deploy/puppet/hieradata/site.yaml <<'EOF'
bigtop::bigtop_repo_uri: http://repos.bigtop.apache.org/releases/3.5.0/ubuntu/24.04/$(ARCH)
bigtop::hadoop_head_node: "host1.example.com"
hadoop_cluster_node::cluster_nodes: ["host1.example.com ", "host2.example.com ", host3.example.com "]
hadoop_cluster_node::cluster_components: ["bigtop-utils", "airflow"]
EOF

$ cp -r bigtop-deploy/puppet/hiera* /etc/puppet/
$ puppet apply ¥
      --hiera_config=/etc/puppet/hiera.yaml ¥
      --modulepath=./bigtop-deploy/puppet/modules:/usr/share/puppet/modules ¥
      ./bigtop-deploy/puppet/manifests
```

Running smoke tests

```
$ curl -sLO https://downloads.apache.org/bigtop/bigtop-3.5.0/bigtop-3.5.0-project.tar.gz
$ tar zxf bigtop-3.5.0-project.tar.gz
$ cd bigtop-3.5.0

$ . /usr/lib/bigtop-utils/bigtop-detect-javahome
$ export AIRFLOW_HOME=/usr/lib/airflow
$ ./gradlew bigtop-tests:smoke-tests:airflow:test -Psmoke.tests --info
```

provisioning and smoke-tests on containers

```
(installing Docker and Docker Compose; building packages and creating local repo )
$ cd provisioner/docker
$ ./docker-hadoop.sh --create 1 --memory 16g ¥
                     --image bigtop/puppet:3.5.0-rockylinux-9 ¥
                     --repo file:///bigtop-home/output ¥
                     --enable-local-repo --disable-gpg-check ¥
                     --stack bigtop-utils,airflow ¥
                     --smoke-tests airflow

$ ./docker-hadoop.sh --list
NAME                            IMAGE                                COMMAND        SERVICE    CREATED
STATUS         PORTS
20251002_144838_r3229_bigtop_1   bigtop/puppet:3.5.0-rockylinux-9   "/sbin/init"   bigtop     3 minutes
ago   Up 3 minutes

$ ./docker-hadoop.sh --exec 1 /bin/bash
[root@17a680a4f14a /]#
```

Why we chose Airflow as our new workflow orchestrator

Why we chose Airflow as our new workflow orchestrator

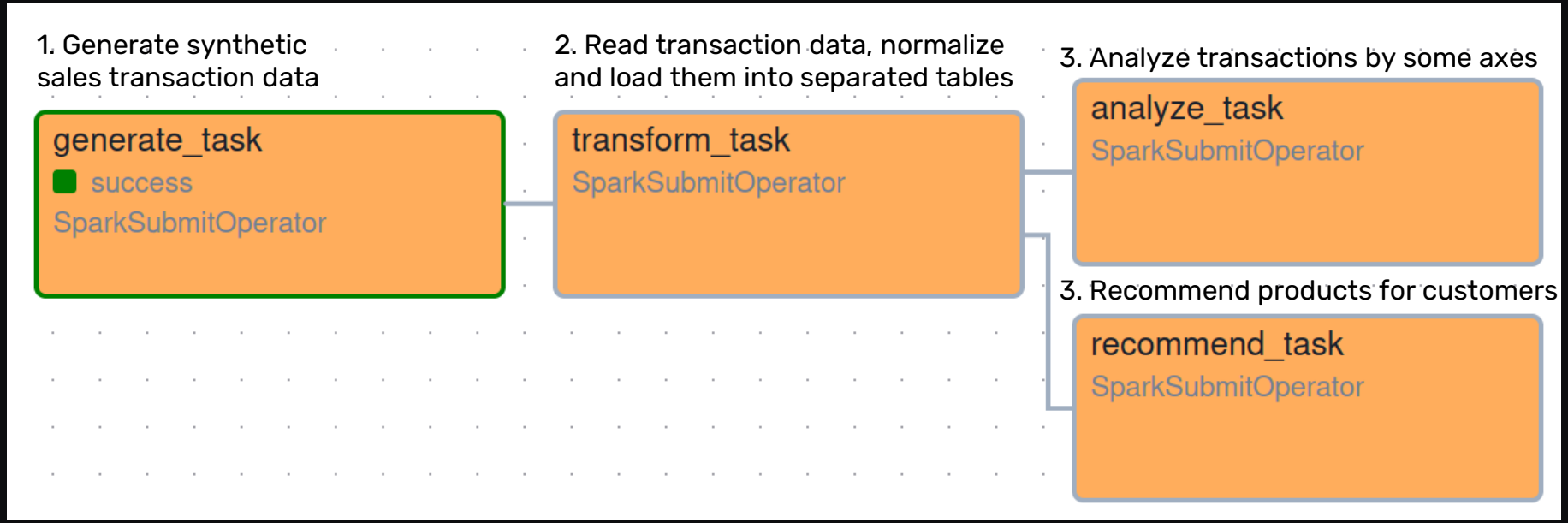
- De-facto standard of workflow orchestrator
- Widespread userbase and vibrant community
- Affinity with the existing Bigtop components

Affinity with the existing Bigtop software stack

- Bigtop is composed of various ASF products, e.g., Hadoop, Spark, Flink, Kafka
- Airflow's diverse providers enable integration between them
- Enterprise-ready features are also supported, e.g., Kerberos support, proven scalability, fine-grained security

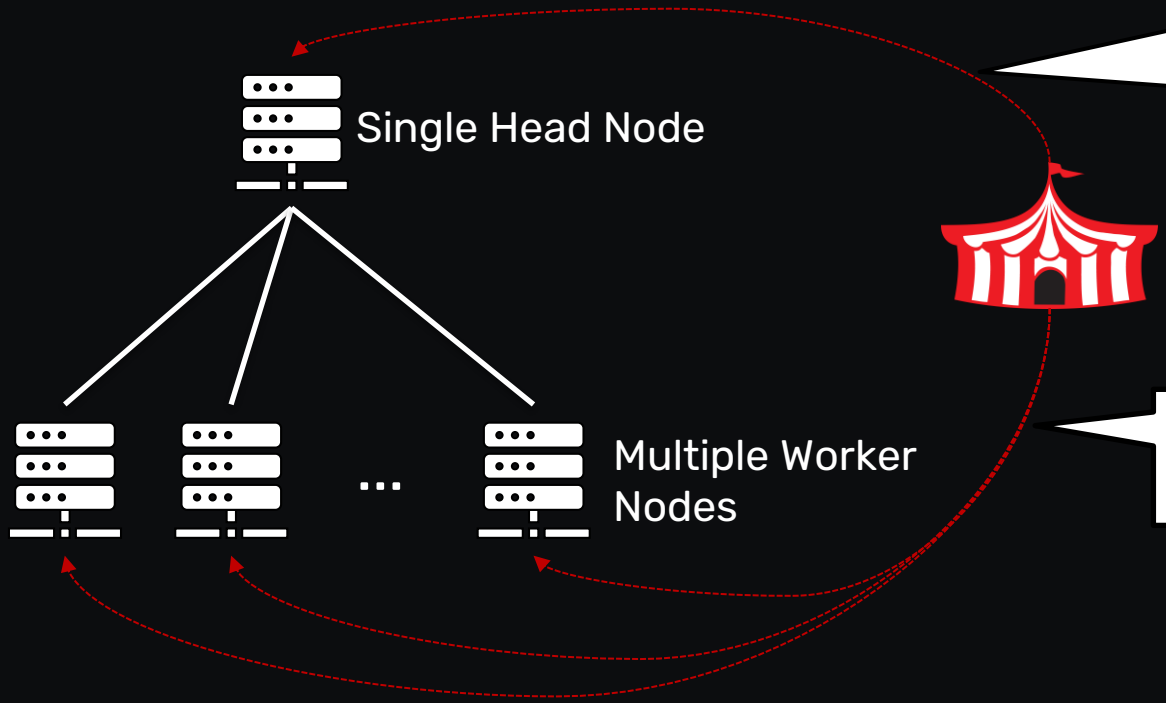
Airflow integration example: BigPetStore DAG

BigPetStore: Simple ETL, data analytics and ML application



For details, see
https://github.com/apache/bigtop/blob/rel/3.5.0/bigtop-bigpetstore/bigpetstore-spark/README.md

System Composition



- Airflow
- HDFS (NameNode)
- YARN (ResourceManager)
- Spark
- Zeppelin

- HDFS (DataNode)
- YARN (NodeManager)

Deployment process

- Download Bigtop 3.5.0 and install Puppet on each node

```
$ curl -sLO https://dlcdn.apache.org/bigtop/bigtop-3.5.0/bigtop-3.5.0-project.tar.gz
$ tar xf bigtop-3.5.0-project.tar.gz
$ sudo bigtop-3.5.0/bigtop_toolchain/bin/puppetize.sh
```

- Enable "install BigPetStore DAG" option (and some required settings) by modifying the configuration file

```
$ tail -5 bigtop-3.5.0/bigtop-deploy/puppet/hieradata/bigtop/cluster.yaml
# Airflow
airflow::server::executor: "LocalExecutor"
airflow::server::load_examples: false
airflow::server::sql_alchemy_conn: "postgresql+psycopg2://..."
airflow::server::install_bigpetstore_example: false
$ cat <<EOT > bigtop-3.5.0/bigtop-deploy/puppet/hieradata/site.yaml
bigtop::hadoop_head_node: fqdn.of.head.node
hadoop::hadoop_storage_dirs: [/data]
hadoop_cluster_node::cluster_components: [airflow, hdfs, yarn, spark, zeppelin]
airflow::server::install_bigpetstore_example: true
EOT
```

Default parameters regarding Airflow

Override parameters in accordance with our requirements

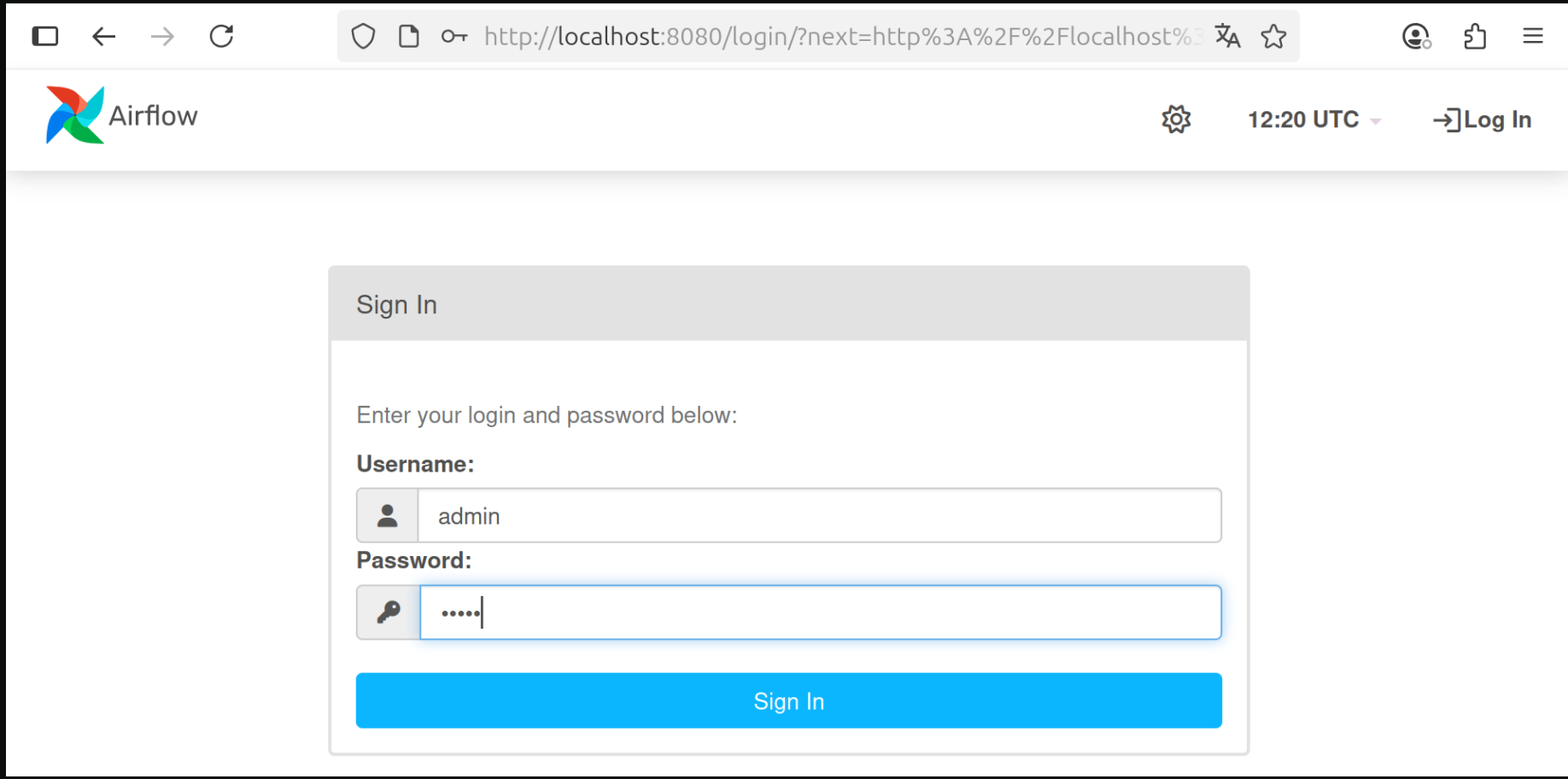
Deployment process (continued)

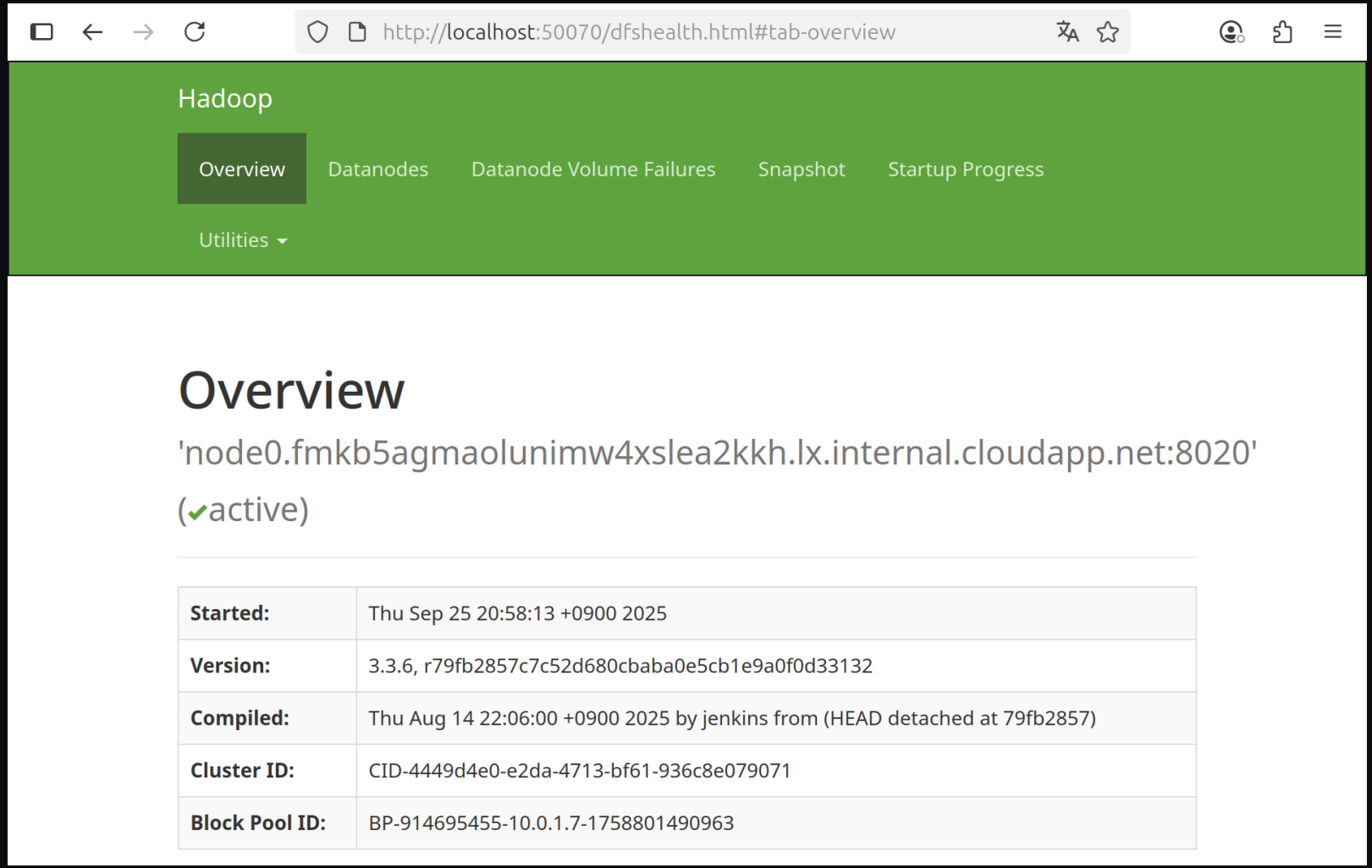
- Distribute configuration file from head node to all of worker nodes

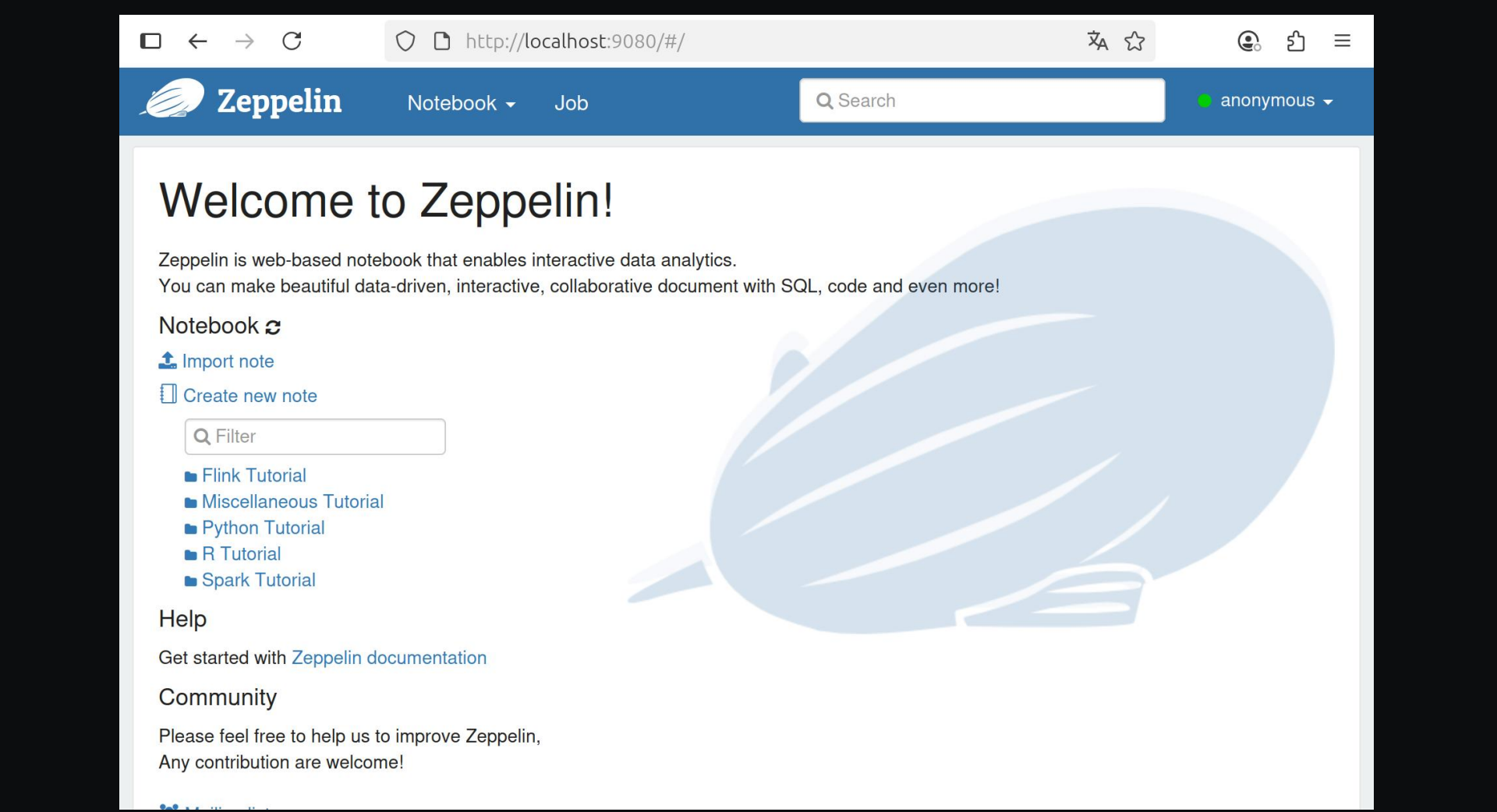
```
$ for node in $NODES; do scp bigtop-3.5.0/bigtop-deploy/puppet/hieradata/site.yaml ¥
> ${node}:~/bigtop-3.5.0/bigtop-deploy/puppet/hieradata/site.yaml; done
```

- Copy configuration files to Puppet's default location and apply them on each node

```
$ sudo cp -r bigtop-3.5.0/bigtop-deploy/puppet/hiera* /etc/puppet/
$ sudo puppet apply --modulepath bigtop-3.5.0/bigtop-deploy/puppet/modules:/usr/share/puppet/modules ¥
> bigtop-3.5.0/bigtop-deploy/puppet/manifests
(snip)
Notice: /Stage[main]/Airflow::Server/Package[airflow]/ensure: created
Notice: /Stage[main]/Airflow::Server/File[/var/lib/airflow/airflow.cfg]/ensure: defined content as
'{sha256}acb4d3f8a5e9b1abe56b4b6d0aba5ae611e8fbbe10a17bbaeadfbd71be345d7d'
Notice: /Stage[main]/Airflow::Server/Service[airflow-webserver]/ensure: ensure changed 'stopped' to 'running'
Notice: /Stage[main]/Airflow::Server/Exec[install-spark-provider]/returns: executed successfully
Notice: /Stage[main]/Airflow::Server/File[/var/lib/airflow/dags]/ensure: created
Notice: /Stage[main]/Airflow::Server/File[/var/lib/airflow/dags/example_bigpetstore.py]/ensure: defined
content as '{sha256}ad9a3c7ef4b76fa1cfbd047207ff48143405b6a687d901690a3d693c7fc5b711'
(snip)
Notice: Applied catalog in 570.91 seconds
```


http://localhost:8080/login/?next=http%3A%2F%2Flocalhost%3
Airflow
12:20 UTC
Log In
Sign In
Enter your login and password below:
Username:
admin
Password:
Sign In


http://localhost:50070/dfshealth.html#tab-overview
Hadoop
Overview
Datanodes
Datanode Volume Failures
Snapshot
Startup Progress
Utilities
Overview
'node0.fmkb5agmaolunimw4xslea2kkh.lx.internal.cloudapp.net:8020'
(✔active)
Started: Thu Sep 25 20:58:13 +0900 2025
Version: 3.3.6, r79fb2857c7c52d680cbaba0e5cb1e9a0f0d33132
Compiled: Thu Aug 14 22:06:00 +0900 2025 by jenkins from (HEAD detached at 79fb2857)
Cluster ID: CID-4449d4e0-e2da-4713-bf61-936c8e079071
Block Pool ID: BP-914695455-10.0.1.7-1758801490963


http://localhost:9080/#/
Zeppelin
Notebook
Job
Search
anonymous
Welcome to Zeppelin!
Zeppelin is web-based notebook that enables interactive data analytics.
You can make beautiful data-driven, interactive, collaborative document with SQL, code and even more!
Notebook
Import note
Create new note
Filter
Flink Tutorial
Miscellaneous Tutorial
Python Tutorial
R Tutorial
Spark Tutorial
Help
Get started with Zeppelin documentation
Community
Please feel free to help us to improve Zeppelin,
Any contribution are welcome!

Some additional steps

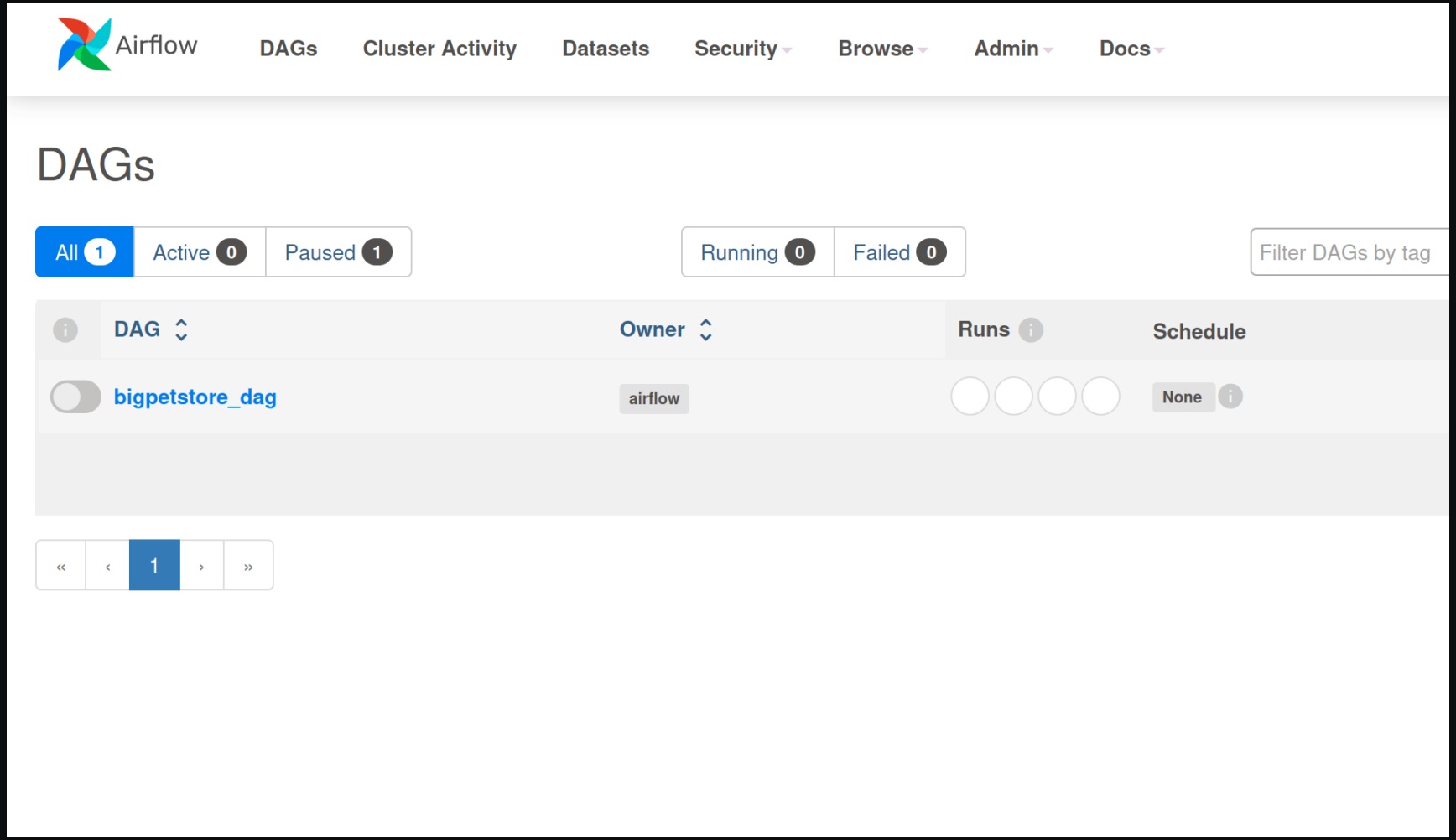
- Build BigPetStore's jar file ourselves on head node

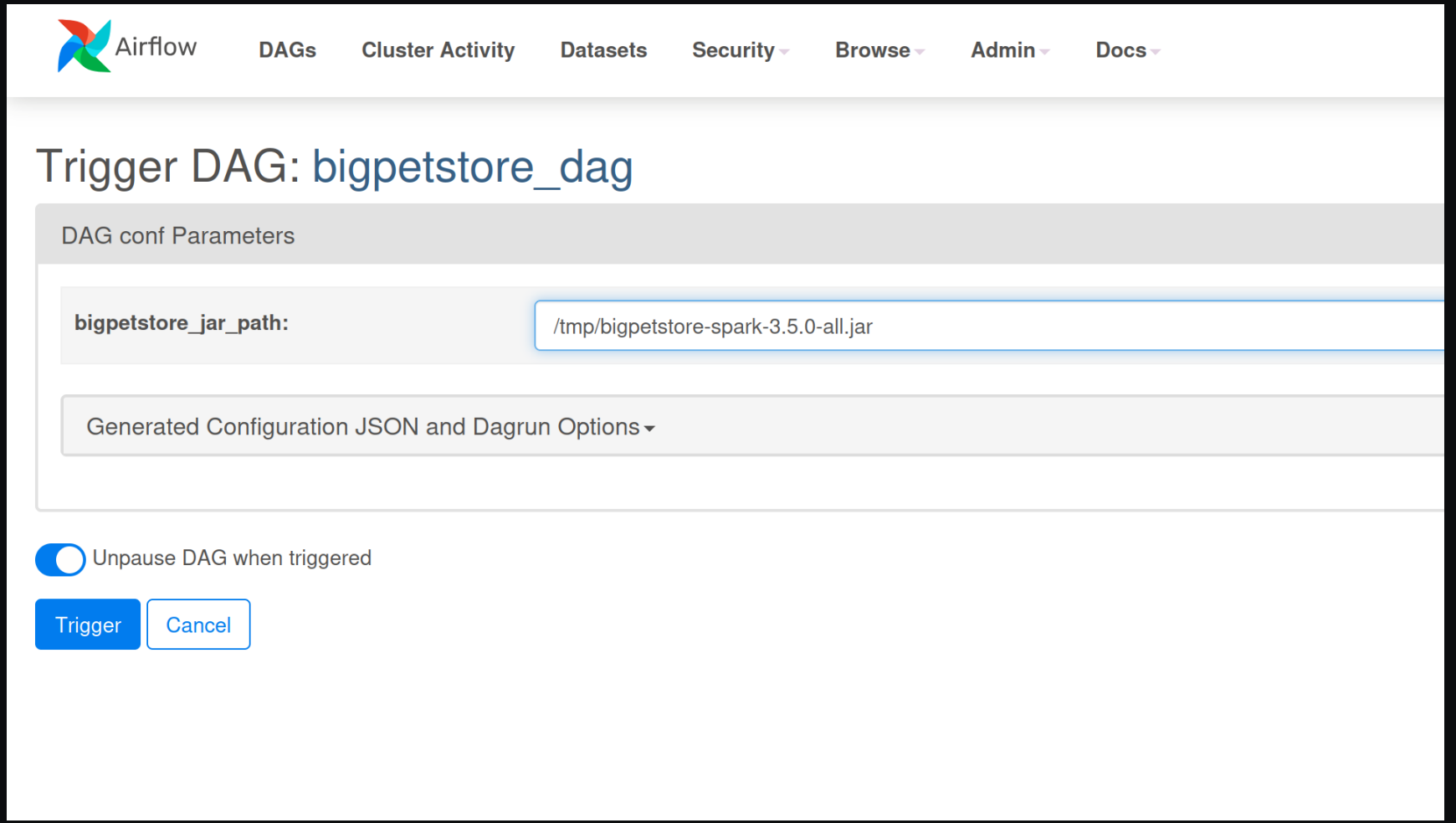
```
$ cd bigtop-3.5.0/bigtop-data-generators
$ ../gradlew clean publishToMavenLocal
$ cd ../bigtop-bigpetstore/bigpetstore-spark
$ ../../gradlew shadowJar
$ mv build/libs/bigpetstore-spark-3.5.0-all.jar /tmp/
```

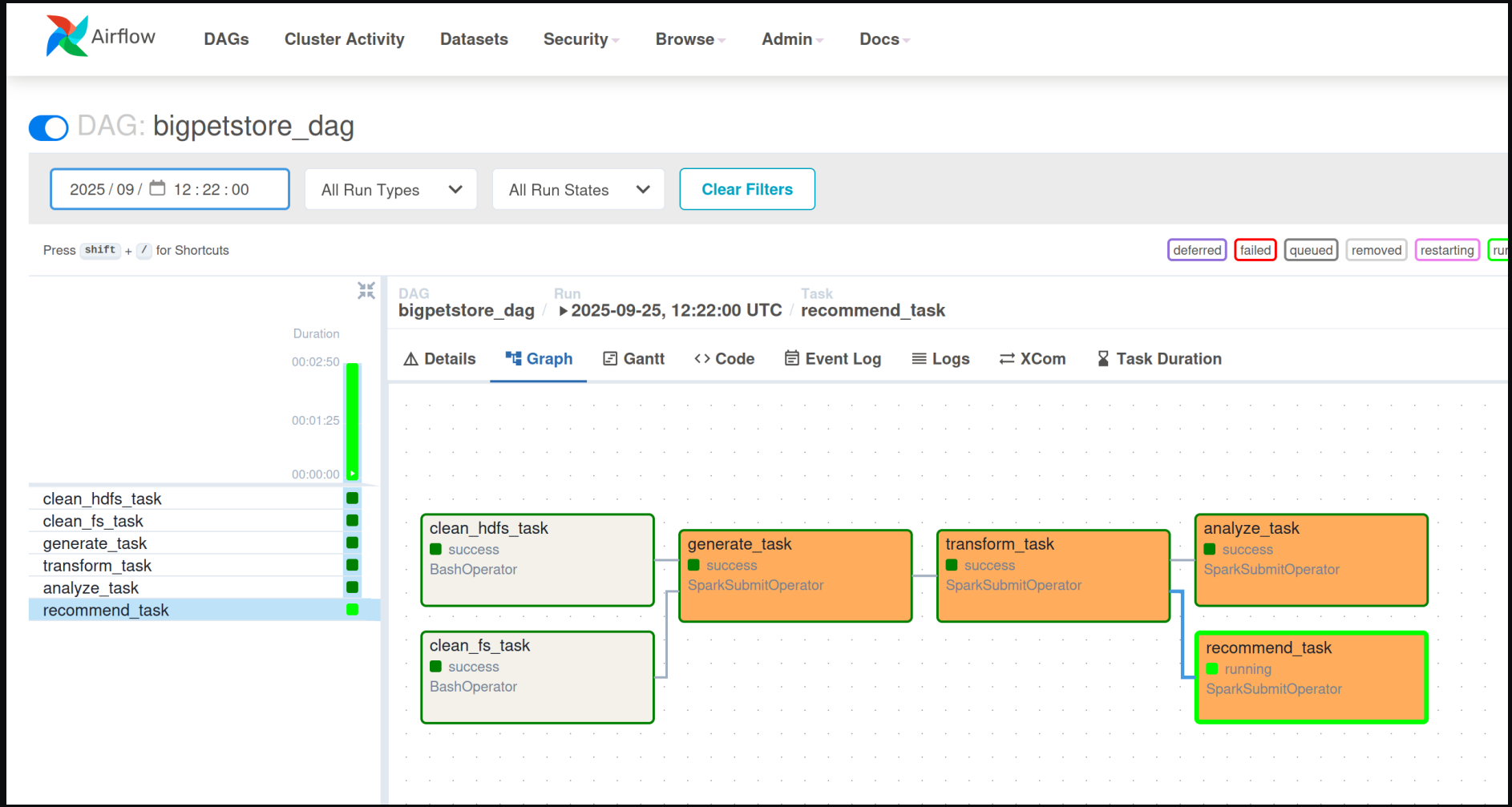
- Create Airflow user's home directory on HDFS

```
$ sudo -u hdfs hdfs dfs -mkdir /user/airflow
$ sudo -u hdfs hdfs dfs -chown airflow:hadoop /user/airflow
```

- These steps will be automatically done in the future release


Airflow
DAGs
Cluster Activity
Datasets
Security
Browse
Admin
Docs
DAGs
All 1
Active 0
Paused 1
Running 0
Failed 0
Filter DAGs by tag
DAG
Owner
Runs
Schedule
bigpetstore_dag
airflow
None
« ‹ 1 › »


Airflow
DAGs
Cluster Activity
Datasets
Security
Browse
Admin
Docs
Trigger DAG: bigpetstore_dag
DAG conf Parameters
bigpetstore_jar_path:
/tmp/bigpetstore-spark-3.5.0-all.jar
Generated Configuration JSON and Dagrun Options
Unpause DAG when triggered
Trigger
Cancel


Airflow
DAGs
Cluster Activity
Datasets
Security
Browse
Admin
Docs
DAG: bigpetstore_dag
2025 / 09 / 12 : 22 : 00
All Run Types
All Run States
Clear Filters
Press shift + / for Shortcuts
deferred
failed
queued
removed
restarting
DAG
bigpetstore_dag
Run
2025-09-25, 12:22:00 UTC
Task
recommend_task
Details
Graph
Gantt
Code
Event Log
Logs
XCom
Task Duration
Duration
00:02:50
00:01:25
00:00:00
clean_hdfs_task
clean_fs_task
generate_task
transform_task
analyze_task
recommend_task
clean_hdfs_task
success
BashOperator
clean_fs_task
success
BashOperator
generate_task
success
SparkSubmitOperator
transform_task
success
SparkSubmitOperator
analyze_task
success
SparkSubmitOperator
recommend_task
running
SparkSubmitOperator

Hadoop

Overview | Datanodes | Datanode Volume Failures | Snapshot | Startup Progress | Utilities

Browse Directory

/user/airflow Go!

Show 25 entries Search:

Permission	Owner	Group	Size	Last Modified	Replication	Block Size	Name
drwxr-xr-x	airflow	hadoop	0 B	Sep 25 21:25	0	0 B	.sparkStaging
drwxr-xr-x	airflow	hadoop	0 B	Sep 25 21:23	0	0 B	generated_data
drwxr-xr-x	airflow	hadoop	0 B	Sep 25 21:24	0	0 B	transformed_data

Showing 1 to 3 of 3 entries

Previous 1 Next

Zeppelin Notebook Job Search anonymous

Untitled Note 1

Head default

```
193,
289,
```

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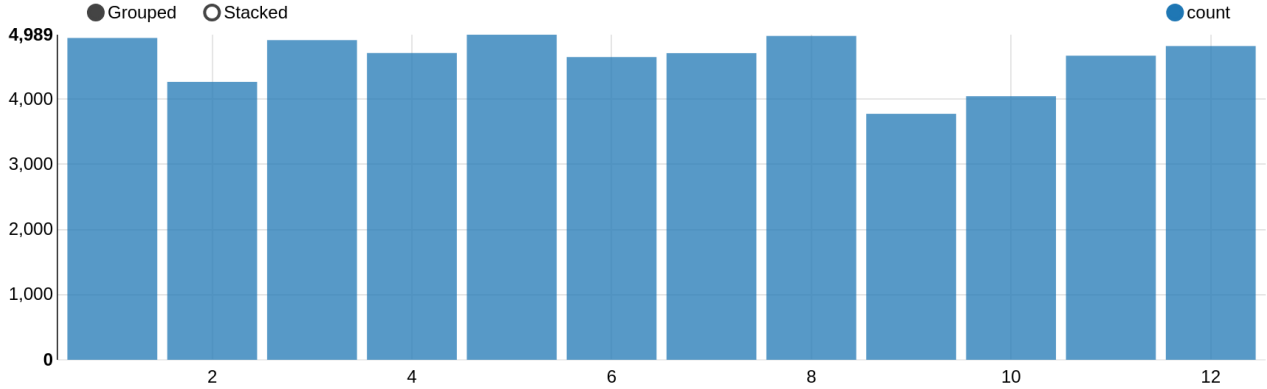
FINISHED

```
%sh
echo %table
echo -e month\\tcount
jq -r '.transactionsByMonth[] | [.month, .count] | @tsv' /tmp/PetStoreStats.json
```

settings



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Zeppelin Notebook Job Search anonymous

Untitled Note 1

Head default

FINISHED

```
%sh
cat /tmp/recommendations.json | jq .recommendations[:10]
```

```
[
  {
    "customerId": 0,
    "productIds": [
      202,
      193,
      141,
      289,
      40
    ]
  },
  {
    "customerId": 1,
    "productIds": [
      202,
      193,
      289,
```

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Conclusion

- Bigtop is an ASF project that offers software distribution for big data processing
- Bigtop adopted Airflow as its new workflow orchestrator since v3.5.0
- By using Bigtop, users can easily build their own data platform including Airflow
- Airflow is a keystone of the integration between diverse Bigtop components
- BigPetStore DAG is an example of that integration and we'll add more diverse usecases and workloads in the future, e.g., streaming, GenAI, etc.

Questions?

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