



Spring Cloud Data Flow Server for Kubernetes

1.1.1.BUILD-SNAPSHOT

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Part I. Introduction

1. Introducing Spring Cloud Data Flow for Kubernetes

This project provides support for orchestrating long-running (*streaming*) and short-lived (*task/batch*) data microservices to Kubernetes using apps packaged as Docker images.

2. Spring Cloud Data Flow

Spring Cloud Data Flow is a cloud-native orchestration service for composable data microservices on modern runtimes. With Spring Cloud Data Flow, developers can create and orchestrate data pipelines for common use cases such as data ingest, real-time analytics, and data import/export.

The Spring Cloud Data Flow architecture consists of a server that deploys [Streams](#) and [Tasks](#). Streams are defined using a [DSL](#) or visually through the browser based designer UI. Streams are based on the [Spring Cloud Stream](#) programming model while Tasks are based on the [Spring Cloud Task](#) programming model. The sections below describe more information about creating your own custom Streams and Tasks

For more details about the core architecture components and the supported features, please review Spring Cloud Data Flow's [core reference guide](#). There're several [samples](#) available for reference.

3. Spring Cloud Stream

Spring Cloud Stream is a framework for building message-driven microservice applications. Spring Cloud Stream builds upon Spring Boot to create standalone, production-grade Spring applications, and uses Spring Integration to provide connectivity to message brokers. It provides opinionated configuration of middleware from several vendors, introducing the concepts of persistent publish-subscribe semantics, consumer groups, and partitions.

For more details about the core framework components and the supported features, please review Spring Cloud Stream's [reference guide](#).

There's a rich ecosystem of Spring Cloud Stream [Application-Starters](#) that can be used either as standalone data microservice applications or in Spring Cloud Data Flow. For convenience, we have generated RabbitMQ and Apache Kafka variants of these application-starters that are available for use from [Docker Hub](#) as docker images.

Do you have a requirement to develop custom applications? No problem. Refer to this guide to create [custom stream applications](#). There're several [samples](#) available for reference.

4. Spring Cloud Task

Spring Cloud Task makes it easy to create short-lived microservices. We provide capabilities that allow short-lived JVM processes to be executed on demand in a production environment.

For more details about the core framework components and the supported features, please review Spring Cloud Task's [reference guide](#).

There's a rich ecosystem of Spring Cloud Task [Application-Starters](#) that can be used either as standalone data microservice applications or in Spring Cloud Data Flow. For convenience, the generated application-starters are available for use from [Docker Hub](#) as docker images. There are several [samples](#) available for reference.

Part II. Architecture

5. Introduction

Spring Cloud Data Flow simplifies the development and deployment of applications focused on data processing use-cases. The major concepts of the architecture are Applications, the Data Flow Server, and the target runtime.

Applications come in two flavors

- Long lived Stream applications where an unbounded amount of data is consumed or produced via messaging middleware.
- Short lived Task applications that process a finite set of data and then terminate.

Depending on the runtime, applications can be packaged in two ways

- Spring Boot uber-jar that is hosted in a maven repository, file, http or any other Spring resource implementation.
- Docker

The runtime is the place where applications execute. The target runtimes for applications are platforms that you may already be using for other application deployments.

The supported runtimes are

- Cloud Foundry
- Apache YARN
- Kubernetes
- Apache Mesos
- Local Server for development

There is a deployer Service Provider Interface (SPI) that enables you to extend Data Flow to deploy onto other runtimes, for example to support Docker Swarm. There are community implementations of Hashicorp's Nomad and RedHat Openshift is available. We look forward to working with the community for further contributions!

The component that is responsible for deploying applications to a runtime is the Data Flow Server. There is a Data Flow Server executable jar provided for each of the target runtimes. The Data Flow server is responsible for interpreting

- A stream DSL that describes the logical flow of data through multiple applications.
- A deployment manifest that describes the mapping of applications onto the runtime. For example, to set the initial number of instances, memory requirements, and data partitioning.

As an example, the DSL to describe the flow of data from an http source to an Apache Cassandra sink would be written as "http | cassandra". These names in the DSL are registered with the Data Flow Server and map onto application artifacts that can be hosted in Maven or Docker repositories. Many source, processor, and sink applications for common use-cases (e.g. jdbc, hdfs, http, router) are provided by the Spring Cloud Data Flow team. The pipe symbol represents the communication between the two applications via messaging middleware. The two messaging middleware brokers that are supported are

- Apache Kafka
- RabbitMQ

In the case of Kafka, when deploying the stream, the Data Flow server is responsible to create the topics that correspond to each pipe symbol and configure each application to produce or consume from the topics so the desired flow of data is achieved.

The interaction of the main components is shown below

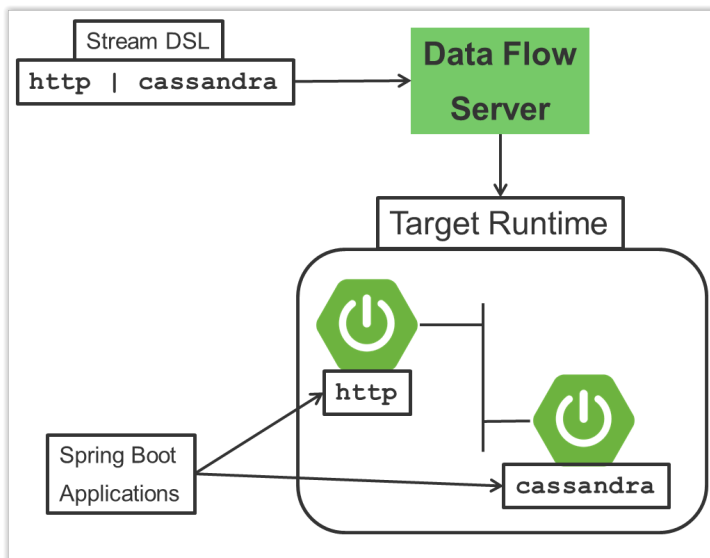


Figure 5.1. The Spring Cloud Data High Level Architecture

In this diagram a DSL description of a stream is POSTed to the Data Flow Server. Based on the mapping of DSL application names to Maven and Docker artifacts, the http-source and cassandra-sink applications are deployed on the target runtime.

6. Microservice Architectural Style

The Data Flow Server deploys applications onto the target runtime that conform to the microservice architectural style. For example, a stream represents a high level application that consists of multiple small microservice applications each running in their own process. Each microservice application can be scaled up or down independent of the other and each has their own versioning lifecycle.

Both Streaming and Task based microservice applications build upon Spring Boot as the foundational library. This gives all microservice applications functionality such as health checks, security, configurable logging, monitoring and management functionality, as well as executable JAR packaging.

It is important to emphasise that these microservice applications are ‘just apps’ that you can run by yourself using ‘java -jar’ and passing in appropriate configuration properties. We provide many common microservice applications for common operations so you don’t have to start from scratch when addressing common use-cases which build upon the rich ecosystem of Spring Projects, e.g Spring Integration, Spring Data, Spring Hadoop and Spring Batch. Creating your own microservice application is similar to creating other Spring Boot applications, you can start using the Spring Initializr web site or the UI to create the basic scaffolding of either a Stream or Task based microservice.

In addition to passing in the appropriate configuration to the applications, the Data Flow server is responsible for preparing the target platform’s infrastructure so that the application can be deployed. For example, in Cloud Foundry it would be binding specified services to the applications and executing the ‘cf push’ command for each application. For Kubernetes it would be creating the replication controller, service, and load balancer.

The Data Flow Server helps simplify the deployment of multiple applications onto a target runtime, but one could also opt to deploy each of the microservice applications manually and not use Data Flow at all. This approach might be more appropriate to start out with for small scale deployments, gradually adopting the convenience and consistency of Data Flow as you develop more applications. Manual deployment of Stream and Task based microservices is also a useful educational exercise that will help you better understand some of the automatic applications configuration and platform targeting steps that the Data Flow Server provides.

6.1 Comparison to other Platform architectures

Spring Cloud Data Flow’s architectural style is different than other Stream and Batch processing platforms. For example in Apache Spark, Apache Flink, and Google Cloud Dataflow applications run on a dedicated compute engine cluster. The nature of the compute engine gives these platforms a richer environment for performing complex calculations on the data as compared to Spring Cloud Data Flow, but it introduces complexity of another execution environment that is often not needed when creating data centric applications. That doesn’t mean you cannot do real time data computations when using Spring Cloud Data Flow. Refer to the analytics section which describes the integration of Redis to handle common counting based use-cases as well as the RxJava integration for functional API driven analytics use-cases, such as time-sliding-window and moving-average among others.

Similarly, Apache Storm, Hortonworks DataFlow and Spring Cloud Data Flow’s predecessor, Spring XD, use a dedicated application execution cluster, unique to each product, that determines where your code should execute on the cluster and perform health checks to ensure that long lived applications are restarted if they fail. Often, framework specific interfaces are required to be used in order to correctly “plug in” to the cluster’s execution framework.

As we discovered during the evolution of Spring XD, the rise of multiple container frameworks in 2015 made creating our own runtime a duplication of efforts. There is no reason to build your own resource management mechanics, when there are multiple runtime platforms that offer this functionality already. Taking these considerations into account is what made us shift to the current architecture where we delegate the execution to popular runtimes, runtimes that you may already be using for other purposes. This is an advantage in that it reduces the cognitive distance for creating and managing data centric applications as many of the same skills used for deploying other end-user/web applications are applicable.

7. Streaming Applications

While Spring Boot provides the foundation for creating DevOps friendly microservice applications, other libraries in the Spring ecosystem help create Stream based microservice applications. The most important of these is Spring Cloud Stream.

The essence of the Spring Cloud Stream programming model is to provide an easy way to describe multiple inputs and outputs of an application that communicate over messaging middleware. These input and outputs map onto Kafka topics or Rabbit exchanges and queues. Common application configuration for a Source that generates data, a Process that consumes and produces data and a Sink that consumes data is provided as part of the library.

7.1 Imperative Programming Model

Spring Cloud Stream is most closely integrated with Spring Integration's imperative "event at a time" programming model. This means you write code that handles a single event callback. For example,

```
@EnableBinding(Sink.class)
public class LoggingSink {

    @StreamListener(Sink.INPUT)
    public void log(String message) {
        System.out.println(message);
    }
}
```

In this case the String payload of a message coming on the input channel, is handed to the log method. The `@EnableBinding` annotation is what is used to tie together the input channel to the external middleware.

7.2 Functional Programming Model

However, Spring Cloud Stream can support other programming styles. The use of reactive APIs where incoming and outgoing data is handled as continuous data flows and it defines how each individual message should be handled. You can also use operators that describe functional transformations from inbound to outbound data flows. The upcoming versions will support Apache Kafka's KStream API in the programming model.

8. Streams

8.1 Topologies

The Stream DSL describes linear sequences of data flowing through the system. For example, in the stream definition `http | transformer | cassandra`, each pipe symbol connects the application on the left to the one on the right. Named channels can be used for routing and to fan out data to multiple messaging destinations.

Taps can be used to ‘listen in’ to the data that is flowing across any of the pipe symbols. Taps can be used as sources for new streams with an independent life cycle.

8.2 Concurrency

For an application that will consume events, Spring Cloud stream exposes a concurrency setting that controls the size of a thread pool used for dispatching incoming messages. See the [Consumer properties](#) documentation for more information.

8.3 Partitioning

A common pattern in stream processing is to partition the data as it moves from one application to the next. Partitioning is a critical concept in stateful processing, for either performance or consistency reasons, to ensure that all related data is processed together. For example, in a time-windowed average calculation example, it is important that all measurements from any given sensor are processed by the same application instance. Alternatively, you may want to cache some data related to the incoming events so that it can be enriched without making a remote procedure call to retrieve the related data.

Spring Cloud Data Flow supports partitioning by configuring Spring Cloud Stream’s output and input bindings. Spring Cloud Stream provides a common abstraction for implementing partitioned processing use cases in a uniform fashion across different types of middleware. Partitioning can thus be used whether the broker itself is naturally partitioned (e.g., Kafka topics) or not (e.g., RabbitMQ). The following image shows how data could be partitioned into two buckets, such that each instance of the average processor application consumes a unique set of data.

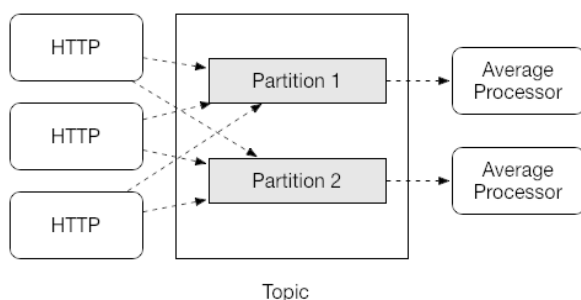


Figure 8.1. Spring Cloud Stream Partitioning

To use a simple partitioning strategy in Spring Cloud Data Flow, you only need set the instance count for each application in the stream and a `partitionKeyExpression` producer property when deploying the stream. The `partitionKeyExpression` identifies what part of the message will be used as the key to partition data in the underlying middleware. An `ingest` stream can be defined as `http | averageprocessor | cassandra` (Note that the Cassandra sink isn’t shown in the diagram above). Suppose the payload being sent to the `http` source was in JSON format and had a field called `sensorId`.

Deploying the stream with the shell command `stream deploy ingest --propertiesFile ingestStream.properties` where the contents of the file `ingestStream.properties` are

```
app.http.count=3
app.averageprocessor.count=2
app.http.producer.partitionKeyExpression=payload.sensorId
```

will deploy the stream such that all the input and output destinations are configured for data to flow through the applications but also ensure that a unique set of data is always delivered to each `averageprocessor` instance. In this case the default algorithm is to evaluate `payload.sensorId % partitionCount` where the `partitionCount` is the application count in the case of RabbitMQ and the partition count of the topic in the case of Kafka.

Please refer to [??? for additional strategies to partition streams during deployment and how they map onto the underlying \[Spring Cloud Stream Partitioning properties\]\(#\).](#)

Also note, that you can't currently scale partitioned streams. Read the section [Section 12.3, "Scaling at runtime"](#) for more information.

8.4 Message Delivery Guarantees

Streams are composed of applications that use the Spring Cloud Stream library as the basis for communicating with the underlying messaging middleware product. Spring Cloud Stream also provides an opinionated configuration of middleware from several vendors, in particular providing [persistent publish-subscribe semantics](#).

The [Binder abstraction](#) in Spring Cloud Stream is what connects the application to the middleware. There are several configuration properties of the binder that are portable across all binder implementations and some that are specific to the middleware.

For consumer applications there is a retry policy for exceptions generated during message handling. The retry policy is configured using the [common consumer properties](#) `maxAttempts`, `backOffInitialInterval`, `backOffMaxInterval`, and `backOffMultiplier`. The default values of these properties will retry the callback method invocation 3 times and wait one second for the first retry. A backoff multiplier of 2 is used for the second and third attempts.

When the number of retry attempts has exceeded the `maxAttempts` value, the exception and the failed message will become the payload of a message and be sent to the application's error channel. By default, the default message handler for this error channel logs the message. You can change the default behavior in your application by creating your own message handler that subscribes to the error channel.

Spring Cloud Stream also supports a configuration option for both Kafka and RabbitMQ binder implementations that will send the failed message and stack trace to a dead letter queue. The dead letter queue is a destination and its nature depends on the messaging middleware (e.g in the case of Kafka it is a dedicated topic). To enable this for RabbitMQ set the [consumer properties](#) `republishToDlq` and `autoBindDlq` and the [producer property](#) `autoBindDlq` to true when deploying the stream. To always apply these producer and consumer properties when deploying streams, configure them as [common application properties](#) when starting the Data Flow server.

Additional messaging delivery guarantees are those provided by the underlying messaging middleware that is chosen for the application for both producing and consuming applications. Refer to the Kafka [Consumer](#) and [Producer](#) and Rabbit [Consumer](#) and [Producer](#) documentation for more details. You will find extensive declarative support for all the native QOS options.

9. Analytics

Spring Cloud Data Flow is aware of certain Sink applications that will write counter data to Redis and provides an REST endpoint to read counter data. The types of counters supported are

- [Counter](#) - Counts the number of messages it receives, optionally storing counts in a separate store such as redis.
- [Field Value Counter](#) - Counts occurrences of unique values for a named field in a message payload
- [Aggregate Counter](#) - Stores total counts but also retains the total count values for each minute, hour day and month.

It is important to note that the timestamp that is used in the aggregate counter can come from a field in the message itself so that out of order messages are properly accounted.

10. Task Applications

The Spring Cloud Task programming model provides:

- Persistence of the Task's lifecycle events and exit code status.
- Lifecycle hooks to execute code before or after a task execution.
- Emit task events to a stream (as a source) during the task lifecycle.
- Integration with Spring Batch Jobs.

11. Data Flow Server

11.1 Endpoints

The Data Flow Server uses an embedded servlet container and exposes REST endpoints for creating, deploying, undeploying, and destroying streams and tasks, querying runtime state, analytics, and the like. The Data Flow Server is implemented using Spring's MVC framework and the [Spring HATEOAS](#) library to create REST representations that follow the HATEOAS principle.



Figure 11.1. The Spring Cloud Data Flow Server

11.2 Customization

Each Data Flow Server executable jar targets a single runtime by delegating to the implementation of the deployer Service Provider Interface found on the classpath.

We provide a Data Flow Server executable jar that targets a single runtime. The Data Flow server delegates to the implementation of the deployer Service Provider Interface found on the classpath. In the current version, there are no endpoints specific to a target runtime, but may be available in future releases as a convenience to access runtime specific features

While we provide a server executable for each of the target runtimes you can also create your own customized server application using Spring Initializr. This lets you add or remove functionality relative to the executable jar we provide. For example, adding additional security implementations, custom

endpoints, or removing Task or Analytics REST endpoints. You can also enable or disable some features through the use of feature toggles.

11.3 Security

The Data Flow Server executable jars support basic http, LDAP(S), File-based, and OAuth 2.0 authentication to access its endpoints. Refer to the [security section](#) for more information.

Authorization via groups is planned for a future release.

12. Runtime

12.1 Fault Tolerance

The target runtimes supported by Data Flow all have the ability to restart a long lived application should it fail. Spring Cloud Data Flow sets up whatever health probe is required by the runtime environment when deploying the application.

The collective state of all applications that comprise the stream is used to determine the state of the stream. If an application fails, the state of the stream will change from 'deployed' to 'partial'.

12.2 Resource Management

Each target runtime lets you control the amount of memory, disk and CPU that is allocated to each application. These are passed as properties in the deployment manifest using key names that are unique to each runtime. Refer to the each platforms server documentation for more information.

12.3 Scaling at runtime

When deploying a stream, you can set the instance count for each individual application that comprises the stream. Once the stream is deployed, each target runtime lets you control the target number of instances for each individual application. Using the APIs, UIs, or command line tools for each runtime, you can scale up or down the number of instances as required. Future work will provide a portable command in the Data Flow Server to perform this operation.

Currently, this is not supported with the Kafka binder (based on the 0.8 simple consumer at the time of the release), as well as partitioned streams, for which the suggested workaround is redeploying the stream with an updated number of instances. Both cases require a static consumer set up based on information about the total instance count and current instance index, a limitation intended to be addressed in future releases. For example, Kafka 0.9 and higher provides good infrastructure for scaling applications dynamically and will be available as an alternative to the current Kafka 0.8 based binder in the near future. One specific concern regarding scaling partitioned streams is the handling of local state, which is typically reshuffled as the number of instances is changed. This is also intended to be addressed in the future versions, by providing first class support for local state management.

12.4 Application Versioning

Application versioning, that is upgrading or downgrading an application from one version to another, is not directly supported by Spring Cloud Data Flow. You must rely on specific target runtime features to perform these operational tasks.

The roadmap for Spring Cloud Data Flow will deploy applications that are compatible with Spinnaker to manage the complete application lifecycle. This also includes automated canary analysis backed by application metrics. Portable commands in the Data Flow server to trigger pipelines in Spinnaker are also planned.

Part III. Getting Started

13. Deploying Streams on Kubernetes

In this getting started guide, the Data Flow Server is deployed to the Kubernetes cluster. This means that we need to make available an RDBMS service for stream and task repositories, app registry plus a transport option of either Kafka or Rabbit MQ. We also need a Redis instance if we are planning on using the analytics features.



Important

Currently, only apps registered with the Docker resource are supported by the Data Flow Server for Kubernetes. I.e. the below app registration is valid:

```
dataflow:>app register --type source --name time --uri docker://springcloudstream/time-source-kafka:latest
```

but any app registered with a Maven, HTTP or File resource (using a URI prefixed with `maven://`, `http://` or `file://`) is *not supported*.

1. Deploy a Kubernetes cluster.

The [Kubernetes Getting Started guide](#) lets you choose among many deployment options so you can pick one that you are most comfortable using. We have successfully used the Vagrant option from a downloaded Kubernetes release.

We have also used the [Minikube](#) project to run a local Kubernetes cluster for testing.

The rest of this getting started guide assumes that you have a working Kubernetes cluster and a `kubectl` command line. For the MySQL service we used the `gcloud` command line utility. See the docs for installing both these utilities: [Installing Cloud SDK](#) and [Installing and Setting up kubectl](#).

2. Create a Kafka service on the Kubernetes cluster.

The Kafka service will be used for messaging between modules in the stream. You can instead use Rabbit MQ, but, in order to simplify, we only show the Kafka configurations in this guide. There are sample replication controller and service YAML files in the `spring-cloud-dataflow-server-kubernetes` repository that you can use as a starting point as they have the required metadata set for service discovery by the modules. For Kafka we use the files with a "zk" and "kafka" prefix.

```
$ git clone https://github.com/spring-cloud/spring-cloud-dataflow-server-kubernetes
$ cd spring-cloud-dataflow-server-kubernetes
$ kubectl create -f src/etc/kubernetes/kafka-zk-controller.yml
$ kubectl create -f src/etc/kubernetes/kafka-zk-service.yml
$ kubectl create -f src/etc/kubernetes/kafka-controller.yml
$ kubectl create -f src/etc/kubernetes/kafka-service.yml
```

You can use the command `kubectl get pods` to verify that the controller and service is running. Use the command `kubectl get services` to check on the state of the service. Use the commands `kubectl delete svc kafka` and `kubectl delete rc kafka-broker` plus `kubectl delete svc kafka-zk` and `kubectl delete rc kafka-zk` to clean up afterwards.

3. Create a MySQL service on the Kubernetes cluster.

We are using MySQL for this guide, but you could use Postgres or H2 database instead. We include JDBC drivers for all three of these databases, you would just have to adjust the database URL and driver class name settings.

Before creating the MySQL service we need to create a persistent disk and modify the password in the config file. To create a persistent disk you can use the following command:

```
$ gcloud compute disks create mysql-disk --size 200 --type pd-standard
```

Modify the password in the `src/etc/kubernetes/mysql-controller.yml` file inside the `spring-cloud-dataflow-server-kubernetes` repository. Then run the following commands to start the database service:

```
$ kubectl create -f src/etc/kubernetes/mysql-controller.yml
$ kubectl create -f src/etc/kubernetes/mysql-service.yml
```

Again, you can use the command `kubectl get pods` to verify that the controller is running. Note that it can take a minute or so until there is an external IP address for the MySQL server. Use the command `kubectl get services` to check on the state of the service and look for when there is a value under the `EXTERNAL_IP` column. Use the commands `kubectl delete svc mysql` and `kubectl delete rc mysql` to clean up afterwards. Use the `EXTERNAL_IP` address to connect to the database and create a `test` database that we can use for our testing. Use your favorite SQL developer tool for this:

```
CREATE DATABASE test;
```

4. Create a Redis service on the Kubernetes cluster.

The Redis service will be used for the analytics functionality. There are sample replication controller and service YAML files in the `spring-cloud-dataflow-server-kubernetes` repository that you can use as a starting point as they have the required metadata set for service discovery by the modules.

```
$ kubectl create -f src/etc/kubernetes/redis-controller.yml
$ kubectl create -f src/etc/kubernetes/redis-service.yml
```



Note

If you don't need the analytics functionality you can turn this feature off by changing `SPRING_CLOUD_DATAFLOW_FEATURES_ANALYTICS_ENABLED` to `false` in the `scdf-controller.yml` file. If you don't install the Redis service then you should also remove the Redis configuration settings in `scdf-config-kafka.yml` mentioned below.

5. Update configuration files with values needed to connect to Kubernetes, MySQL and Redis.

The Data Flow Server uses the [Fabric8 Java client library](#) to connect to the Kubernetes cluster. We are using environment variables to set the values needed when deploying the Data Flow server to Kubernetes. We are also using the [Fabric8 Spring Cloud integration with Kubernetes library](#) to access Kubernetes [ConfigMap](#) and [Secrets](#) settings. The ConfigMap settings are specified in the `src/etc/kubernetes/scdf-config.yml` file and the Secrets in the `src/etc/kubernetes/scdf-secrets.yml` file. Modify the password for MySQL in the latter if you changed it. It has to be provided encoded as base64.

This approach supports using one Data Flow Server instance per Kubernetes namespace.

6. Deploy the Spring Cloud Data Flow Server for Kubernetes using the Docker image and the configuration settings you just modified.

```
$ kubectl create -f src/etc/kubernetes/scdf-config-kafka.yml
$ kubectl create -f src/etc/kubernetes/scdf-secrets.yml
$ kubectl create -f src/etc/kubernetes/scdf-service.yml
$ kubectl create -f src/etc/kubernetes/scdf-controller.yml
```



We haven't tuned the memory use of the OOTB apps yet, so to be on the safe side we are increasing the memory for the pods by providing the following property:

```
spring.cloud.deployer.kubernetes.memory=640Mi
```

Use the `kubectl get svc` command to locate the `EXTERNAL_IP` address assigned to `scd-f`, we use that to connect from the shell.

```
$ kubectl get svc
```

NAME	CLUSTER-IP	EXTERNAL-IP	PORT(S)	AGE
kafka	10.103.248.211	<none>	9092/TCP	14d
kubernetes	10.103.240.1	<none>	443/TCP	16d
mysql	10.103.251.179	104.154.246.220	3306/TCP	10d
redis	10.103.242.191	<none>	6379/TCP	8d
scdf	10.103.246.82	130.211.203.246	9393/TCP	4m
zk	10.103.243.29	<none>	2181/TCP	14d

7. Download and run the Spring Cloud Data Flow shell.

```
wget http://repo.spring.io/release/org/springframework/cloud/spring-cloud-dataflow-shell/1.1.0.RELEASE/spring-cloud-dataflow-shell-1.1.0.RELEASE.jar

$ java -jar spring-cloud-dataflow-shell-1.1.0.RELEASE.jar
```

Configure the Data Flow server URI with the following command (use the IP address from previous step and at the moment we are using port 9393):

[illegible]

1.1.0.RELEASE

```
Welcome to the Spring Cloud Data Flow shell. For assistance hit TAB or type "help".
server-unknown:>dataflow config server --uri http://130.211.203.246:9393
Successfully targeted http://130.211.203.246:9393
dataflow:>
```

8. Register the Kafka version of the `time` and `log` apps using the shell and also register the `timestamp` app.

```
dataflow:>app register --type source --name time --uri docker:springcloudstream/time-source-
kafka:latest
dataflow:>app register --type sink --name log --uri docker:springcloudstream/log-sink-kafka:latest
dataflow:>app register --type task --name timestamp --uri docker:springcloudtask/timestamp-
task:latest
```

9. Alternatively, if you would like to register all out-of-the-box stream applications built with the Kafka binder in bulk, you can with the following command. For more details, review how to [register applications](#).

```
dataflow:>app import --uri http://bit.ly/stream-applications-kafka-docker
```

10 Deploy a simple stream in the shell

```
dataflow:>stream create --name ticktock --definition "time | log" --deploy
```

You can use the command `kubectl get pods` to check on the state of the pods corresponding to this stream. We can run this from the shell by running it as an OS command by adding a `!` before the command.

```
dataflow:>! kubectl get pods
command is:kubectl get pods
NAME                READY    STATUS    RESTARTS   AGE
kafka-d207a          1/1      Running   0           50m
ticktock-log-gnk72   1/1      Running   0           2m
ticktock-time-r65cn  1/1      Running   0           2m
```

Look at the logs for the pod deployed for the log sink.

```
$ kubectl logs -f ticktock-log-gnk72
...
2015-12-28 18:50:02.897 INFO 1 --- [          main] o.s.c.s.module.log.LogSinkApplication :
    Started LogSinkApplication in 10.973 seconds (JVM running for 50.055)
2015-12-28 18:50:08.561 INFO 1 --- [hannel-adapter1] log.sink :
    2015-12-28 18:50:08
2015-12-28 18:50:09.556 INFO 1 --- [hannel-adapter1] log.sink :
    2015-12-28 18:50:09
2015-12-28 18:50:10.557 INFO 1 --- [hannel-adapter1] log.sink :
    2015-12-28 18:50:10
2015-12-28 18:50:11.558 INFO 1 --- [hannel-adapter1] log.sink :
    2015-12-28 18:50:11
```



Note

If you need to specify any of the app specific configuration properties then you must use "long-form" of them including the app specific prefix like `--jdbc.tableName=TEST_DATA`. This is due to the server not being able to access the metadata for the Docker based starter apps. You will also not see the configuration properties listed when using the `app info` command or in the Dashboard GUI.



Note

If you need to be able to connect from outside of the Kubernetes cluster to an app that you deploy, like the `http-source`, then you can provide a deployment property of `spring.cloud.deployer.kubernetes.createLoadBalancer=true` for the app module to specify that you want to have a LoadBalancer with an external IP address created for your app's service.

To register the `http-source` and use it in a stream where you can post data to it, you can use the following commands:

```
dataflow:>app register --type source --name http --uri docker:springcloudstream/http-source-kafka:latest
dataflow:>stream create --name test --definition "http | log"
```

```
dataflow:>stream deploy test --properties
"app.http.spring.cloud.deployer.kubernetes.createLoadBalancer=true"
```

Now, look up the external IP address for the `http` app (it can sometimes take a minute or two for the external IP to get assigned):

```
dataflow:>! kubectl get service
command is:kubectl get service
```

NAME	CLUSTER-IP	EXTERNAL-IP	PORT(S)	AGE
kafka	10.103.240.92	<none>	9092/TCP	7m
kubernetes	10.103.240.1	<none>	443/TCP	4h
test-http	10.103.251.157	130.211.200.96	8080/TCP	58s
test-log	10.103.240.28	<none>	8080/TCP	59s
zk	10.103.247.25	<none>	2181/TCP	7m

Next, post some data to the `test-http` app:

```
dataflow:>http post --target http://130.211.200.96:8080 --data "Hello"
```

Finally, look at the logs for the `test-log` pod:

```
dataflow:>! kubectl get pods
command is:kubectl get pods
```

NAME	READY	STATUS	RESTARTS	AGE
kafka-o20qq	1/1	Running	0	9m
mysql-o2v83	1/1	Running	0	9m
redis-zb87a	1/1	Running	0	8m
test-http-9obkq	1/1	Running	0	2m
test-log-ysiz3	1/1	Running	0	2m

```
dataflow:>! kubectl logs test-log-ysiz3
command is:kubectl logs test-log-ysiz3
...
2016-04-27 16:54:29.789 INFO 1 --- [          main] o.s.c.s.b.k.KafkaMessageChannelBinder$3 :
started inbound.test.http.test
2016-04-27 16:54:29.799 INFO 1 --- [          main] o.s.c.support.DefaultLifecycleProcessor :
Starting beans in phase 0
2016-04-27 16:54:29.799 INFO 1 --- [          main] o.s.c.support.DefaultLifecycleProcessor :
Starting beans in phase 2147482647
2016-04-27 16:54:29.895 INFO 1 --- [          main] s.b.c.e.t.TomcatEmbeddedServletContainer :
Tomcat started on port(s): 8080 (http)
2016-04-27 16:54:29.896 INFO 1 --- [ kafka-binder-] log.sink
Hello
```

A useful command to help in troubleshooting issues, such as a container that has a fatal error starting up, add the options `--previous` to view last terminated container log. You can also get more detailed information about the pods by using the `kubectl describe` like:

```
kubectl describe pods/ticktock-log-qnk72
```

11 Destroy the stream

```
dataflow:>stream destroy --name ticktock
```

12 Create a task and launch it

Let's create a simple task definition and launch it.

```
dataflow:>task create task1 --definition "timestamp"
dataflow:>task launch task1
```

We can now list the tasks and executions using these commands:

```
dataflow:>task list
```

```
#####
#Task Name#Task Definition#Task Status#
#####
#task1    #timestamp      #running   #
#####

dataflow:>task execution list
#####
#Task Name#ID#          Start Time          #          End Time          #Exit Code#
#####
#task1    #1 #Fri Jun 03 18:12:05 EDT 2016#Fri Jun 03 18:12:05 EDT 2016#0      #
#####
```

13 Destroy the task

```
dataflow:>task destroy --name task1
```

Part IV. Server Configuration

In this section you will learn how to configure Spring Cloud Data Flow server's features such as the relational database to use and security.

14. Feature Toggles

Data Flow server offers specific set of features that can be enabled/disabled when launching. These features include all the lifecycle operations, REST endpoints (server, client implementations including Shell and the UI) for:

1. Streams

2. Tasks

3. Analytics

You can enable or disable these features by setting the following boolean environment variables when launching the Data Flow server:

- `SPRING_CLOUD_DATAFLOW_FEATURES_STREAMS_ENABLED`
- `SPRING_CLOUD_DATAFLOW_FEATURES_TASKS_ENABLED`
- `SPRING_CLOUD_DATAFLOW_FEATURES_ANALYTICS_ENABLED`

By default, all the features are enabled.



Note

Since analytics feature is enabled by default, the Data Flow server is expected to have a valid Redis store available as analytic repository as we provide a default implementation of analytics based on Redis. This also means that the Data Flow server's `health` depends on the redis store availability as well. If you do not want to enable HTTP endpoints to read analytics data written to Redis, then disable the analytics feature using the property mentioned above.

The REST endpoint `/features` provides information on the features enabled/disabled.

15. General Configuration

Configuration properties can be passed to the Data Flow Server using Kubernetes [ConfigMap](#) and [Secrets](#). The server uses the Fabric8 [spring-cloud-kubernetes](#) module to process both ConfigMap and Secrets settings. You just need to enable the ConfigMap support by passing in an environment variable of `SPRING_CLOUD_KUBERNETES_CONFIG_NAME` and setting that to the name of the ConfigMap. Same is true for the Secrets where the environment variable is `SPRING_CLOUD_KUBERNETES_SECRETS_NAME`. To use the Secrets you also need to set `SPRING_CLOUD_KUBERNETES_SECRETS_ENABLE_API` to true.

An example configuration could look like the following where we configure Kafka, MySQL and Redis for the server:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: scdf-config
data:
  application.yaml: |-
    spring:
      cloud:
        deployer:
          kubernetes:
            environmentVariables: 'SPRING_CLOUD_STREAM_KAFKA_BINDER_BROKERS=${KAFKA_SERVICE_HOST}:
${KAFKA_SERVICE_PORT},SPRING_CLOUD_STREAM_KAFKA_BINDER_ZK_NODES=${KAFKA_ZK_SERVICE_HOST}:
${KAFKA_ZK_SERVICE_PORT},SPRING_REDIS_HOST=${REDIS_SERVICE_HOST},SPRING_REDIS_PORT=
${REDIS_SERVICE_PORT}'
            datasource:
              url: jdbc:mysql://${MYSQL_SERVICE_HOST}:${MYSQL_SERVICE_PORT}/test
              driverClassName: org.mariadb.jdbc.Driver
              testOnBorrow: true
              validationQuery: "SELECT 1"
            redis:
              host: ${REDIS_SERVICE_HOST}
              port: ${REDIS_SERVICE_PORT}
```

We assume here that Kafka is deployed using `kafka` and `kafka_zk` as the service names. For the MySQL we assume the service name is `mysql` and for Redis we assume it is `redis`. Kubernetes will publish these services host and port values as environment variables that we can use when configuring any deployed apps.

We prefer to provide the MySQL connection secrets in a Secrets file:

```
apiVersion: v1
kind: Secret
metadata:
  name: scdf-secrets
data:
  spring.datasource.username: cm9vdA==
  spring.datasource.password: eW91cnBhc3N3b3Jk
```

The username and password are provided as base64 encoded values.

16. Database Configuration

Spring Cloud Data Flow provides schemas for H2, HSQLDB, MySQL, Oracle, Postgresql, DB2 and SqlServer that will be automatically created when the server starts.

The JDBC drivers for **MySQL** (via MariaDB driver), **HSQLDB**, **PostgreSQL** along with embedded **H2** are available out of the box. If you are using any other database, then the corresponding JDBC driver jar needs to be on the classpath of the server.

For instance, If you are using **MySQL** in addition to username and password in the Secrets file provide the following properties in the ConfigMap:

```
data:
  application.yaml: |-
    spring:
      datasource:
        url: jdbc:mysql://${MYSQL_SERVICE_HOST}:${MYSQL_SERVICE_PORT}/test
        driverClassName: org.mariadb.jdbc.Driver
```

For **PostgreSQL**:

```
data:
  application.yaml: |-
    spring:
      datasource:
        url: jdbc:postgresql://${PGSQL_SERVICE_HOST}:${PGSQL_SERVICE_PORT}/database
        driverClassName: org.postgresql.Driver
```

For **HSQLDB**:

```
data:
  application.yaml: |-
    spring:
      datasource:
        url: jdbc:hsqldb:hsqldb://${HSQLDB_SERVICE_HOST}:${HSQLDB_SERVICE_PORT}/database
        driverClassName: org.hsqldb.jdbc.JDBCdriver
```



Note

There is a schema update to the Spring Cloud Data Flow datastore when upgrading from version 1.0.x to 1.1.x. Migration scripts for specific database types can be found [here](#).

17. Monitoring and Management

We recommend using the `kubectl` command for troubleshooting streams and tasks.

You can list all artifacts used by using the following command:

```
kubectl get cm,secrets,svc,rc,pod
```

17.1 Server

You can access the server log by using the following command (just supply the name of pod for the server):

```
kubectl logs <scdf-pod-name>
```

17.2 Streams

The streams apps are deployed with the stream name followed by the name of the app and for processors and sinks there is also an instance index appended.

To see details for a specific app deployment you can use (just supply the name of pod for the app):

```
kubectl details <app-pod-name>
```

For the application logs use:

```
kubectl logs <app-pod-name>
```

If you would like to tail a log you can use:

```
kubectl logs -f <app-pod-name>
```

17.3 Tasks

Tasks are launched as bare pods without a replication controller. The pods remain after the tasks complete and you would have to delete them manually once they are no longer needed.

For the task logs use:

```
kubectl logs <task-pod-name>
```

To delete the task pod use:

```
kubectl delete pod <task-pod-name>
```

Part V. Dashboard

This section describe how to use the Dashboard of Spring Cloud Data Flow.

18. Introduction

Spring Cloud Data Flow provides a browser-based GUI and it currently includes 6 tabs:

- **Apps** Lists all available applications and provides the control to register/unregister them
- **Runtime** Provides the Data Flow cluster view with the list of all running applications
- **Streams** List, create, deploy, and destroy Stream Definitions
- **Tasks** List, create, launch and destroy Task Definitions
- **Jobs** Perform Batch Job related functions
- **Analytics** Create data visualizations for the various analytics applications

Upon starting Spring Cloud Data Flow, the Dashboard is available at:

`http://<host>:<port>/dashboard`

For example: <http://localhost:9393/dashboard>

If you have enabled https, then it will be located at `https://localhost:9393/dashboard`. If you have enabled security, a login form is available at `http://localhost:9393/dashboard/#/login`.

Note: The default Dashboard server port is 9393

About

Spring Cloud Data Flow is a unified, distributed, and extensible system for data ingestion, real time analytics, batch processing, and data export. The project's goal is to simplify the development of big data applications.

Dataflow Server Implementation	
Name	spring-cloud-dataflow-server-local
Version	1.0.0.BUILD-SNAPSHOT (7188a69)
Description	Local Data Flow Server

Need Help or Found an Issue?

Project Page	http://cloud.spring.io/spring-cloud-dataflow/
Sources	https://github.com/spring-cloud/spring-cloud-dataflow
Documentation	http://docs.spring.io/spring-cloud-dataflow/docs/current/reference/html/
API Docs	http://docs.spring.io/spring-cloud-dataflow/docs/current/api/
Support Forum	http://stackoverflow.com/questions/tagged/spring-cloud
Issue Tracker	https://github.com/spring-cloud/spring-cloud-dataflow/issues

Figure 18.1. The Spring Cloud Data Flow Dashboard

19. Apps

The *Apps* section of the Dashboard lists all the available applications and provides the control to register/unregister them (if applicable). It is possible to import a number of applications at once using the **Bulk Import Applications** action.

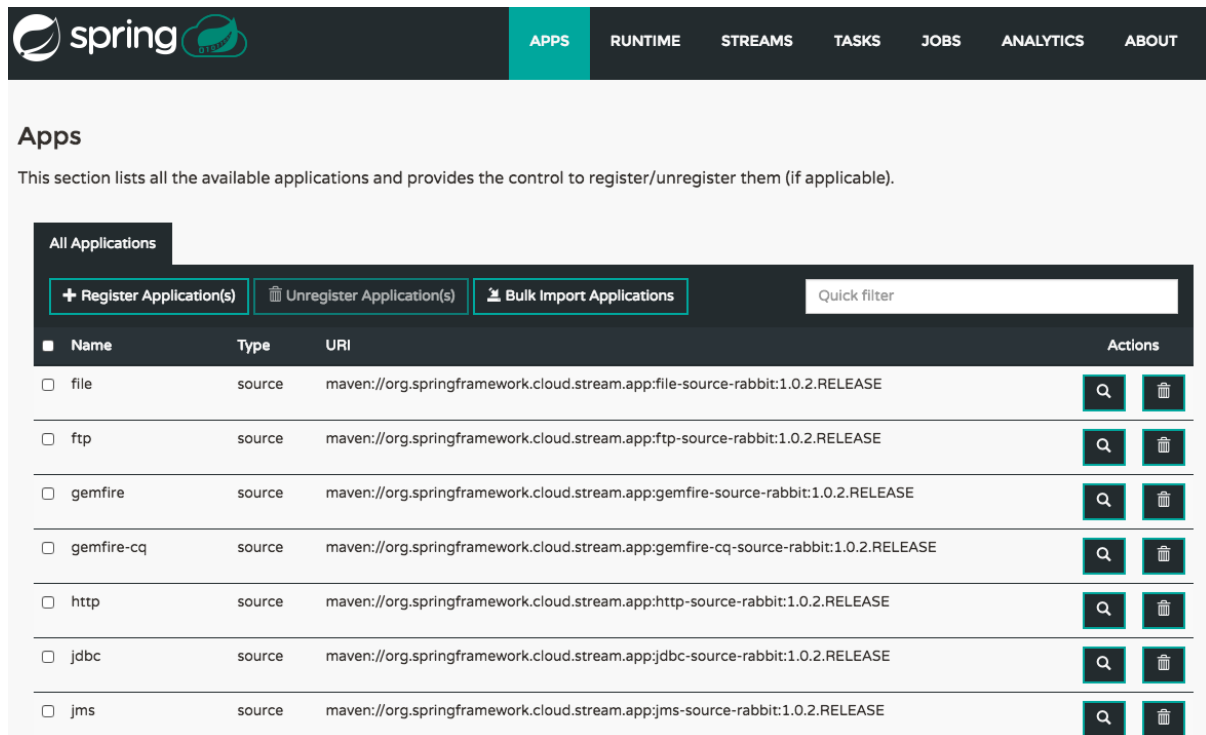


Figure 19.1. List of Available Applications

19.1 Bulk Import of Applications

The bulk import applications page provides numerous options for defining and importing a set of applications in one go. For bulk import the application definitions are expected to be expressed in a properties style:

```
<type>.<name> = <coordinates>
```


For example:

```
task.timestamp=maven://org.springframework.cloud.task.app:timestamp-  
task:1.0.0.BUILD-SNAPSHOT
```

```
processor.transform=maven://org.springframework.cloud.stream.app:transform-  
processor-rabbit:1.0.3.BUILD-SNAPSHOT
```

At the top of the bulk import page an *Uri* can be specified that points to a properties file stored elsewhere, it should contain properties formatted as above. Alternatively, using the textbox labeled *Apps as Properties* it is possible to directly list each property string. Finally, if the properties are stored in a local file the *Select Properties File* option will open a local file browser to select the file. After setting your definitions via one of these routes, click **Import**.

At the bottom of the page there are quick links to the property files for common groups of stream apps and task apps. If those meet your needs, simply select your appropriate variant (rabbit, kafka, docker, etc) and click the **Import** action on those lines to immediately import all those applications.



[APPS](#)
[RUNTIME](#)
[STREAMS](#)
[TASKS](#)
[JOBS](#)
[ANALYTICS](#)
[ABOUT](#)

Bulk Import Applications

Import and register applications in bulk. Simply provide a URI that points to the location of the **properties** file where the keys are formatted as **type.name** and the values are the URIs of the apps. For convenience, a list of out-of-the-box Stream and Task app starters is provided below, as well.

Uri

Please provide a valid URI pointing to the respective properties file.

OR

Apps as Properties

Example:

```
task.timestamp=maven://org.springframework.cloud.task.app:timestamp-task:1.0.0.BUILD-SNAPSHOT
task.spark-client=maven://org.springframework.cloud.task.app:spark-client-task:1.0.0.BUILD-SNAPSHOT
```

Please provide a valid properties where the keys are formatted as **type.name** and the values are the URIs of the apps.

Select Properties File

No file chosen

Please provide a text file containing properties. This will be used to populate the text area above.

☐ Force

Out-of-the-box Stream app-starters

Name	Force	Action
Maven based Stream Applications with RabbitMQ Binder	<input type="checkbox"/>	
Maven based Stream Applications with Kafka Binder	<input type="checkbox"/>	
Docker based Stream Applications with RabbitMQ Binder	<input type="checkbox"/>	
Docker based Stream Applications with Kafka Binder	<input type="checkbox"/>	

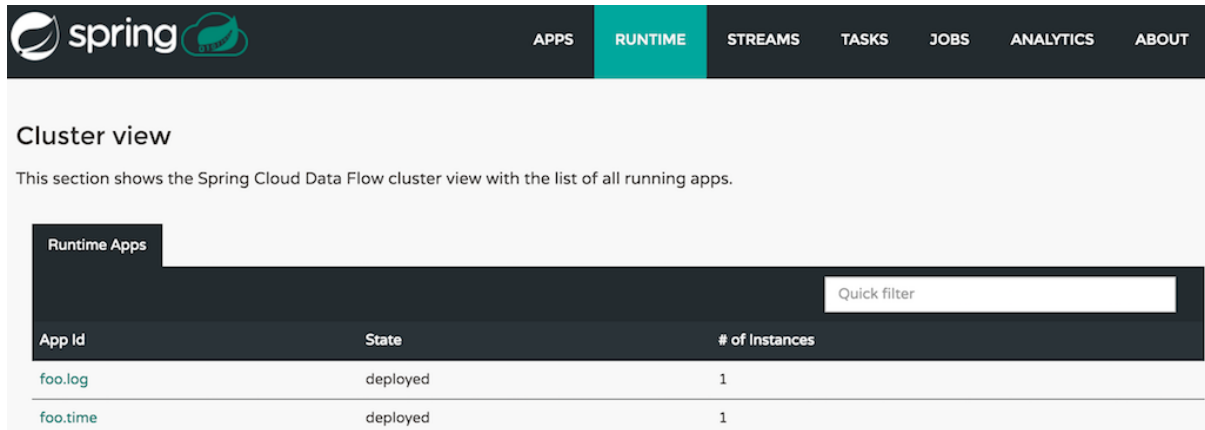
Out-of-the-box Task app-starters

Name	Force	Action
Maven based Task Applications	<input type="checkbox"/>	
Docker based Task Applications	<input type="checkbox"/>	

Figure 19.2. Bulk Import Applications

20. Runtime

The *Runtime* section of the Dashboard application shows the Spring Cloud Data Flow cluster view with the list of all running applications. For each runtime app the state of the deployment and the number of deployed instances is shown. A list of the used deployment properties is available by clicking on the app id.



The screenshot shows the 'Runtime' tab selected in the dashboard. Below the navigation bar, the 'Cluster view' section contains a description and a table of runtime apps. The table has columns for 'App Id', 'State', and '# of Instances'. Two apps are listed: 'foo.log' and 'foo.time', both in a 'deployed' state with 1 instance each. A 'Quick filter' input field is located to the right of the table header.

App Id	State	# of Instances
foo.log	deployed	1
foo.time	deployed	1

Figure 20.1. List of Running Applications

21. Streams

The *Streams* section of the Dashboard provides the *Definitions* tab that provides a listing of Stream definitions. There you have the option to **deploy** or **undeploy** those stream definitions. Additionally you can remove the definition by clicking on **destroy**. Each row includes an arrow on the left, which can be clicked to see a visual representation of the definition. Hovering over the boxes in the visual representation will show more details about the apps including any options passed to them. In this screenshot the timer stream has been expanded to show the visual representation:

The screenshot shows the 'Definitions' tab in the Spring Cloud Data Flow Dashboard. At the top, there are tabs for 'Definitions' and 'Create Stream'. Below these are buttons for 'Expand All' and 'Collapse All', and a 'Quick filter' input field. The main table lists three stream definitions:

Name	Definition	Status	Actions
▶ minutes	:timer.time > transform --expression=payload.substring(2,4) log	deployed	Details Undeploy Deploy Destroy
▶ seconds	:timer.time > transform --expression=payload.substring(4) log	deployed	Details Undeploy Deploy Destroy
▼ timer	time --date-format=hhmmss log	deployed	Details Undeploy Deploy Destroy

Below the table, the 'timer' stream is expanded to show its visual representation. It consists of a 'time' component connected to a 'log' component. A zoom slider at the top right of the diagram is set to 173.

Figure 21.1. List of Stream Definitions

If the **details** button is clicked the view will change to show a visual representation of that stream and also any related streams. In the above example, if clicking **details** for the timer stream, the view will change to the one shown below which clearly shows the relationship between the three streams (two of them are tapping into the timer stream).

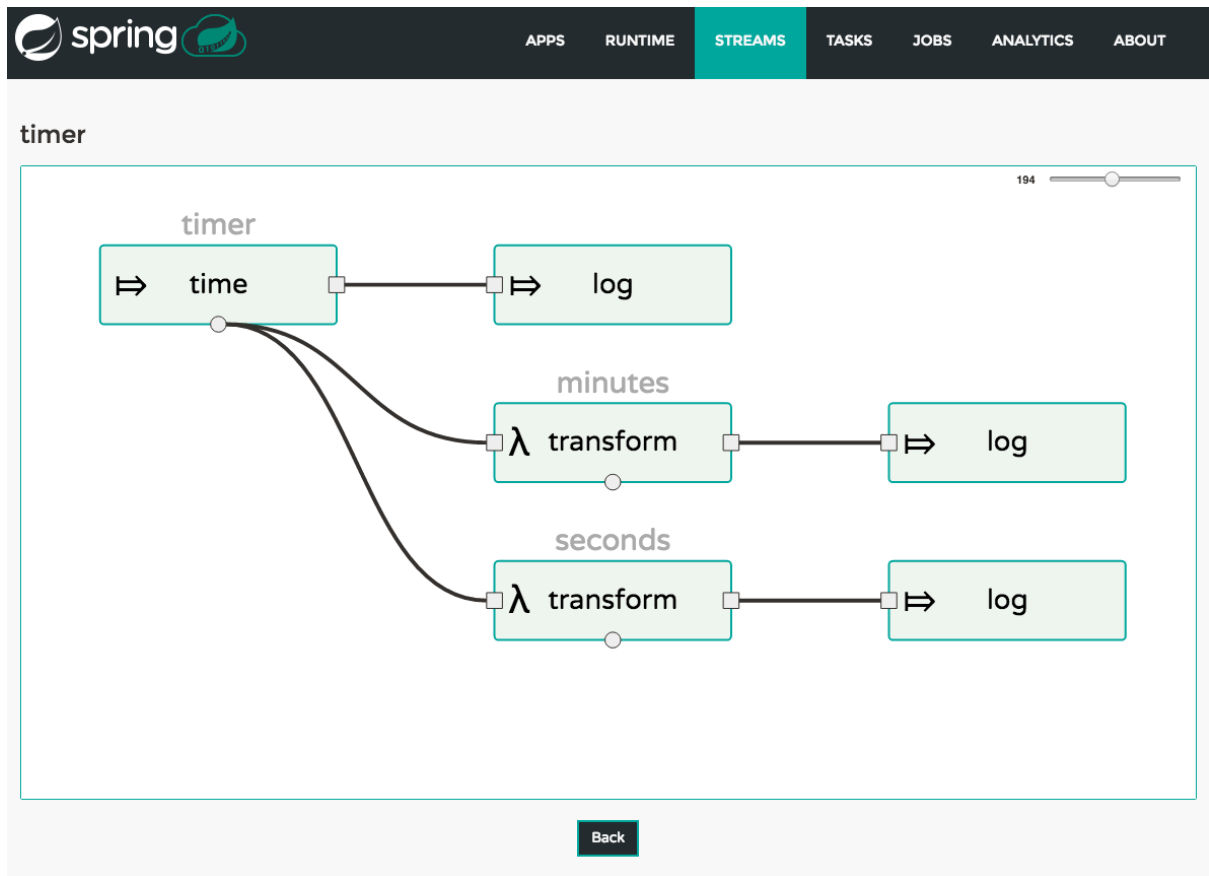


Figure 21.2. Stream Details Page

22. Create Stream

The *Create Stream* section of the Dashboard includes the [Spring Flo](#) designer tab that provides the canvas application, offering an interactive graphical interface for creating data pipelines.

In this tab, you can:

- Create, manage, and visualize stream pipelines using DSL, a graphical canvas, or both
- Write pipelines via DSL with content-assist and auto-complete
- Use auto-adjustment and grid-layout capabilities in the GUI for simpler and interactive organization of pipelines

Watch this [screencast](#) that highlights some of the "Flo for Spring Cloud Data Flow" capabilities. Spring Flo [wiki](#) includes more detailed content on core Flo capabilities.

The screenshot shows the Spring Cloud Data Flow Dashboard's 'Streams' section. The 'Create Stream' tab is selected, showing a DSL editor with the following content:

```
1 STREAM_1=time | scriptable-transform --script="return '#{payload.tr('^A-Za-z0-9', '')}'" --language=ruby | log
2 :STREAM_1.time > scriptable-transform --script="function double(p) {\n    return p + '--' + p;\n}\ndouble(payload);" --
  language=javascript | log
3 :STREAM_1.time > scriptable-transform --script="return payload + ':' + payload" --language=groovy | log
```

Below the DSL editor, a visual canvas displays a stream named 'STREAM_1'. It starts with a 'time' source node, which branches into three parallel paths. Each path consists of a 'scriptable-transform' node (represented by a lambda symbol) followed by a 'log' sink node. A 'source' panel on the left lists various input options like 'file', 'ftp', 'http', 'jdbc', 'jms', and 'load-gener...'.

Figure 22.1. Flo for Spring Cloud Data Flow

23. Tasks

The *Tasks* section of the Dashboard currently has three tabs:

- Apps
- Definitions
- Executions

23.1 Apps

Apps encapsulate a unit of work into a reusable component. Within the Data Flow runtime environment *Apps* allow users to create definitions for *Streams* as well as *Tasks*. Consequently, the *Apps* tab within the *Tasks* section allows users to create *Task* definitions.

Note: You will also use this tab to create Batch Jobs.

Name	Coordinates	Actions
spark-client		
spark-cluster		
spark-yarn		
sqoop-job		
sqoop-tool		
timestamp		

Figure 23.1. List of Task Apps

On this screen you can perform the following actions:

- View details such as the task app options.
- Create a Task Definition from the respective App.

Create a Task Definition from a selected Task App

On this screen you can create a new Task Definition. As a minimum you must provide a name for the new definition. You will also have the option to specify various properties that are used during the deployment of the app.

Note: Each parameter is only included if the *Include* checkbox is selected.

View Task App Details

On this page you can view the details of a selected task app, including the list of available options (properties) for that app.

23.2 Definitions

This page lists the Data Flow Task definitions and provides actions to **launch** or **destroy** those tasks. It also provides a shortcut operation to define one or more tasks using simple textual input, indicated by the **bulk define tasks** button.

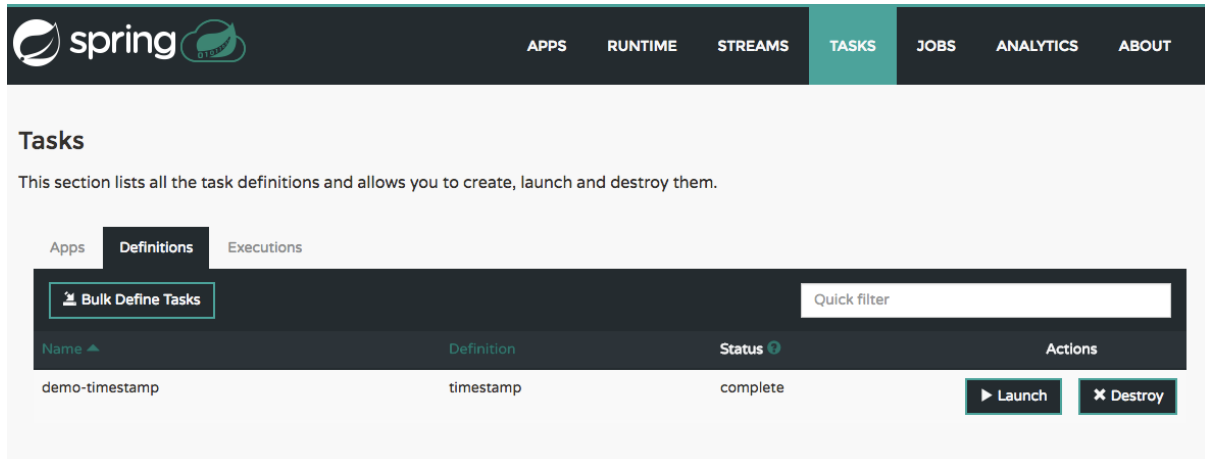


Figure 23.2. List of Task Definitions

Creating Task Definitions using the bulk define interface

After pressing **bulk define tasks**, the following screen will be shown.

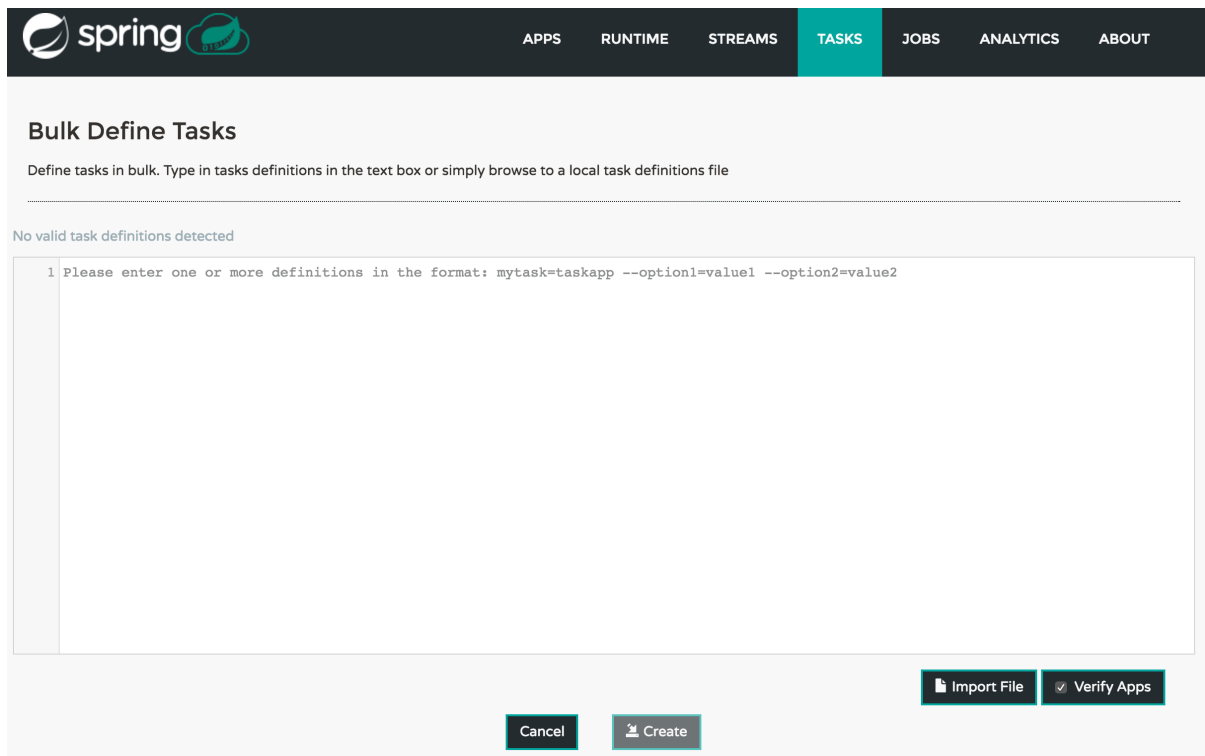


Figure 23.3. Bulk Define Tasks

It includes a textbox where one or more definitions can be entered and then various actions performed on those definitions. The required input text format for task definitions is very basic, each line should be of the form:

```
<task-definition-name> = <task-application> <options>
```

For example:

```
demo-timestamp = timestamp --format=hhmmss
```

After entering any data a validator will run asynchronously to verify both the syntax and that the application name entered is a valid application and it supports the options specified. If validation fails the editor will show the errors with more information via tooltips.

To make it easier to enter definitions into the text area, content assist is supported. Pressing **Ctrl+Space** will invoke content assist to suggest simple task names (based on the line on which it is invoked), task applications and task application options. Press **ESC** to close the content assist window without taking a selection.

If the validator should not verify the applications or the options (for example if specifying non-whitelisted options to the applications) then turn off that part of validation by toggling the checkbox off on the **Verify Apps** button - the validator will then only perform syntax checking. When correctly validated, the **create** button will be clickable and on pressing it the UI will proceed to create each task definition. If there are any errors during creation then after creation finishes the editor will show any lines of input, as it cannot be used in task definitions. These can then be fixed up and creation repeated. There is an **import file** button to open a file browser on the local file system if the definitions are in a file and it is easier to import than copy/paste.

Launching Tasks

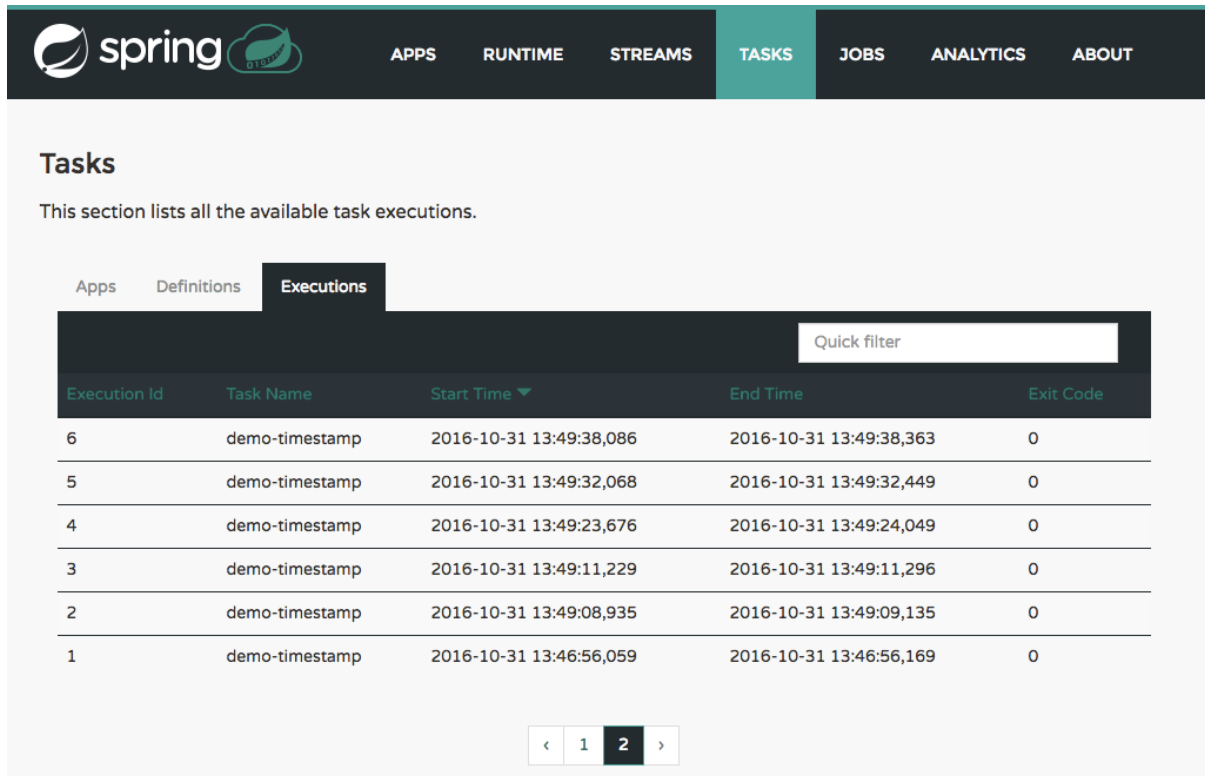
Once the task definition is created, they can be launched through the Dashboard as well. Navigate to the **Definitions** tab. Select the Task you want to launch by pressing **Launch**.

On the following screen, you can define one or more Task parameters by entering:

- Parameter Key
- Parameter Value

Task parameters are not typed.

23.3 Executions



The screenshot shows the 'Tasks' section of the Spring Cloud Data Flow Server interface. The top navigation bar includes 'APPS', 'RUNTIME', 'STREAMS', 'TASKS' (highlighted), 'JOBS', 'ANALYTICS', and 'ABOUT'. Below the navigation bar, the 'Tasks' section is titled, and a subtitle states: 'This section lists all the available task executions.' There are three tabs: 'Apps', 'Definitions', and 'Executions' (selected). A 'Quick filter' input field is present. The main content is a table with the following columns: 'Execution Id', 'Task Name', 'Start Time', 'End Time', and 'Exit Code'. The table lists six executions, all with 'demo-timestamp' as the task name and an exit code of 0. The start and end times are in ISO 8601 format. At the bottom, there is a pagination control showing '1' and '2' (selected), with arrows for navigation.

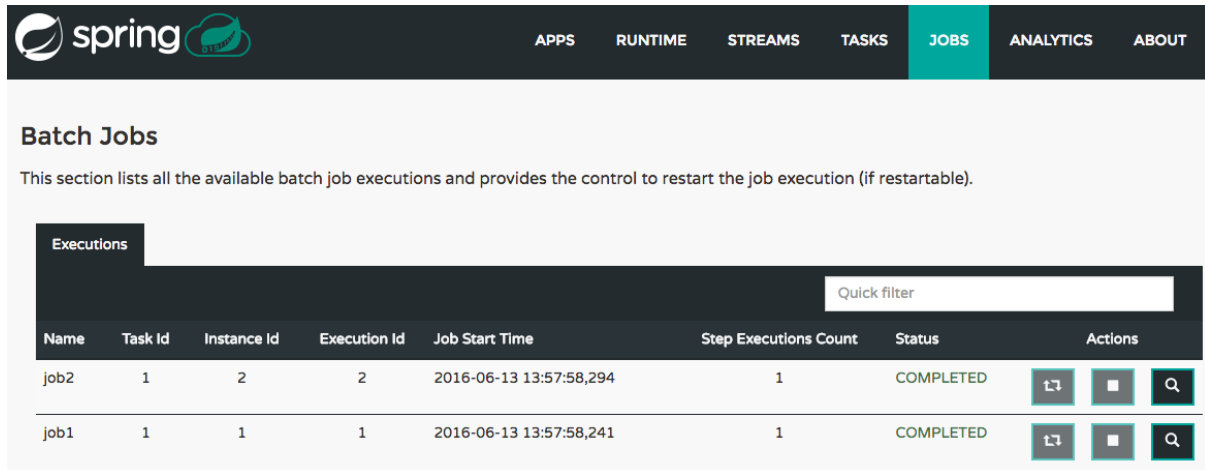
Execution Id	Task Name	Start Time	End Time	Exit Code
6	demo-timestamp	2016-10-31 13:49:38,086	2016-10-31 13:49:38,363	0
5	demo-timestamp	2016-10-31 13:49:32,068	2016-10-31 13:49:32,449	0
4	demo-timestamp	2016-10-31 13:49:23,676	2016-10-31 13:49:24,049	0
3	demo-timestamp	2016-10-31 13:49:11,229	2016-10-31 13:49:11,296	0
2	demo-timestamp	2016-10-31 13:49:08,935	2016-10-31 13:49:09,135	0
1	demo-timestamp	2016-10-31 13:46:56,059	2016-10-31 13:46:56,169	0

Figure 23.4. List of Task Executions

24. Jobs

The *Jobs* section of the Dashboard allows you to inspect **Batch Jobs**. The main section of the screen provides a list of Job Executions. **Batch Jobs** are **Tasks** that were executing one or more **Batch Job**. As such each Job Execution has a back reference to the **Task Execution Id** (Task Id).

In case of a failed job, you can also restart the task. When dealing with long-running Batch Jobs, you can also request to stop it.



Name	Task Id	Instance Id	Execution Id	Job Start Time	Step Executions Count	Status	Actions
job2	1	2	2	2016-06-13 13:57:58,294	1	COMPLETED	[Restart] [Stop] [Search]
job1	1	1	1	2016-06-13 13:57:58,241	1	COMPLETED	[Restart] [Stop] [Search]

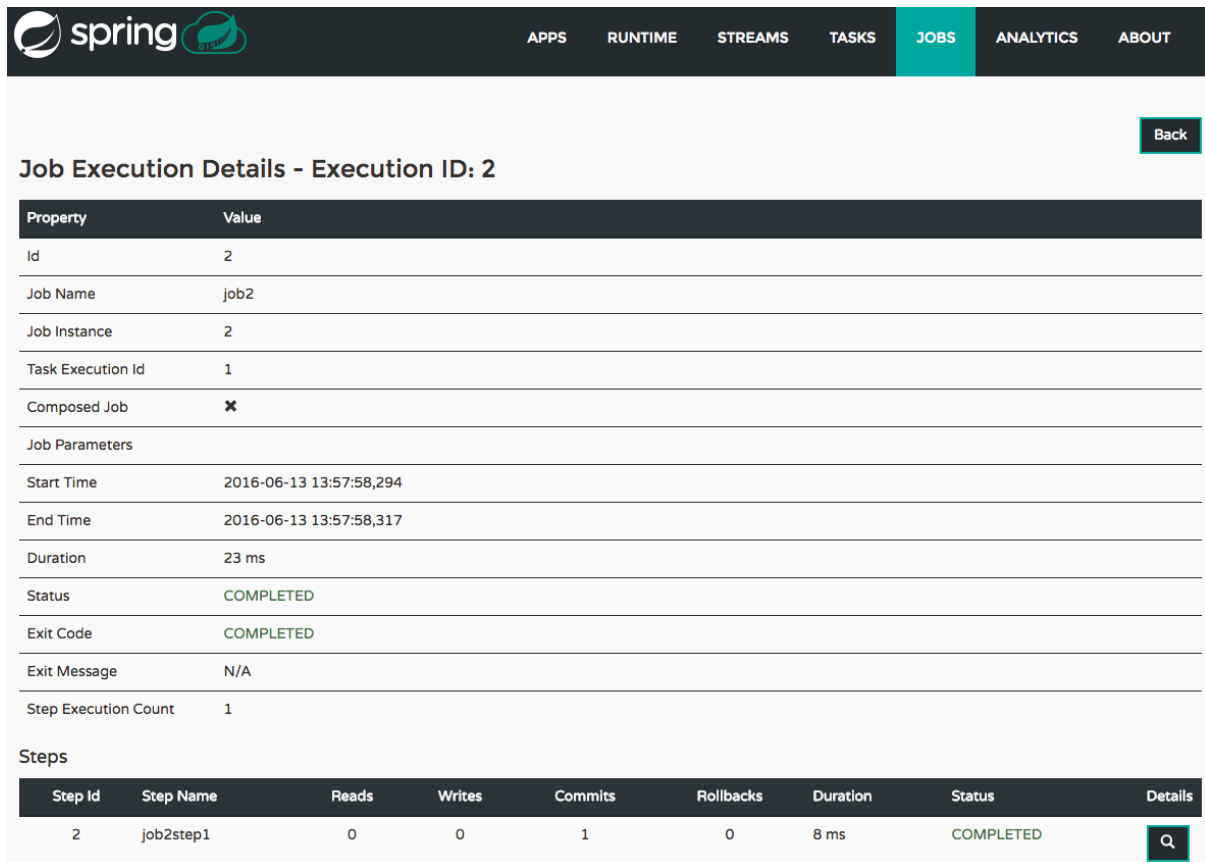
Figure 24.1. List of Job Executions

24.1 List job executions

This page lists the Batch Job Executions and provides the option to **restart** or **stop** a specific job execution, provided the operation is available. Furthermore, you have the option to view the Job execution details.

The list of Job Executions also shows the state of the underlying Job Definition. Thus, if the underlying definition has been deleted, *deleted* will be shown.

Job execution details



Job Execution Details - Execution ID: 2

Property	Value
Id	2
Job Name	job2
Job Instance	2
Task Execution Id	1
Composed Job	✖
Job Parameters	
Start Time	2016-06-13 13:57:58,294
End Time	2016-06-13 13:57:58,317
Duration	23 ms
Status	COMPLETED
Exit Code	COMPLETED
Exit Message	N/A
Step Execution Count	1

Steps


Step Id	Step Name	Reads	Writes	Commits	Rollbacks	Duration	Status	Details
2	job2step1	0	0	1	0	8 ms	COMPLETED	

Figure 24.2. Job Execution Details

The Job Execution Details screen also contains a list of the executed steps. You can further drill into the *Step Execution Details* by clicking onto the magnifying glass.

Step execution details

On the top of the page, you will see progress indicator the respective step, with the option to refresh the indicator. Furthermore, a link is provided to view the *step execution history*.

The Step Execution details screen provides a complete list of all Step Execution Context key/value pairs.



Important

In case of exceptions, the *Exit Description* field will contain additional error information. Please be aware, though, that this field can only have a maximum of **2500 characters**. Therefore, in case of long exception stacktraces, trimming of error messages may occur. In that case, please refer to the server log files for further details.

Step Execution Progress

On this screen, you can see a progress bar indicator in regards to the execution of the current step. Under the **Step Execution History**, you can also view various metrics associated with the selected step such as **duration**, **read counts**, **write counts** etc.

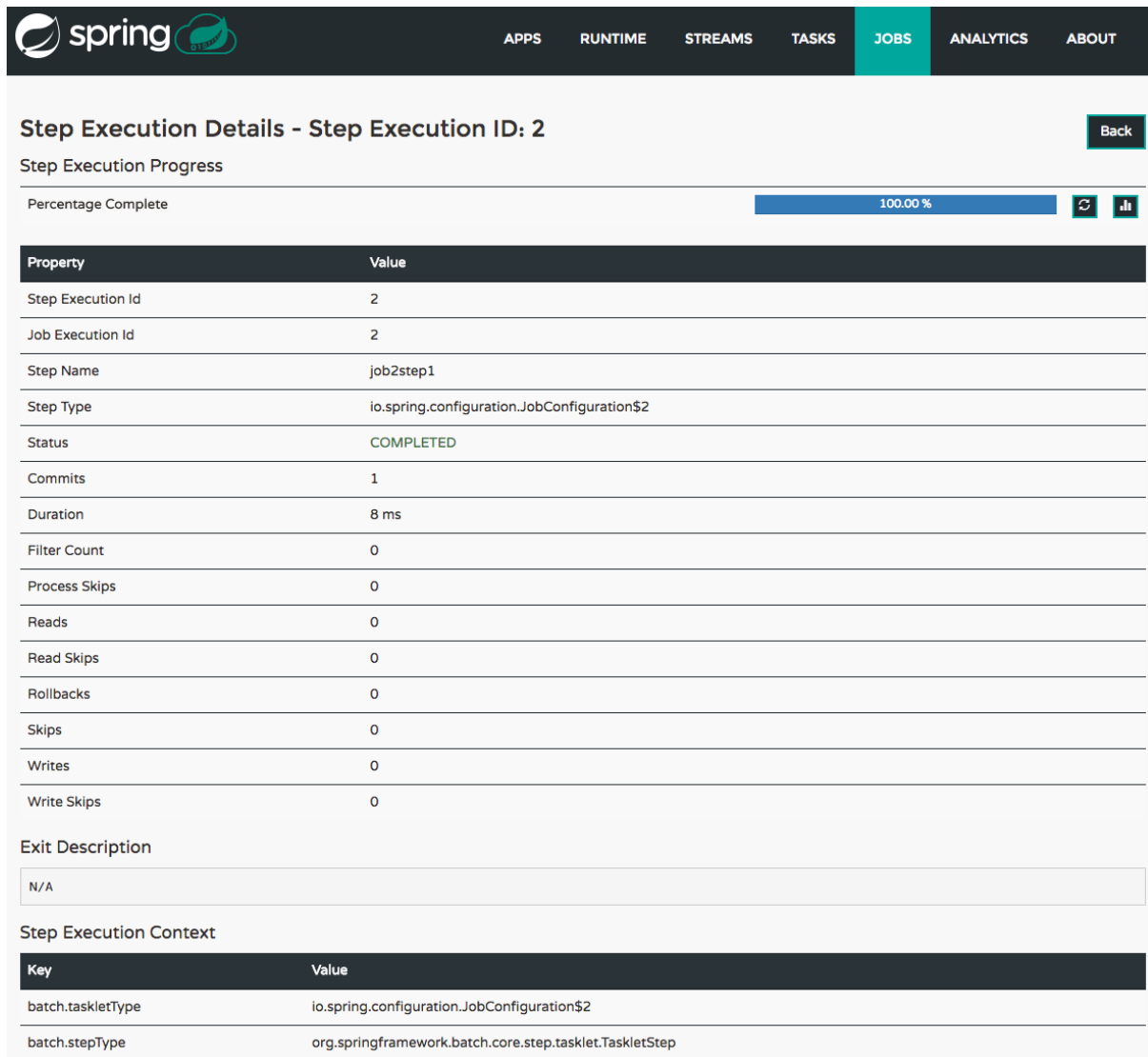


Figure 24.3. Step Execution History

25. Analytics

The *Analytics* section of the Dashboard provided data visualization capabilities for the various analytics applications available in *Spring Cloud Data Flow*:

- Counters
- Field-Value Counters
- Aggregate Counters

For example, if you have created the `springtweets` stream and the corresponding counter in the [Counter chapter](#), you can now easily create the corresponding graph from within the **Dashboard** tab:

1. Under `Metric Type`, select `Counters` from the select box
2. Under `Stream`, select `tweetcount`
3. Under `Visualization`, select the desired chart option, `Bar Chart`

Using the icons to the right, you can add additional charts to the Dashboard, re-arrange the order of created dashboards or remove data visualizations.

Part VI. Server Implementation

26. Server Properties

The Spring Data Flow Kubernetes Server has several properties you can configure that let you control the default values to set the `cpu` and `memory` requirements for the pods. The configuration is controlled by configuration properties under the `spring.cloud.deployer.kubernetes` prefix. For example you might declare the following section in an `application.properties` file or pass them as command line arguments when starting the Server.

```
spring.cloud.deployer.kubernetes.memory=512Mi
spring.cloud.deployer.kubernetes.cpu=500m
```

See [KubernetesAppDeployerProperties](#) for more of the supported options.

Data Flow Server properties that are common across all of the Data Flow Server implementations that concern maven repository settings can also be set in a similar manner. See the section on Common Data Flow Server Properties for more information.

Part VII. ‘How-to’ guides

This section provides answers to some common ‘how do I do that...’ type of questions that often arise when using Spring Cloud Data Flow.

If you are having a specific problem that we don’t cover here, you might want to check out stackoverflow.com to see if someone has already provided an answer; this is also a great place to ask new questions (please use the `spring-cloud-dataflow` tag).

We’re also more than happy to extend this section; If you want to add a ‘how-to’ you can send us a [pull request](#).

27. Logging

Spring Cloud Data Flow is built upon several Spring projects, but ultimately the dataflow-server is a Spring Boot app, so the logging techniques that apply to any [Spring Boot](#) application are applicable here as well.

While troubleshooting, following are the two primary areas where enabling the DEBUG logs could be useful.

27.1 Deployment Logs

Spring Cloud Data Flow builds upon [Spring Cloud Deployer](#) SPI and the platform specific dataflow-server uses the respective [SPI implementations](#). Specifically, if we were to troubleshoot deployment specific issues; such as the network errors, it'd be useful to enable the DEBUG logs at the underlying deployer and the libraries used by it.

1. For instance, if you'd like to enable DEBUG logs for the [kubernetes-deployer](#), you'd be starting the server with following environment variable set.

```
LOGGING_LEVEL_ORG_SPRINGFRAMEWORK_CLOUD_DEPLOYER_SPI_KUBERNETES=DEBUG
```

=== Application Logs

The streaming applications in Spring Cloud Data Flow are Spring Boot applications and they can be independently setup with logging configurations.

For instance, if you'd have to troubleshoot the header and payload specifics that are being passed around source, processor and sink channels, you'd be deploying the stream with the following options.

```
dataflow:>stream create foo --definition "http --logging.level.org.springframework.integration=DEBUG
/ transform --logging.level.org.springframework.integration=DEBUG / log --
logging.level.org.springframework.integration=DEBUG" --deploy
```

(where, *org.springframework.integration* is the global package for everything Spring Integration related, which is responsible for messaging channels)

These properties can also be specified via `deployment` properties when deploying the stream.

```
dataflow:>stream deploy foo --properties "app.*.logging.level.org.springframework.integration=DEBUG"
```

Part VIII. Appendices

Appendix A. Migrating from Spring XD to Spring Cloud Data Flow

A.1 Terminology Changes

Old	New
XD-Admin	Server (<i>implementations</i> : local, cloud foundry, apache yarn, kubernetes, and apache mesos)
XD-Container	N/A
Modules	Applications
Admin UI	Dashboard
Message Bus	Binders
Batch / Job	Task

A.2 Modules to Applications

If you have custom Spring XD modules, you'd have to refactor them to use Spring Cloud Stream and Spring Cloud Task annotations, with updated dependencies and built as normal Spring Boot "applications".

Custom Applications

- Spring XD's stream and batch modules are refactored into [Spring Cloud Stream](#) and [Spring Cloud Task](#) application-starters, respectively. These applications can be used as the reference while refactoring Spring XD modules
- There are also some samples for [Spring Cloud Stream](#) and [Spring Cloud Task](#) applications for reference
- If you'd like to create a brand new custom application, use the getting started guide for [Spring Cloud Stream](#) and [Spring Cloud Task](#) applications and as well as review the development [guide](#)
- Alternatively, if you'd like to patch any of the out-of-the-box stream applications, you can follow the procedure [here](#)

Application Registration

- Custom Stream/Task application requires being installed to a maven repository for Local, YARN, and CF implementations or as docker images, when deploying to Kubernetes and Mesos. Other than maven and docker resolution, you can also resolve application artifacts from `http`, `file`, or as `hdfs` coordinates
- Unlike Spring XD, you do not have to upload the application bits while registering custom applications anymore; instead, you're expected to [register](#) the application coordinates that are hosted in the maven repository or by other means as discussed in the previous bullet

- By default, none of the out-of-the-box applications are preloaded already. It is intentionally designed to provide the flexibility to register app(s), as you find appropriate for the given use-case requirement
- Depending on the binder choice, you can manually add the appropriate binder dependency to build applications specific to that binder-type. Alternatively, you can follow the Spring Initializr [procedure](#) to create an application with binder embedded in it

Application Properties

- counter-sink:
 - The peripheral `redis` is not required in Spring Cloud Data Flow. If you intend to use the `counter-sink`, then `redis` becomes required, and you're expected to have your own running `redis` cluster
- field-value-counter-sink:
 - The peripheral `redis` is not required in Spring Cloud Data Flow. If you intend to use the `field-value-counter-sink`, then `redis` becomes required, and you're expected to have your own running `redis` cluster
- aggregate-counter-sink:
 - The peripheral `redis` is not required in Spring Cloud Data Flow. If you intend to use the `aggregate-counter-sink`, then `redis` becomes required, and you're expected to have your own running `redis` cluster

A.3 Message Bus to Binders

Terminology wise, in Spring Cloud Data Flow, the message bus implementation is commonly referred to as binders.

Message Bus

Similar to Spring XD, there's an abstraction available to extend the binder interface. By default, we take the opinionated view of [Apache Kafka](#) and [RabbitMQ](#) as the production-ready binders and are available as GA releases. We also have an experimental version of the [Gemfire](#) binder.

Binders

Selecting a binder is as simple as providing the right binder dependency in the classpath. If you're to choose Kafka as the binder, you'd register stream applications that are pre-built with Kafka binder in it. If you were to create a custom application with Kafka binder, you'd add the following dependency in the classpath.

```
<dependency>
  <groupId>org.springframework.cloud</groupId>
  <artifactId>spring-cloud-stream-binder-kafka</artifactId>
  <version>1.0.2.RELEASE</version>
</dependency>
```

- Spring Cloud Stream supports [Apache Kafka](#), [RabbitMQ](#) and an experimental [Gemfire](#) binder implementation. All binder implementations are maintained and managed in their individual repositories

- Every Stream/Task application can be built with a binder implementation of your choice. All the out-of-the-box applications are pre-built for both Kafka and Rabbit and they're readily available for use as maven artifacts [[Spring Cloud Stream](#) / [Spring Cloud Task](#) or docker images [[Spring Cloud Stream](#) / [Spring Cloud Task](#)]. Changing the binder requires selecting the right binder [dependency](#). Alternatively, you can download the pre-built application from this version of [Spring Initializr](#) with the desired “binder-starter” dependency

Named Channels

Fundamentally, all the messaging channels are backed by pub/sub semantics. Unlike Spring XD, the messaging channels are backed only by `topics` or `topic-exchange` and there's no representation of `queues` in the new architecture.

- `${xd.module.index}` is not supported anymore; instead, you can directly interact with named destinations
- `stream.index` changes to `:<stream-name>.<label/app-name>`
 - *for instance:* `ticktock.0` changes to `:ticktock.time`
- “topic/queue” prefixes are not required to interact with named-channels
 - *for instance:* `topic:foo` changes to `:foo`
 - *for instance:* `stream create stream1 --definition ":foo > log"`

Directed Graphs

If you're building non-linear streams, you could take advantage of named destinations to build directed graphs.

for instance, in Spring XD:

```
stream create f --definition "queue:foo > transform --expression=payload+'-foo' | log" --deploy
stream create b --definition "queue:bar > transform --expression=payload+'-bar' | log" --deploy
stream create r --definition "http | router --expression=payload.contains('a')?'queue:foo':'queue:bar'"
--deploy
```

for instance, in Spring Cloud Data Flow:

```
stream create f --definition ":foo > transform --expression=payload+'-foo' | log" --deploy
stream create b --definition ":bar > transform --expression=payload+'-bar' | log" --deploy
stream create r --definition "http | router --expression=payload.contains('a')?'foo':'bar'" --deploy
```

A.4 Batch to Tasks

A Task by definition, is any application that does not run forever, including Spring Batch jobs, and they end/stop at some point. Task applications can be majorly used for on-demand use-cases such as database migration, machine learning, scheduled operations etc. Using [Spring Cloud Task](#), users can build Spring Batch jobs as microservice applications.

- Spring Batch [jobs](#) from Spring XD are being refactored to Spring Boot applications a.k.a link: [Spring Cloud Task applications](#)
- Unlike Spring XD, these “Tasks” don't require explicit deployment; instead, a task is ready to be launched directly once the definition is declared

A.5 Shell/DSL Commands

Old Command	New Command
module upload	app register / app import
module list	app list
module info	app info
admin config server	dataflow config server
job create	task create
job launch	task launch
job list	task list
job status	task status
job display	task display
job destroy	task destroy
job execution list	task execution list
runtime modules	runtime apps

A.6 REST-API

Old API	New API
/modules	/apps
/runtime/modules	/runtime/apps
/runtime/modules/{moduleId}	/runtime/apps/{appId}
/jobs/definitions	/task/definitions
/jobs/deployments	/task/deployments

A.7 UI / Flo

The Admin-UI is now renamed as Dashboard. The URI for accessing the Dashboard is changed from localhost:9393/admin-ui to localhost:9393/dashboard

- (New) Apps: Lists all the registered applications that are available for use. This view includes informational details such as the URI and the properties supported by each application. You can also register/unregister applications from this view
- Runtime: Container changes to Runtime. The notion of `xd-container` is gone, replaced by out-of-the-box applications running as autonomous Spring Boot applications. The Runtime tab displays the applications running in the runtime platforms (*implementations*: cloud foundry, apache yarn, apache mesos, or kubernetes). You can click on each application to review relevant details about the application such as where it is running with, and what resources etc.

- [Spring Flo](#) is now an OSS product. Flo for Spring Cloud Data Flow's "Create Stream", the designer-tab comes pre-built in the Dashboard
- (New) Tasks:
 - The sub-tab "Modules" is renamed to "Apps"
 - The sub-tab "Definitions" lists all the Task definitions, including Spring Batch jobs that are orchestrated as Tasks
 - The sub-tab "Executions" lists all the Task execution details similar to Spring XD's Job executions

A.8 Architecture Components

Spring Cloud Data Flow comes with a significantly simplified architecture. In fact, when compared with Spring XD, there are less peripherals that are necessary to operationalize Spring Cloud Data Flow.

ZooKeeper

ZooKeeper is not used in the new architecture.

RDBMS

Spring Cloud Data Flow uses an RDBMS instead of Redis for stream/task definitions, application registration, and for job repositories. The default configuration uses an embedded H2 instance, but Oracle, DB2, SqlServer, MySQL/MariaDB, PostgreSQL, H2, and HSQLDB databases are supported. To use Oracle, DB2 and SqlServer you will need to create your own Data Flow Server using [Spring Initializr](#) and add the appropriate JDBC driver dependency.

Redis

Running a Redis cluster is only required for analytics functionality. Specifically, when the `counter-sink`, `field-value-counter-sink`, or `aggregate-counter-sink` applications are used, it is expected to also have a running instance of Redis cluster.

Cluster Topology

Spring XD's `xd-admin` and `xd-container` server components are replaced by stream and task applications themselves running as autonomous Spring Boot applications. The applications run natively on various platforms including Cloud Foundry, Apache YARN, Apache Mesos, or Kubernetes. You can develop, test, deploy, scale +/-, and interact with (Spring Boot) applications individually, and they can evolve in isolation.

A.9 Central Configuration

To support centralized and consistent management of an application's configuration properties, [Spring Cloud Config](#) client libraries have been included into the Spring Cloud Data Flow server as well as the Spring Cloud Stream applications provided by the Spring Cloud Stream App Starters. You can also [pass common application properties](#) to all streams when the Data Flow Server starts.

A.10 Distribution

Spring Cloud Data Flow is a Spring Boot application. Depending on the platform of your choice, you can download the respective release uber-jar and deploy/push it to the runtime platform (cloud foundry,

apache yarn, kubernetes, or apache mesos). For example, if you're running Spring Cloud Data Flow on Cloud Foundry, you'd download the Cloud Foundry server implementation and do a `cf push` as explained in the [reference guide](#).

A.11 Hadoop Distribution Compatibility

The `hdfs-sink` application builds upon Spring Hadoop 2.4.0 release, so this application is compatible with following Hadoop distributions.

- Cloudera - cdh5
- Pivotal Hadoop - phd30
- Hortonworks Hadoop - hdp24
- Hortonworks Hadoop - hdp23
- Vanilla Hadoop - hadoop26
- Vanilla Hadoop - 2.7.x (default)

A.12 YARN Deployment

Spring Cloud Data Flow can be deployed and used with Apache YARN in two different ways.

- Deploy the server [directly](#) in a YARN cluster
- Leverage Apache Ambari [plugin to provision](#) Spring Cloud Data Flow as a service

A.13 Use Case Comparison

Let's review some use-cases to compare and contrast the differences between Spring XD and Spring Cloud Data Flow.

Use Case #1

(It is assumed both XD and SCDF distributions are already downloaded)

Description: Simple `ticktock` example using local/singlenode.

Spring XD	Spring Cloud Data Flow
Start <code>xd-singlenode</code> server from CLI # <code>xd-singlenode</code>	Start a binder of your choice Start <code>local-server</code> implementation of SCDF from the CLI # <code>java -jar spring-cloud-dataflow-server-local-1.0.0.BUILD-SNAPSHOT.jar</code>
Start <code>xd-shell</code> server from the CLI # <code>xd-shell</code>	Start <code>dataflow-shell</code> server from the CLI

Spring XD	Spring Cloud Data Flow
	<pre># java -jar spring-cloud-dataflow-shell-1.0.0.BUILD-SNAPSHOT.jar</pre>
Create ticktock stream <code>xd:>stream create ticktock --definition "time log" --deploy</code>	Create ticktock stream <code>dataflow:>stream create ticktock --definition "time log" --deploy</code>
Review ticktock results in the xd-singlenode server console	Review ticktock results by tailing the ticktock.log/stdout_log application logs

Use Case #2

(It is assumed both XD and SCDF distributions are already downloaded)

Description: Stream with custom module/application.

Spring XD	Spring Cloud Data Flow
Start xd-singlenode server from CLI <pre># xd-singlenode</pre>	Start a binder of your choice Start local-server implementation of SCDF from the CLI <pre># java -jar spring-cloud-dataflow-server-local-1.0.0.BUILD-SNAPSHOT.jar</pre>
Start xd-shell server from the CLI <pre># xd-shell</pre>	Start dataflow-shell server from the CLI <pre># java -jar spring-cloud-dataflow-shell-1.0.0.BUILD-SNAPSHOT.jar</pre>
Register custom “processor” module to transform payload to a desired format <code>xd:>module upload --name toupper --type processor --file <CUSTOM_JAR_FILE_LOCATION></code>	Register custom “processor” application to transform payload to a desired format <code>dataflow:>app register --name toupper --type processor --uri <MAVEN_URI_COORDINATES></code>
Create a stream with custom module <code>xd:>stream create testupper --definition "http toupper log" --deploy</code>	Create a stream with custom application <code>dataflow:>stream create testupper --definition "http toupper log" --deploy</code>
Review results in the xd-singlenode server console	Review results by tailing the testupper.log/stdout_log application logs

Use Case #3

(It is assumed both XD and SCDF distributions are already downloaded)

Description: Simple batch-job.

Spring XD	Spring Cloud Data Flow
Start xd-singlenode server from CLI <pre># xd-singlenode</pre>	Start local-server implementation of SCDF from the CLI <pre># java -jar spring-cloud-dataflow-server-local-1.0.0.BUILD-SNAPSHOT.jar</pre>
Start xd-shell server from the CLI <pre># xd-shell</pre>	Start dataflow-shell server from the CLI <pre># java -jar spring-cloud-dataflow-shell-1.0.0.BUILD-SNAPSHOT.jar</pre>
Register custom “batch-job” module <pre>xd:>module upload --name simple-batch --type job --file <CUSTOM_JAR_FILE_LOCATION></pre>	Register custom “batch-job” as task application <pre>dataflow:>app register --name simple-batch --type task --uri <MAVEN_URI_COORDINATES></pre>
Create a job with custom batch-job module <pre>xd:>job create batchtest --definition "simple-batch"</pre>	Create a task with custom batch-job application <pre>dataflow:>task create batchtest --definition "simple-batch"</pre>
Deploy job <pre>xd:>job deploy batchtest</pre>	NA
Launch job <pre>xd:>job launch batchtest</pre>	Launch task <pre>dataflow:>task launch batchtest</pre>
Review results in the xd-singlenode server console as well as Jobs tab in UI (executions sub-tab should include all step details)	Review results by tailing the batchtest/ stdout_log application logs as well as Task tab in UI (executions sub-tab should include all step details)

Appendix B. Building

To build the source you will need to install JDK 1.8.

The build uses the Maven wrapper so you don't have to install a specific version of Maven. To enable the tests for Redis you should run the server before building. See below for more information on how to run Redis.

The main build command is

```
$ ./mvnw clean install
```

You can also add '-DskipTests' if you like, to avoid running the tests.



Note

You can also install Maven ($\geq 3.3.3$) yourself and run the `mvn` command in place of `./mvnw` in the examples below. If you do that you also might need to add `-P spring` if your local Maven settings do not contain repository declarations for spring pre-release artifacts.



Note

Be aware that you might need to increase the amount of memory available to Maven by setting a `MAVEN_OPTS` environment variable with a value like `-Xmx512m -XX:MaxPermSize=128m`. We try to cover this in the `.mvn` configuration, so if you find you have to do it to make a build succeed, please raise a ticket to get the settings added to source control.

The projects that require middleware generally include a `docker-compose.yml`, so consider using [Docker Compose](#) to run the middleware servers in Docker containers. See the README in the [scripts demo repository](#) for specific instructions about the common cases of mongo, rabbit and redis.

B.1 Documentation

There is a "full" profile that will generate documentation. You can build just the documentation by executing

```
$ ./mvnw clean package -DskipTests -P full -pl spring-cloud-dataflow-server-kubernetes-docs -am
```

B.2 Working with the code

If you don't have an IDE preference we would recommend that you use [Spring Tools Suite](#) or [Eclipse](#) when working with the code. We use the [m2eclipse](#) eclipse plugin for maven support. Other IDEs and tools should also work without issue.

Importing into eclipse with m2eclipse

We recommend the [m2eclipse](#) eclipse plugin when working with eclipse. If you don't already have m2eclipse installed it is available from the "eclipse marketplace".

Unfortunately m2e does not yet support Maven 3.3, so once the projects are imported into Eclipse you will also need to tell m2eclipse to use the `.settings.xml` file for the projects. If you do not do this

you may see many different errors related to the POMs in the projects. Open your Eclipse preferences, expand the Maven preferences, and select User Settings. In the User Settings field click Browse and navigate to the Spring Cloud project you imported selecting the `.settings.xml` file in that project. Click Apply and then OK to save the preference changes.

**Note**

Alternatively you can copy the repository settings from [.settings.xml](#) into your own `~/ .m2/ settings.xml`.

Importing into eclipse without m2eclipse

If you prefer not to use m2eclipse you can generate eclipse project metadata using the following command:

```
$ ./mvnw eclipse:eclipse
```

The generated eclipse projects can be imported by selecting `import existing projects` from the `file` menu.

Appendix C. Contributing

Spring Cloud is released under the non-restrictive Apache 2.0 license, and follows a very standard Github development process, using Github tracker for issues and merging pull requests into master. If you want to contribute even something trivial please do not hesitate, but follow the guidelines below.

C.1 Sign the Contributor License Agreement

Before we accept a non-trivial patch or pull request we will need you to sign the [contributor's agreement](#). Signing the contributor's agreement does not grant anyone commit rights to the main repository, but it does mean that we can accept your contributions, and you will get an author credit if we do. Active contributors might be asked to join the core team, and given the ability to merge pull requests.

C.2 Code Conventions and Housekeeping

None of these is essential for a pull request, but they will all help. They can also be added after the original pull request but before a merge.

- Use the Spring Framework code format conventions. If you use Eclipse you can import formatter settings using the `eclipse-code-formatter.xml` file from the [Spring Cloud Build](#) project. If using IntelliJ, you can use the [Eclipse Code Formatter Plugin](#) to import the same file.
- Make sure all new `.java` files to have a simple Javadoc class comment with at least an `@author` tag identifying you, and preferably at least a paragraph on what the class is for.
- Add the ASF license header comment to all new `.java` files (copy from existing files in the project)
- Add yourself as an `@author` to the `.java` files that you modify substantially (more than cosmetic changes).
- Add some Javadocs and, if you change the namespace, some XSD doc elements.
- A few unit tests would help a lot as well — someone has to do it.
- If no-one else is using your branch, please rebase it against the current master (or other target branch in the main project).
- When writing a commit message please follow [these conventions](#), if you are fixing an existing issue please add `Fixes gh-XXXX` at the end of the commit message (where XXXX is the issue number).